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FLORISTIC COMPOSITION AND WOODY SPECIES DIVERSITY IN NATIONAL PARK OF MADHUPUR TRACT UNDER TANGAIL NORTH FOREST DIVISION, BANGLADESH

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ABSTRACT

The floristic composition, species diversity and structural characteristics of woody species in National Park range under Tangail North Forest Division, were investigated based on bit-wise classification. There were five bits in the range. We recorded 18 families, 21 genera, 21 species and 500 woody individuals from the study area (0.5 ha). Fabaceae was the most species rich family and each genus was represented by a single species. Sal (*Shorea robusta* C.F. Gaertn) was the most dominant species in terms of its highest and tremendously high importance values *IV*% in the total area and all bits, respectively. More than 40% species had very low *IV*%, indicating their disappearance or may not be strongly associated with Sal. These species need appropriate management to prevent their disappearance or extinction from the forest area. The values of Shannon's index H' and Pielou's index J' (evenness) for the study area were 2.01 and 0.45, respectively. These values show low species diversity as compared to other forests in Bangladesh. Among the bits, the values of H' and J' were more or less similar with low index values (from 1.34 to 1.74 and from 0.44 to 0.65, respectively) which may be due to similar species composition with low similarity index values (0.24 t0 0.48). The structural characteristics of woody species diversity showed that the highest species diversity was observed at 5 cm< D ≤10 cm diameter class. In addition, the mean height and basal area of woody species increased with increasing dbh. A few numbers of small trees habitat in the study sites, because the Sal forests in the study area are considered to face a severe threat to their existence due to high anthropogenic disturbances occurred inside and outside the boundary.

Contribution/Originality: This study is one of very few studies which investigated the floristic and structural characteristics of forest which will be helpful for forest management and policy makers to know the present and future situation of the forest.

1. INTRODUCTION

The flora of the Bangladesh tropical forest is one of the ten global hot spot zones for biodiversity [1] and retains rich biological diversity due to its exceptional geophysical location [2-4]. The forest land and natural forest cover of this country are 1.442 million ha and 1.204 million ha respectively [5] which are managed by the forest department, land ministry and other individuals [6]. Tropical forests are ecologically and economically important

for the livelihood of local communities. For the last few decades, the natural forests of the country are rapidly decreasing at an alarming rate by 1-4% of their current land area [7] due to overpopulation, land-use alterations, unsuitable and poor management practices [8]. The net forest loss in South and Southeast Asia, from 2010 to 2015 is about 25% higher compared to 1990 [9] and Bangladesh is also situated in this zone. Agricultural extension, deforestation, extreme removal of woody and non-woody resources, urbanization, and applying unfitted management tools are the major causes of forest degradation in Bangladesh [10].

The Sal (*Shorea robusta* C.F. Gaertn) forest of Bangladesh is a part of the tropical moist deciduous forest, locally known as the inland Sal forest [11]. Madhupur Sal forest is the largest patch, which has a high economic and ecological significance in the central part of Bangladesh [12]. This is located in greater districts of Dhaka, Tangail, Mymensingh and Netrokona. In addition, Sal (*Shorea robusta*) stands of timber value, these forests are composed of many medicinal plants like Hartaki (*Termina liachebula*), Bohera (*Terminalia belerica*), Arjune (*Terminalia arjuna*) and Kurchi (*Holarrhena antidysentrica*) [13]. Biological diversity is a key issue in nature conservation and species diversity. Tree species diversity is fundamental to overall forest biodiversity because trees provide resources and habitats for almost all other forest species [14-17]. For understanding the actions and dynamics of forest ecosystems the knowledge of the floristic arrangement, their quantitative structure, and diversity are vital [18, 19]. Moreover, woody species composition is considered a biodiversity indicator and an important attribute of forest ecosystems [20]. The biodiversity of Sal forests is very wide and interesting both from ecological and conservation point of view. Along with trees, shrubs and herbs, the climber is an integrated part of its biodiversity [21]. Potential information for many native tree species is received from various studies that focused on natural regeneration status in different natural forests of Bangladesh [22-28]. Furthermore, Madhupur National Park Sadar Range contains a huge variety of floral composition and diversity of woody tree species, but there is no enough study on this particular region about floral composition and diversity of woody tree species. The main aim of this study is to know the approximate floral composition and diversity of woody tree species at Madhupur National Park Sadar Range under Tangail north forest division.

