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Full Length Research Paper

Tree and shrub diversity, composition and stand structure of Tropical Deciduous Sal Forests of Bangladesh

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Abstract

Moist deciduous Sal (*Shorea robusta*) forests are one of the most ecological and economically important forest types in Bangladesh. Therefore, the study was conducted to analyze the tree and shrub species diversity, vegetation covers and structural composition of the major Sal forests of the Madhupur and Bhawal region in Bangladesh. The Quadrat method was used to investigate the biodiversity patterns. Madhupur National Park (MNP) possessed an important diversity of 69 plant species belongs to 26 families and 55 genera. Contrary, Bhawal National Park (BNP) consisted of 28 plant species belongs to 16 families and 22 genera. However, 27 plant species were similar between these two forests and considering the important value index (IVI), Dipterocarpaceae family was the most dominant family in both MNP and BNP. In both forests, Sal was the most dominant species followed by Fulkhori. On the contrary, in both forests have considerable number of species having IVI value of less than 1, indicating these species needs immediate conservation strategy. However, these threaten ecosystems still have important numbers of plant diversity which creates attention to the policymakers as well as the forest department of Bangladesh.

Keywords: Biodiversity, Madhupur Sal, Bhawal Sal, National Park, Vegetation cover.

INTRODUCTION

Bangladesh is a sub-tropical South Asian country having only 17.08% forest land area (BFD, 2016; Islam et al. 2017; Rahman and Miah, 2017; Alauddin et al. 2020). However, FAO (2015; Alauddin et al 2020) estimated the real forest cover of Bangladesh is only 11%. The per capita forest cover (less than 0.015 ha; FAO, 2015) is very poor compare to 0.145 ha of Asia and 0.597 ha of whole global perspectives. The Sal forest of Bangladesh is a part of the tropical moist deciduous forest (Hasan et al., 2018; 2020), locally known as 'inland Sal forest'. In Bangladesh, the Sal forests are one of the three major forest resources (other types are tropical evergreen and coastal forests) covering about 32% of the total forestland and 10% forest coverage (Rahman and Vacik 2010). The total area of Sal forests is 110 thousand ha in Bangladesh, out of which 86% is in the central region and 14% in northern region. Sal forests have been dramatically reduced in area and now exist only in a number of widely scattered and degraded patches (Islam and Hyakumura 2019, 2021). Forests consist of the districts Dhaka, Mymensingh, Tangail, Dinajpur, Rangpur and Rajshahi. The largest belt and the major Sal forests lies in the districts of greater Dhaka, Mymensingh and Tangail which is known as "Madhupur Tract" (Rahman and Vacik 2010) is about 100 km long in the north-south direction and 10-40 km wide in the east-west direction (Islam et al. 2015). The southern part of this tract is known as 'Bhawal Garh' and the northern part as 'Madhupur Garh'. 'Madhupur and Bhawal Garh' together represents unique characteristics of Sal forest of Bangladesh which covered more than 80% area of this deciduous forest. Due to the abundance of Sal trees (*Shorea robusta*), this forest coined the name 'Sal forest'. Sal trees occur gregariously on the southern slopes of the Himalayas and are distributed in Bangladesh

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India and Nepal (Gautam and Devoe 2006; Rahman and Vacik 2010). Its presence is additionally indicated in South China and Bhutan (Islam and Sato 2012; Rahman and Vacik 2010). It is evident that Sal forests are the potential to yield alternative forest products also. Additionally, a Sal tree produces fuel and timber wood, fodder, seeds for the oil production , leaves for plates, food, latex or resin from wood, tannic acid and gum from bark (Islam et al. 2013)). Besides, associates of Sal are known to produce edible fruits, fodder and compost, fibers, leaves for umbrellas, medicinal plants, thatch, grass, brooms and many other products depending on the species composition (Alam et al. 2008)).

Sal forest ecosystem supports a rich and diverse variety of flora and fauna (Jahan et al 2017a; 2017b; Rahman and Jahan 2019; Alauddin et al 2020; Shome et al. 2020), which includes 221 plant species and 220 animal species (Alam et al. 2008). Approximately 500 undergrowth species have been reported in association with Sal trees. It has been reported that 24 species of climbers, 27 species of grasses, 3 species of palms, 105 species of herbs, 19 species of shrubs, and 43 species of trees have been found in the Sal forests. A total of 220 species of vertebrates, including 12 amphibians, 25 reptiles, 148 birds, and 35 mammal species, are found in the Sal forests (Hossain 1995). Few decades ago, Sal forest was the richest biodiversity spot of Bangladesh. Various trees, shrubs, herbs, climbers, mycorrhiza, birds and animals were commonly found inside the Bhawal and Madhupur Sal forest area of Bangladesh (Jahan et al. 2017). For conserving biodiversity, maintaining ecological balance condition, forest productivity and maintain sound environment for human beings as well as wildlife forest resource conservation is essential in Bangladesh as well as world perspectives. Madhupur Tract (Madhupur Garh) is the major part of plain land Sal forest of Bangladesh which is now severely degraded and encroached which is upto 15%-35% (Islam and Sato 2013; Kabir et al 2020). Bhawal and Madhupur Sal forest play a vital role for the sound environment, biodiversity conservation, healthy economy and proper social life of Bangladesh (Hasan and Khalid 2014; Islam et al. 2016) as well as other South Asian countries. These forests provide valuable commodities such as timber, fuelwood, fruit, fodder, medicinal ingredients, industrial raw materials, etc. But these Sal forests are encroaching drastically and biodiversity is also severely degraded (Hasan et al 2020; Alam et al. 2008). Besides this, most of the studies on Indian Sal forests are concerned with vegetation analysis of *Shorea* communities (Gupta and Shukla 1991; Singh et al. 1995; Pande 1999; Pandey and Shukla 1999). In Bangladesh, there are some lists of plants found in Sal Forest areas (Alam et al. 2008; Choudhury et al. 2004; Rashid and Mia 2001). However, detailed studies on tree and shrub diversity of Sal forests in Bangladesh are not available (Rahman et al. 2007b). Considering the above facts present study was undertaken to assess the diversity and structural composition of plant species in the Bhawal and Madhupur forests which is an integral part of Bangladesh plain land Sal forests. These baseline data have been expected to visualize the current status of which can be used for biodiversity conservation and setting proper management strategies for these endangered ecosystems.

MATERIALS AND METHODS

Study area

Madhupur Tract is the largest belt of the Sal forests lay in the districts of greater Dhaka, Mymensingh and Tangail of Bangladesh.The southern part of this tract is known as ‘Bhawal Garh’ and the northern part as ‘Madhupur Garh’. ‘Bhawal Garh’ Sal forest is divided into six different ranges viz. Bhawal National Park Range, Bhawal Range, Rajendrapur Range, Sripur Range, Kaliakoir Range and Kachighata range. ‘Madhupur Garh’ Sal forest is divided into four different ranges viz. Madhupur National Park Range, Madhupur range, Dokhola range, Aronkhola range. ‘Bhawal National Park Range’ (Figure 1) of ‘Bhawal Garh’ and ‘Madhupur National Park Range’ (Figure 1) of ‘Madhupur Garh’ is the study area of this research.

Geographically, Bhawal National Park (BNP) lies between the latitudes 24°02' to 24°11' N and longitude 90°21' to 90°28' E (Kabir and Ahmed 2005; Alauddin et al. 2020). besides the National Highway of Dhaka-Mymensingh, having an area of 12,436 ha (Figure 1). The BNP is divided into two zones: a core area and buffer zone area (Alauddin et al. 2020). Again BNP range is divided into three small units as ‘Bit’ and these are Bankharia, Baupara and Park bit (Masum et al.2015; Alauddin et al. 2020). In this range ‘Bhawal national Park’ was established on May 11, 1982 with an area of 5022 ha (Jahan et al.2017; Alauddin et al. 2020). The climatic conditions are moderate. The temperature ranges from 11.5°C to 38.5°C during January-February and April to June, respectively. The area experiences an annual rainfall of about 1500 mm, the maximum in June-August and minimum in December-February. Mean annual Relative Humidity (RH) and total evaporation are 85.2% and 1023.5 mm, respectively.