2. MATERIALS AND METHODS

2.1 Study Site

Madhupur forest is a tropical, moist, and a deciduous type of forest. Madhupur National Park (MNP) is located at 24°45′N Latitude and 90°05′ E Longitude, on the Tangail-Mymensingh main road, encompass a Gazette notified area of 8,436 ha [29]. It is under the territorial jurisdiction of the Tangail Forest Division. Actually, this forest is present in lowland and flood plain based area. In our country, only this forest contains pure Sal (*Shorea robusta).* The Park was established by the Forest Department in 1962 and formally notified in Gazette in 1982. At present, the tract of Madhupur forest (MF) consists an area of 45,565.18 acres out of which 2,525 acres are reserved and 4,304 acres land is under the process to be declared as reserved forest [29]. For the purpose of biodiversity conservation, the Government declared Madhupur Garh, which is also known as 'Madhupur National Park' comprising an area of 20,837.23 acres by a gazette, notifying on 24th February 1982. Out of that, 20,244.23 acres are under Madhupur upazilla of Tangail district and 593.00 acres are under Muktagacha upazilla of Mymensingh district [29]. Madhupur National Park has four ranges, ten bits, and one nursery center [29]. The present study site, Madhupur National Park sadar range is one of them and total area is 11936.14 acres. It has five bits (National Park Sadar bit, Rajabari bit, Beribide bit, Lohoria bit, Gasabari bit).

2.2. Sampling Plot

A total of fifty plots (each plot size:10m×10m) were sampled at five bits of National Park range in Tangail North Forest Division. Ten sample plots were selected from each bit using simple random sampling method. Trees were identified to species level and their DBH and height were measured.

3. DATA ANALYSIS

3.1. Species Dominance

The dominance of a species was defined by its importance value (*IV*%) expressed as follows [29]:

$$\text{IV} = \left(\frac{n_i}{\sum_{i=1}^{Q} n_i} \times 100 + \frac{a_i}{\sum_{i=1}^{Q} a_i} \times 100 + \frac{f_i}{\sum_{i=1}^{Q} f_i} \times 100 \right) \Big/ 3$$

where n_i is the number of individuals of the *ith* species, a_i is the basal area at a height at DBH of the *ith* species, f_i is the number of quadrats in which the *ith* species appeared and Q is the total number of quadrats.

3.2. Floristic Similarity

The similarity of floristic composition among bits was calculated using the Jaccard's similarity index based on presence and absence data by the application of Multivariate statistical analysis [30].

The value of index is 1.0 when the number of individuals belonging to a species is the same for the two sites for all species, i.e. floristic composition is completely the same in the two sites, and is 0.0 when they have no common species.

3.3. Species diversity and Equitability Index

The following Shannon's index H' [31] and Pielou's equitability index J' [32] were used to measure woody species diversity. The Shannon's index is calculated from the equation: $H' = \sum_{i=1}^{s} \frac{n_i}{N} \log_2 \frac{N}{n_i}$

Where n_i is the number of individuals of *i*th species, N is the total number of individuals.
Therefore, the ratio of observed diversity to maximum diversity can be used to measure evenness (J'):

$$J' = \frac{H'}{H'_{\max}} \; (H'_{\max} = \log_2 S)$$

The maximum diversity ($H'_{\max}$) that could possibly occur in a situation where all species had equal abundances, in other words if ($H'_{\max} = \log_2 S$). As a heterogeneity measure the equitability index takes into account the degree of evenness in species abundances. None the less, it is possible to calculate a separate evenness measure. The value of the equitability index is less than 1. The value would be 1 when the relative abundances of individuals of all species in a community are the same. This circumstance is naturally or biologically impossible.

4. RESULTS

4.1. Species Composition and Dominance

As shown in Table 1, a total of 500 individuals was encountered from 21 species, 21 genera and 18 families. Fabaceae was the most species rich family, with three species, whereas each genus has single species. Sal (*Shorea robusta* C.F. Gaertn) is the major species in terms of the largest number of individuals (346) which is 69% of the total number of individuals. In terms of the importance value *IV*%, Sal was the most dominant species (59.81%) and Ajuli (*Dillenia pentagyna* Roxb) was the second most dominant species (9.86%) for the entire range. Sal was also the most dominant species in each bit with the highest *IV*% Table 1.