On the contrary, Madhupur National Park (MNP) is located at approximately 24°42' to 24°46' N longitude and 90°03' to 90°07' E latitude, having an area of 24,150 ha (Khan and Naher 2020). MNP range is divided into five small units as ‘Bit’ and these are Rajabari, Sadar, Beribaid, Gachabari and Laharia bit. The ‘Madhupur National Park’ was established on 24 February 1982, encompasses an area of 8,430 ha distributed partially over National Park and Dokhola Ranges. The average temperatures vary from 29.3°C to 21.1°C in summer, falling to 20°C in winter, with extreme lows of 10°C. The average rainfall is 2011.6

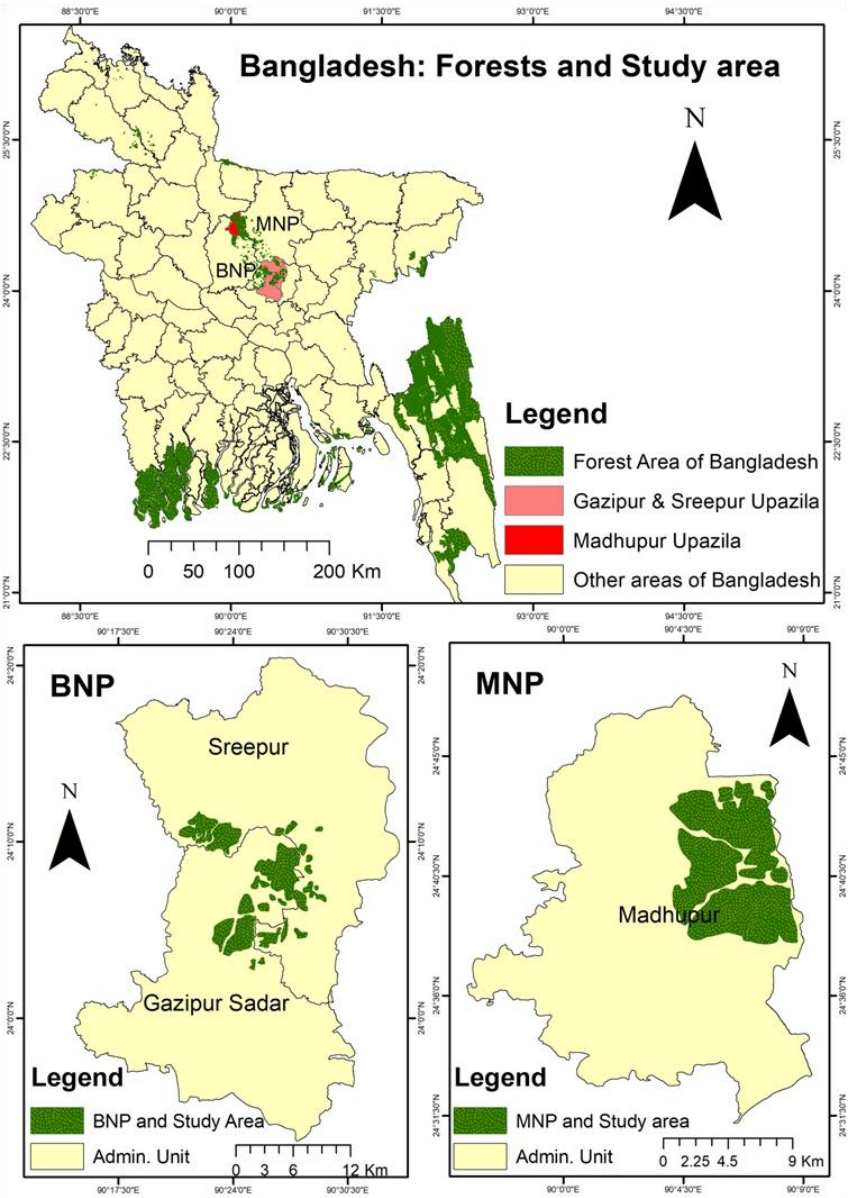

Figure 1: Study area showing BNP and MNP maps.

mm. Mean annual Relative Humidity (RH) and total evaporation are 84.8% and 1050 mm, respectively.

METHODS

For estimating structural composition, floristic composition and species richness, information of plant species (trees, shrubs, herbs and climber) were collected using 'Count Quadrat method. Plant sampling was done in the Bhawal and Madhupur national park ranges of Sal forest from2009 to 2011. The quadrats size was 10 m × 10 m. Total of 10 quadrats (10 m × 10 m) was surveyed for each forest beat *i.e.* total of 30 (3 beats × 10) quadrats in Bhawal National Park Range and 50 (5 beats × 10) quadrats in Madhupur National Park Range of Sal forest were surveyed. The surveyed area of each forest range was more than 5-10% area of total Range area which fulfill the minimum requirement of 'Count Quadrats or list-count quadrats' methods of forest sampling (Islam and Hyakumura 2021). And map of the study area was created using ArcGIS software with version 10.3.

Data analysis

Based on individual records in the discrete plot sample, vegetation data were estimated as Density, Relative density, Frequency, Relative frequency, Abundance, Dominance, Relative dominance of a species, Total basal coverage, Importance value index, Species diversity and Beta diversity. The density, frequency and abundance of

listed plants were estimated using Curtis and Mcintosh (1950) methods. Relative values of density, frequency and abundance of listed plants were estimated as per Phillips (1959) rules. The Basal Area (BA) of each species was calculated using the formula,

$$BA\ (m^2 tree^{-1}) = \pi(CBH/2\pi)^2 \quad (1)$$

Here, CBH denotes circumference at breast height.
Finally, the total basal cover (TBC) for the species was measured as,

$$TBC\ for\ Species\ (m^2 \square a^{-1}) = BA\ of\ species \times Den. \quad (2)$$

Importance Value Index **(**IVI) was calculated using the formula (Curtis and McIntosh 1950)

$$IVI = Relative\ Density\ (RD) + Relative\ Frequency\ (RF) \quad (3)$$

The diversity index (H) was determined by using Shannon and Wiener (1963). Also known as Shannon-Wiener index:

$$H = -\Sigma \left(\frac{Ni}{N}\right) \ln\left(\frac{Ni}{N}\right) \quad (4)$$

Here, Ni is the no. of individual for a species I and N is the total individual of all the species in a stand.
Concentration of dominance (D) was calculated following the index by Simpson (1949). Also known as Simpson's index:

$$D = \sum\left(\frac{Ni}{N}\right)^2 \quad (5)$$

where, Ni and N are the same as those for ShannoneWeiner information function.
Number of dominant species was also calculated according to Simpson (1949)

$$No.of\ dominant\ species = \frac{1}{D} \quad (6)$$

Equitability of evenness refers to the degree of relative dominance of each species in that area. It was calculated according to Pielou (1966) as:

$$Evenness\ (e) = H/\log_{10} S \quad (7)$$

where, H is Shannon index and S is the number of species.
Species richness was determined by Margalef index (Margalef 1968) as:

$$d = S/\log_{10} N \quad (8)$$

where, S is the number of species and N is the number of individuals.
Finally, the Sorensen index or Beta diversity was determined by using the Sorensen (1948) equation as,

$$Beta\ diversity\ (\beta) = 2C/(S_1 + S_2) \quad (9)$$

Here, S_1 = Total number of species recorded in the first community, S_2 = Total number of species recorded in the second community and C = the number of species common to both communities.

RESULTS

A total of 2,265 tree and shrub individuals belonging to 28 species among 22 genera and 16 families from thirty 100 m^2 plots (in 3 beats) were enumerated in Bhawal National Park (BNP) of Bangladesh while a total of 3,059 tree and shrub individuals belonging to 69 species among 55 genera and 26 families from fifty 100 m^2 plots (in 5 beats) were enumerated (Table 1) in Madhupur National Park (MNP) of Bangladesh. In both BNP and MNP, twenty-seven (27) species were common while 1 and 42 species were uncommon in BNP and MNP respectively. Diversity of tree species in the study area calculated using the Shannone-Weiner index (H) showed that higher diversity was in MNP (2.35) and lower diversity was in BNP (1.47), with dominance of Simpson's value 0.42 and 0.17 respectively. No. of effective or dominant species (1-D) was 2 and 6 in BNP and MNP respectively. Similarly, evenness index was lower at BNP (1.02) and maximum at MNP (1.28), and Margalef index was higher in MNP with 19.80 (Table 1). In this study Sorensen index for Bhawal and Madhupur Sal forest is 0.557. Overall species and population density were higher in MNP (18.64 and 59.88 per 100 m^2 land area respectively) while they were lower in BNP with 14.5 and 54.73 per 100 m^2 land area respectively. But TBC of BNP range was little bit more (42.281 m^2 ha^{-1}) compared to MNP range with 38.3 m^2 ha^{-1} (Table 1).
Plant population and plant species density of BNP Sal forest were not similar in the entire Range. BNP was subdivided into three beats namely, Bankharia, Baupara and Park. The average density of plant population and plant species in BNP were 54.7 (trees/100m^2) and 14.5 (species/100m^2), respectively. Among the three forest beats of the BNP range, the highest density of plant population (59.5 per 100m^2) and plant species (16.5 per 100m^2) was found in Bankharia beat followed by Baupara (56.4 and 14.5 per 100m^2 respectively). And the lowest density of plant population and plant species was in the park beat 48.3 and 12.5 per 100m^2 respectively (Table 2).
The average density of plant population and plant species in MNP were 59.88 (tree/100m^2) and 18.64 (species/100m^2), respectively. MNP was subdivided into five beats namely, Rajabari, Sadar, Beribaid, Gachabari and Laharia. Among the five forest beats of the MNP range, significantly highest density of plant population (63.5 per 100m^2) and plant species (20.5 per 100m^2) were found in Gachabari beat followed by Beribaid (62.3 and 19.6 per 100m^2 respectively), Laharia (60.4 and 19.3 per