Table-1. List of twenty-one species in order of species rank determined by the importance value (*IV*%) in National Park range in Tangail North Forest Division.

Species Rank	Local name	Scientific Name	Family	IV%					
				Total Range	Beri Baid Bit (1821ha)	Raja Bari Bit(687.9 ha)	Gasabari Bit (632.8 ha)	Lohorie Bit (1278 ha)	National Park Sadar Bit (1567 ha)
1	Sal	*Shorea robusta* C.F. Gaertn	Dipterocarpaceae	59.81	52.80	63.05	58.72	54.52	63.07
2	Ajuli	*Dillenia pentagyna* Roxb	Dilleniaceae	9.86	1.97	17.45	3.37	13.70	11.16
3	Datoi	*Grewia microcos* L	Tiliaceae	4.81	6.65	0.0	0.0	10.13	6.01
4	Akashmoni	*Acacia auriculiformis* Willd.	Fabaceae	4.17	0.0	0.0	23.70	0.0	0.0
5	Behula	*Semecarpus anacardium* L.f	Anacardiaceae	4.16	2.00	2.98	5.99	10.10	0.0
6	koroi	*Albizia lebbek* (L) Benth	Fabaceae	2.67	1.78	2.46	0.0	2.20	6.57
7	Anaikota	*Ziziphus rugosa* Lamk	Rhamnaceae	2.67	3.26	7.59	0.0	1.71	0.0
8	Banorhola	*Duabanga sonneratioides* Buch.-Ham	Lythraceae	1.92	2.77	0.0	0.0	4.08	2.06
9	Gamar	*Gmelina arborea* (Roxb.) DC	Verbenaceae	1.44	0.0	0.0	8.21	0.0	0.0
10	Uja	*Cryptocarya amygdalina* Nees	Lauraceae	1.24	2.50	1.90	0.0	0.0	0.0
11	Bon Sonalu	*Stereospermum suaveolens* (Roxb.) DC	Bignoniaceae	1.10	0.0	0.0	0.0	0.0	5.87
12	Bohera	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	0.96	1.96	2.58	0.0	0.0	0.0
13	Bajna	*Zanthoxylum rhetsa* (Roxb.) DC.	Rutaceae	0.87	3.99	0.0	0.0	0.0	0.0
14	Sinduria	*Mallotus philippensis* (Lamk.) Muell.-Arg	Euphorbiaceae	0.81	3.47	0.0	0.0	0.0	0.0
15	Gandhi gazari	*Miliusa velutina* (Dunal) Hk.f.&Thoms	Annonaceae	0.81	0.0	0.0	0.0	3.53	0.0
16	Gadhila	*Careya arborea* Roxb.	Lecythidaceae	0.52	0.0	0.0	0.0	0.0	2.81
17	Haldu	*Adina cordifolia* (Roxb.) Hook. f. ex Brandis	Rubiaceae	0.52	2.32	0.0	0.0	0.0	0.0
18	kanchon	*Bauhinia acuminata* Linn.	Fabaceae	0.46	0.0	0.0	0.0	0.0	2.44
19	Joinagota	*Schleichera oleosa* (Lour.)Oken	Sapindaceae	0.41	1.73	0.0	0.0	0.0	0.0
20	Sidha	*Lagerstroemia parviflora* (L.) Roxb.	Lythraceae	0.39	0.0	1.98	0.0	0.0	0.0
21	Pitraj	*Aphanamixis polystachya* (Wall.) R. N. Park.	Meliaceae	0.39	12.75	0.0	0.0	0.0	0.0

4.2. Floristic Similarities among Bits

The floristic similarities among five bits were classified using the dendrogram of the Jaccard similarity index. (Figure 1). The highest similarity was found between Beribaid bit and Rajabari bit and the similarity index value was 0.48. The second and third highest similarities were between the Beribaid bit + Rajabari bit and the Lohore bit (index value=0.46); and between the Beribaid bit + Rajabari bit + the Lohore bit and the National Park bit (index value= 0.35), respectively. The lowest index value of 0.24 was found between the Gasabari bit and the combination of other four bits.