Table 1. Floristic richness, number of individuals, and diversity indices of BNP and MNP.

Variable	BNP	MNP
No. of Individuals	2265	3059
No. of species	28	69
No. of genera	22	55
No. of families	16	26
Common plant species	27	27
Uncommon species	1	42
Shannone (H)	1.47	2.35
Simpson (D)	0.42	0.17
No. of dominant species (1/D)	2.38	5.88
Evenness (e)	1.02	1.28
Margalef (d)	8.35	19.80
Sorensen /Beta diversity (β)	0.557	0.557
Total TBC (m^2 ha^{-1})	45.2	31.795
Species density ($100m^{-2}$)	14.5	18.64
Population density ($100m^{-2}$)	54.7	59.88
Latitude	24°02' to 24°11' N	24°36' to 24°42' N,
Longitude	90°21' to 90°28' E	90°00' to 90°06' E

Here, BNP: Bhawal National Park; MNP: Madhupur National Park.

Table 2. Plant density in Bhawal National Park (BNP) area of Bangladesh.

Forest Beat of BNP	Plant density per (per 100 m^2) Plant population density	Species density
Bankharia	59.5 a	16.5 a
Baupara	56.4 b	14.5 b
Park	48.3 c	12.5 c
Mean	**54.7**	**14.5**

Means in column followed by the different letter are significantly different by DMRT at P≤0.05.

$100m^2$ respectively), Rajabari (59.7 and 18.3 per $100m^2$) and the lowest population and species density (53.5 and 15.5 per $100m^2$ respectively) was in the Sadar beat (Table 3). This indicates Plant population and species density of MNP was not similar in the entire Range.

The number of plant families in the BNP was 16 taxonomically well-represented families. Leguminosae and Moraceae had the maximum number of species (5 species each) followed by Rhamnaceae, Rubiaceae, Rutaceae and Anacardiaceae (2 species each). Ten families, Annonaceae, Combretaceae, Compositae, Dipterocarpaceae, Euphorbiaceae, Lecythidaceae, Meliaceae, Myrtaceae, Tiliaceae and Verbenaceae had only a single species in the study area (Table 4). Based on density, Dipterocarpaceae contributed 62.91% of the stand density followed by Compositae (10.82%), Verbenaceae (7.95%), Rubiaceae (5.43%) and Rutaceae 4.06% (Table4). Dipterocarpaceae contributed 153.17 IVI followed by Compositae (23.53), Moraceae (21.01), Verbenaceae (20.19), Leguminosae (17.81), Rubiaceae (15.76), Rutaceae (13.29) and Meliaceae (12.42).

The number of plant families in the MNP was 26 taxonomically well-represented families. Leguminosae and Moraceae had the maximum number of species (8 species each) followed by Rubiaceae (5 species); Apocynaceae, Euphorbiaceae and Rutaceae (4 species each); Anacardiaceae, Annonaceae, Combretaceae and Verbenaceae (3 species each); Bigoniaceae, Compositae, Dipterocarpaceae, Lythraceae, Meliaceae, Myrtaceae, Rhamnaceae and Sterculiaceae (2 species each). Eight families, Asclepiadaceae, Burseraceae, Dilleniaceae, Lauraceae, Lecythidaceae, Oxalidaceae, Sapindaceae and Tiliaceae had only a single species in the study area (Table 5). Based on density, Dipterocarpaceae contributed

Table 3. Plant density in Madhupur National Park (MNP) area of Bangladesh.

Forest Beat	Plant density (per 100 m^2)	
	Plant population density	**Species density**
Rajabari	59.7 b	18.3 b
Sadar	53.5 c	15.5 c
Beribaid	62.3 a	19.6 a
Gachabari	63.5 a	20.5 a
Laharia	60.4 b	19.3 ab
Mean	**59.88**	**18.64**

Means in column followed by the different letters are significantly different by DMRT at P≤ 0.05.

Table 4. Different families based on importance value index (IVI) and number of species, genera, and individuals of BNP.

Sl	Family	No. of Species	No. of Genera	No. of individual	IVI
1	Anacardiaceae	2	2	8	3.49
2	Annonaceae	1	1	2	1.05
3	Combretaceae	1	1	3	1.57
4	Compositae	1	1	245	23.53
5	Dipterocarpaceae	1	1	1425	153.17
6	Euphorbiaceae	1	1	25	6.3
7	Lecythidaceae	1	1	10	4.83
8	Leguminosae	5	3	47	17.81
9	Meliaceae	1	1	60	12.42
10	Moraceae	5	2	29	21.01
11	Myrtaceae	1	1	3	1.08
12	Rhamnaceae	2	1	3	1.52
13	Rubiaceae	2	2	123	15.76
14	Rutaceae	2	2	92	13.29
15	Tiliaceae	1	1	10	2.98
16	Verbenaceae	1	1	180	20.19
	Total	**28**	**22**	**2265**	**300**

31.94% of the stand density followed by Compositae (21%), Verbenaceae (10.43%), Euphorbiaceae (8.73%), Rubiaceae (8.27%) and Rutaceae 6.37% (Table 5). Dipterocarpaceae contributed 93.617 IVI followed by Compositae (34.698), Euphorbiaceae (32.319), Rubiaceae (22.547), Verbenaceae (18.922), Meliaceae (14.017), Moraceae (13.942), and Rutaceae (13.554).

Structural composition BNP:

A total of twenty-eight (28) trees and shrubs species were recorded in this forest (Table 6). The density of these species ranges from 3.3 to 4750 trees/ha and frequency ranges from 3.3 to 100%. Sal (*Shorea robusta*), Fulkhori (*Ageratum conyzoiodes*) and Bhat (*Clerodendrum infortunatum*) were found in all sampled quadrats in all forest beats of BNP with an average density of 4750, 816.7 and 600 trees/ha respectively (Table 6).

Considering all tree and shrub species total basal cover (TBC) was about 45.2 m^2 ha^{-1} where maximum was in Sal (*Shorea robusta;* 35.63 m^2 ha^{-1}; 78.83%) followed by Pakur (*Ficus infectoria;* 1.80 m^2 ha^{-1}; 3.98%), Bot (*Ficus*

Table 5. Different families based on importance value index (IVI) and number of species, genera, and individuals of Madhupur National Park (MNP).

Sl	Family	No. of Species	No. of Genera	No. of individual	IVI
1	Anacardiaceae	3	3	19	4.496
2	Annonaceae	3	2	10	2.611
3	Apocynaceae	4	4	31	6.027
4	Asclepiadaceae	1	1	67	9.115
5	Bigoniaceae	2	2	19	3.544
6	Burseraceae	1	1	9	1.325
7	Combretaceae	3	1	12	3.151
8	Compositae	2	2	644	34.698
9	Dilleniaceae	1	1	24	5.999
10	Dipterocarpaceae	2	2	977	93.617
11	Euphorbiaceae	4	3	267	32.319
12	Lauraceae	1	1	1	0.263
13	Lecythidaceae	1	1	13	2.319
14	Leguminosae	8	6	32	6.231
15	Lythraceae	2	1	11	2.950
16	Meliaceae	2	2	92	14.017
17	Moraceae	8	3	28	13.942
18	Myrtaceae	2	2	6	1.012
19	Oxalidaceae	1	1	1	0.349
20	Rhamnaceae	2	1	5	1.342
21	Rubiaceae	5	5	253	22.547
22	Rutaceae	4	3	195	13.554
23	Sapindaceae	1	1	5	1.808
24	Sterculiaceae	2	2	3	0.563
25	Tiliaceae	1	1	16	3.280
26	Verbenaceae	3	3	319	18.922
	Total	**69**	**55**	**3059**	**300**

benghalensis; 1.56 m^2 ha^{-1}; 3.45%), Dumur (*Ficus carica;* 0.77 m^2 ha^{-1}; 1.7%), Amloki (*Phyllanthus emblica;* 0.63 m^2 ha^{-1}; 1.4%) and Pitraj (*Aphanamixis polystachya;* 0.62 m^2 ha^{-1}; 1.37%) and the lowest TBC was in Jangliboroi (*Ziziphus rugosa*) as 0.02 m^2 ha^{-1} (0.04%; Table 6) which also indicates the dominancy of Sal tree in this forest.