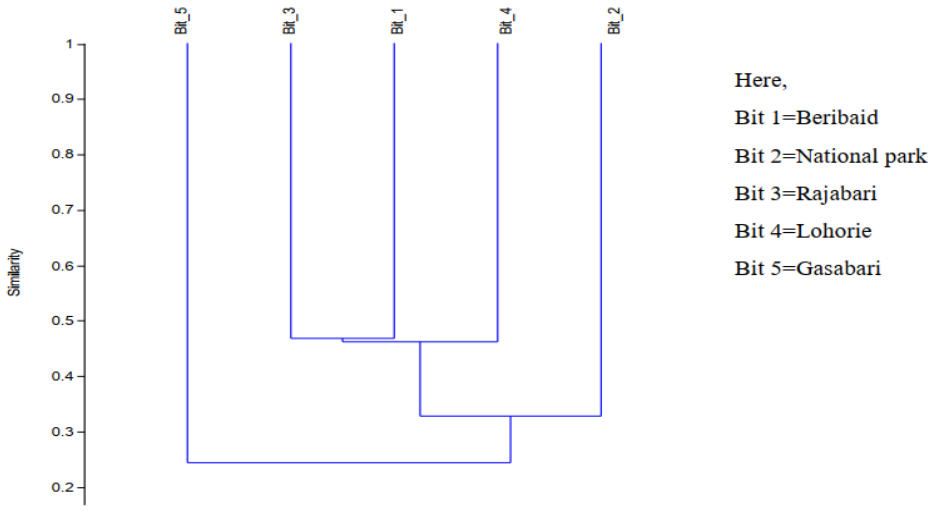

Figure-1. Floristic similarity among bits of National Park range in Tangail North Forest Division.

4.3. Woody Species Diversity

It is shown in Table 2, the highest and the lowest basal area were observed respectively in the Rajabari bit (49.55 ha^{-1}) and in the Gasabari bit (32.62 ha^{-1}). The density of the woody species was uppermost in Gasabari bit (234 stem ha^{-1}) and second uppermost was Beribaid (222 stem ha^{-1}) and other densities were more or less similar.

In case of the analysis of diversity indices, the values of H' and J' were respectively 1.67 and 0.55 for the National Park Sadar bit, 1.72 and 0.45 for the Beri Baid bit, 1.34 and 0.44 for the Raja Bari bit, 1.52 and 0.65 for the Gasabari bit, 1.60 and 0.53 for the Lohorie bit, and 2.01 and 0.45 for the whole range of Tangail North Forest Division Table 2. When species diversity was compared among the bits, the Beri Baid bit was the most diverse. This is because the highest species richness (14 species) and a considerable value of J' (0.45) resulted the highest H'-value in the bit. On the other hand, the Gasabari bit was the least diverse in species composition. This is because the lowest J' value (0.44) in the bit, though species richness was higher or the same (8 species) with compare to other bits.

Table-2. Abundance, species richness, basal area, density and diversity indices in National Park range in Tangail North Forest Division

Name of Range	Name of Bit	Per sample area		Total Area (ha)	Basal area m^2/ha	Density stem/ha	H'	J'
		No of trees	No of species					
National Park	National Park Sadar	90	8	1567	46.85	180	1.67	0.55
	Beri Baid	111	14	1821	40.71	222	1.72	0.45
	Raja Bari	92	8	687.9	49.55	184	1.34	0.44
	Gasabari	117	5	632.8	32.62	234	1.52	0.65
	Lohorie	90	8	1278.8	48.03	180	1.60	0.53
Total Range		500	21	5987.5	43.55	200	2.01	0.45