Maximum abundance value was recorded for Sal *(Shorea robusta)* tree as 47.5 followed by *Fulkhuri* (*Ageratum conyzoiodes;* 8.2), *Bhat* (*Clerodendrum infortunatum*; 6.0), *Monkata* (*Randia dumetorum;* 5.7), *Motkila* (*Glycosmis pentaphyla;* 4.9) and *Pitraj* (*Aphanamixis polystachya;* 2.72). Tewelve species, *Mangifera indica* (Am/Mango), *Aegle marmelos* (Bel), *Terminalia bellirica* (Bohera), *Ziziphus mauritiana* (Boroi/Jujube), *Ficus benghalensis* (Bot), *Polyalthia longifolia* (Debdaru), *Ficus carica* (Dumur), *Careya arborea* (Gadila), *Ziziphus rugosa* (Jangliboroi), *Anthocephalus cadamba* (Kadam), *Artocarpus heterophyllus* (Jackfruit) and *Ficus hirta* (Khandadumur) had abundance only 1 in BNP (Table 6).

IVI of plant community in the BNP areas ranges from 153.17 to 0.48 (Table 6). Highest IVI value was found in *Shorea robusta* (Sal; 153.17), followed by *Ageratum conyzoiodes* (Fulkhori; 23.53), *Clerodendrum infortunatum* (Bhat; 20.19), *Randia dumetorum* (Monkata; 14.02), *Aphanamixis polystachya* (Pitraj; 12.42), *Glycosmis pentaphyla* (Mouhati; 11.21) *Ficus infectoria* (Pakur; 8.84) and *Butea monosperma* (Palash; 7.48; Fig. 2). And the lowest IVI was found in *Ziziphus rugosa* (Jangliboroi; 0.48) followed by *Mangifera indica* (Am/Mango; 0.71), *Ziziphus mauritiana* (Boroi/Jujube; 1.04), *Polyalthia longifolia*(Deb-

Table 6. Structural composition of trees and shrubs species in Bhawal National Park (BNP) area of Bangladesh.