4.4. Structural Characteristics of Woody Species

The woody species in the entire range of Tangail North Forest Division were classified in to five diameter classes (0<D ≤5, 5< D ≤10, 10< D ≤15, 15< D ≤20, and D >20) (Table 3). Based on the diameter class, stem density, mean height and basal area were respectively 22/ha, 6.73m and 0.03 m²/ha for the diameter class 0<D ≤5; 170/ha, 9.73 m, and 0.95 m²/ha for the diameter class 5< D ≤10; 360/ha,13.75 m, and 4.56 m²/ha for the diameter class10<D≤15; 278/ha,18.40 m, and 6.80 m²/ha for the diameter class15<D ≤20; and 168/ha, 20.76 m, and 9.45 m²/ha for the diameter class D>20. In case of species diversity, the values of *H′* were 1.68, 2.26, 2.16, 1.40 and 1.06 for the diameter classes 0<D ≤5, 5< D ≤10, 10< D ≤15, 15< D ≤20, and D >20, respectively. The highest diversity was found at 5<D ≤10 diameter class and the lowest value was at D >20. The value of stem density was the highest (360/ha) at 10< D ≤15 diameter class and lowest (22/ha) at 0<D ≤5. The value of mean height was the highest (20.76m) at D>20 diameter class and lowest (6.73m) at 0<D ≤5. The value of the basal area was the highest (9.45 m²/ha) at D>20 diameter class and lowest (0.03m²/ha) at 0<D ≤5.

Table-3. Species structural characteristic based on diameter class.

Diameter class (cm)	0<D≤5	>5 D ≤10	>10 D ≤15	>15 D ≤20	D >20
No. of species	4	16	17	13	6
Stem density /ha	22	170	360	278	168
Mean height (m)	6.73	9.73	13.75	18.40	20.76
Basal area(m²/ha)	0.03	0.95	4.56	6.80	9.45
Diversity index, *H′*	1.68	2.26	2.16	1.40	1.06

5. DISCUSSION

Bangladesh is rich in field crops, fruits, nuts and forest plants covering a wide array of species, genera and families [33]. Some of these species, especially fruit and timber yielding plants, are very common and distributed all over the country. The present investigation indicates that some of the common plant species are also present in the Madhupur Sal forest which are similar to those of others [34, 35]. A total of 500 individual trees of 21 species under 18 families was recorded from the study area. It is evident that almost all the families at the forests were represented by single genera and each genus was represented by a single species (Table 1). Therefore, the woody floristic composition of the present study is a little rich than that in south eastern Bangladesh (17 species under 10 families) [36], whereas it is lower than the study (42 species under 26 families) taken in natural Sal forest at Kaliakair Upazilla under Gazipur district Rahaman, et al. [28]. The number of woody tree species found at Madhupur Sal forest was lower than the other studies, such as Ukhia Range (50 species) [37], Rampahar Natural Forest (50 species under 28 families) and Lawachara forest (78 species) [38], Sitapahar Reserve forest (85 species) [39], Bamu reserve forest (85 species) [40], Tankawati natural forest (62 species) [41], Teknaf Wildlife Sanctuary (150 species) [42], Inani Protected Forest (151 species) [43], Teknaf Wildlife Sanctuary (143 species) [44], Chunati Wildlife Sanctuary (92 species) [45] and Himchari National Park (88 species) of Cox's Bazar [46]. It is indicated that there exists a poor woody floral composition at family, genus and species levels in Madhupur National Park Sadar Range. It may be little worthy to compare the present study with other studies done in different forests in Bangladesh considered non tree plant species with woody tree species in larger sample area. That is why, the forests of these studies have rich floristic composition. Nonetheless, this situation demands urgent attention to enrich the floristic composition as well as plant diversity in the study area from family to species levels to avoid the risk of extinction of a single species or genera with a single species.

Sal (*Shorea robusta* C.F. Gaertn) was the most dominant species, because it appeared with the highest and tremendously high importance values *IV*% in the total area and all bits, respectively (Table 1). *Dillenia pentagyna* Roxb, *Grewia microcos* L, *Acacia auriculiformis* Willd., *Semecarpus anacardium* L.f, *Albizia lebbek* (L) Benth, and *Ziziphus rugosa* Lamk are the most associated species of Sal, because they found in almost all bits with considerably high *IV*%. In addition, *Zanthoxylum rhetsa* (Roxb.) DC, *Mallotus philippensis* (Lamk.) Muell.-Arg, *Miliusa velutina*

(Dunal) Hk.f.&Thoms, *Careya arborea* Roxb., *Adina cordifolia* (Roxb.) Hook. f. ex Brandis, *Bauhinia acuminata* Linn., *Schleichera oleosa* (Lour.) Oken, *Lagerstroemia parviflora* (L.) Roxb. *Aphanamixis polystachya* (Wall.) R. N. Park. had a very low *IV*% which indicates that these species may not be strongly associated species of *S. robusta*. These species with low *IV*% need special care of management to prevent their disappearance or extinction from the forest area.

Among five bits at Madhupur National Park Sadar Range under Tangail north forest division, Gasabari bit comprises the highest woody species density (234 stem ha^{-1}) (Table 2). The mean density of the present study (200 stem ha^{-1}) was higher than that in south eastern Bangladesh (121 stem ha^{-1}) [36], but was lower than that of other forest parts (250 to 400 stem ha^{-1}) of Bangladesh [28, 37, 38, 40, 41, 43, 46]. In case of basal area, the highest basal area was found in the Rajabari bit (49.55 m^2ha^{-1}) as well as the lowest was in the Gasabari bit (32.62 m^2ha^{-1}) (Table 2). The mean basal area (43.55 m^2ha^{-1}) of the study was higher than that of Himchari National Park (10.98 m^2ha^{-1}) [46] and of south eastern Bangladesh (11.53 m^2ha^{-1}) [36]. On the other hand, the mean basal area of this study was lower than that of Sitapahar reserve forests (53.5 m^2 ha^{-1}) [39] and that of Tankawati natural forest (47.02 - 62.16 m^2 ha^{-1}) [41].

The values of Shannon's index H' and Pielou's index J' (evenness) for the entire range were respectively 2.01 and 0.45 (Table 2). The values of H' and J' in the present forest are lower than the values of those reported in Himchari National Park (H'= 3.733, J'= 0.853) [46, 47], Sithapahar reserve forest (H'= 2.98) [43], Tankawati natural forest of Chittagong (South) Forest Division (H'= 3.25), Garo Hills of India (H'= 4.27) [37] and in south eastern part of Bangladesh (J'= 0.613) [36], whereas mean stem density and basal area are higher in the present forest area than those in the Himchari National Park and south eastern part of Bangladesh, but lower than those in other latter forest areas. It can be concluded that the Sal Forest areas in Tangail north forest division seems to be most likely unequillibrium in floristic composition with low species diversity. Among the bits, the values of H' and J' were more or less similar with low index values, i.e. H' and J' values changes from 1.34 to 1.74 and from 0.44 to 0.65, respectively (Table 2). In case of Jaccard similarity index, species similarities among the bits were also more or less similar with low index values (0.24 t0 0.48) (Figure 1). Therefore, it can be concluded that low species diversity among the bits of Madhupur National Park Sadar Range is due to the low value of species similarity among the bits.

According to the structural characteristics of woody species diversity of the study sites, the highest diversity was found at $5< D \leq 10$ diameter class. It indicates that species richness was more than others at $5< D \leq 10$ diameter class. Same result was found in Himchari National Park where 65.97% of species diversity belonged to dbh range 5 - <15 cm [46]. The value of stem density was the highest in class $10 <D \leq 15$ (360/ha) and lowest in class $0 <D \leq 5$ (22/ha). The value of mean height was the highest in class D>20 (20.76m) and lowest in class $0 <D \leq 5$ (6.73m). The value of basal area was the highest in class D>20 (9.45 m^2/ha) and lowest in class $0 <D \leq 5$ (0.03m^2/ha) (Table 3). The number of individuals is fewer at $0 <D \leq 5$ diameter class. The results indicate that mean height and basal area increased with increasing dbh. A few number of small woody species habitat in the study sites, because the Madupur Sal forests are considered to face a severe threat to their existence due to high anthropogenic disturbances occurred inside and outside the boundary [48].

6. CONCLUSIONS

The result of the present study provides a complete view of species composition, species diversity, species similarity and structural characteristics of woody species of the National Park Range in Tangail North Forest Division. It will be helpful to know the present condition and the future situation of the forest. According to the result, Government can make future plan to enrich the floristic composition as well as species diversity in the study sites. If this study can drive different parts of Bangladesh and apply its result in the field of management, that can aid to know our forest extensively and ability to save our valuable biodiversity from being smashed up.

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