Sl.	Scientific Name	Local Name	Total Plants	No. of quadrats occur	Density (trees ha^{-1})	ABA (m^2 $tree^{-1}$)	TBC (m^2 ha^{-1})	Frequency (%)	Abundance	RD (%)	RF (%)	R Dom (%)	IVI
1	*Mangifera indica*	Am/Mango	1	1	3.3	0.039	0.13	3.3	1.0	0.04	0.38	0.29	0.71
2	*Phyllanthus emblica*	Amloki	25	10	83.3	0.008	0.63	33.3	2.5	1.10	3.82	1.38	6.30
3	*Aegle marmelos*	Bel	4	4	13.3	0.013	0.17	13.3	1.0	0.18	1.53	0.38	2.08
4	*Terminalia bellirica*	Bohera	3	3	10.0	0.013	0.13	10.0	1.0	0.13	1.15	0.29	1.57
5	*Ziziphus mauritiana*	Boroi/Jujube	2	2	6.7	0.013	0.09	6.7	1.0	0.09	0.76	0.19	1.04
6	*Ficus benghalensis*	Bot	3	3	10.0	0.156	1.56	10.0	1.0	0.13	1.15	3.45	4.73
7	*Albizia chinensis*	Chechra	6	5	20.0	0.008	0.16	16.7	1.2	0.26	1.91	0.36	2.54
8	*Microcos paniculata*	Datai	10	6	33.3	0.003	0.11	20.0	1.7	0.44	2.29	0.25	2.98
9	*Polyalthia longifolia*	Debdaru	2	2	6.7	0.013	0.09	6.7	1.0	0.09	0.76	0.20	1.05
10	*Ficus carica*	Dumur	5	5	16.7	0.046	0.77	16.7	1.0	0.22	1.91	1.70	3.83
11	*Careya arborea*	Gadila/Kumbi	10	10	33.3	0.008	0.26	33.3	1.0	0.44	3.82	0.57	4.83
12	*Syzygium cumini*	Jam/Kalojam/Berry	3	2	10.0	0.008	0.08	6.7	1.5	0.13	0.76	0.18	1.08
13	*Ziziphus rugosa*	Jangliboroi	1	1	3.3	0.007	0.02	3.3	1.0	0.04	0.38	0.05	0.48
14	*Lannea coromandelica*	Jiga/Bhadi/Jeol/	7	6	23.3	0.004	0.08	20.0	1.2	0.31	2.29	0.18	2.78
15	*Anthocephalus cadamba*	Kadam	3	3	10.0	0.021	0.21	10.0	1.0	0.13	1.15	0.46	1.74
16	*Artocarpus heterophyllus*	Kanthal/Jackfruit	2	2	6.7	0.013	0.09	6.7	1.0	0.09	0.76	0.19	1.05
17	*Ficus hirta*	Khandadumur	4	4	13.3	0.029	0.39	13.3	1.0	0.18	1.53	0.86	2.56
18	*Albizia procera*	Koroi/Sil Koroi	6	5	20.0	0.008	0.15	16.7	1.2	0.26	1.91	0.34	2.51
19	*Xylia kerrii*	Lohakat	5	3	16.7	0.008	0.13	10.0	1.7	0.22	1.15	0.28	1.64
20	*Ficus infectoria*	Pakur	15	11	50.0	0.036	1.80	36.7	1.4	0.66	4.20	3.98	8.84
21	*Butea monosperma*	Palash	20	16	66.7	0.003	0.22	53.3	1.3	0.88	6.11	0.49	7.48
22	*Aphanamixis polystachya*	Pitraj/Raina	60	22	200.0	0.003	0.62	73.3	2.7	2.65	8.40	1.37	12.42
23	*Shorea robusta*	Sal	1425	30	4750.0	0.008	35.63	100.0	47.5	62.91	11.45	78.81	153.17
24	*Albizia lebbeck*	Shirish/Kalo Koroi	10	7	33.3	0.007	0.24	23.3	1.4	0.44	2.67	0.52	3.64
25	*Clerodendrum infortunatum*	Bhat	180	30	600.0	0.001	0.36	100.0	6.0	7.95	11.45	0.80	20.19
26	*Ageratum conyzoiodes*	Fulkhori	245	30	816.7	0.001	0.57	100.0	8.2	10.82	11.45	1.26	23.53
27	*Randia dumetorum*	Monkata/Mankanta	120	21	400.0	0.001	0.32	70.0	5.7	5.30	8.02	0.71	14.02
28	*Glycosmis pentaphyla*	Mouhati/Matkila	88	18	293.3	0.001	0.21	60.0	4.9	3.89	6.87	0.45	11.21
	Total		**2265**	**–**	**7550.0**	**–**	**45.2**	**873.3**	**–**	**100.0**	**100.0**	**100.0**	**300.0**

ABA = Average Basal Area, TBC = Total Basal Cover, RD = Relative Density, RF = Relative Frequency, R Dom = Relative Frequency, IVI = Important Value Index.

daru) and *Artocarpus heterophyllus* (Kanthal/Jackfruit; 1.05 each) and *Syzygium cumini* (Jam/Berry; 1.08).

Structural composition MNP

Total sixty-nine (69) trees and shrubs species were recorded in this forest (Table 7). Density of these species ranges from 2 to 1952 trees/ha and frequency ranges from 2 to 100%. Sal (*Shorea robusta*) and Fulkhuri (*Ageratum conyzoiodes*) were found in all sampled quadrats in all forest beats of MNP with an average density of 1952 and 1266 trees/ha respectively (Table 7).

Considering all tree and shrub species total basal cover (TBC) was about 31.79 m^2 ha^{-1} where maximum was in Sal (*Shorea robusta;* 16.59 m^2 ha^{-1}; 52.2%) followed by Sinduri (*Mallotus philippenses*; 3.19 m^2 ha^{-1}; 10%), Bot (*Ficus benghalensis*; 1.83 m^2 ha^{-1}; 5.8%), Pitraj (*Aphanamixis polystachya*; 1.58 m^2 ha^{-1}; 5%), Monkata/Mainkata (*Randia dumetorum*; 0.89 m^2 ha^{-1}; 2.8%), Fulkhori (*Ageratum conyzoiodes*; 0.76 m^2 ha^{-1}; 2.4%) and Ajuli (*Dillenia pentagyna*; 0.66 m^2 ha^{-1}; 2%) and the lowest TBC was in Sarpagandha

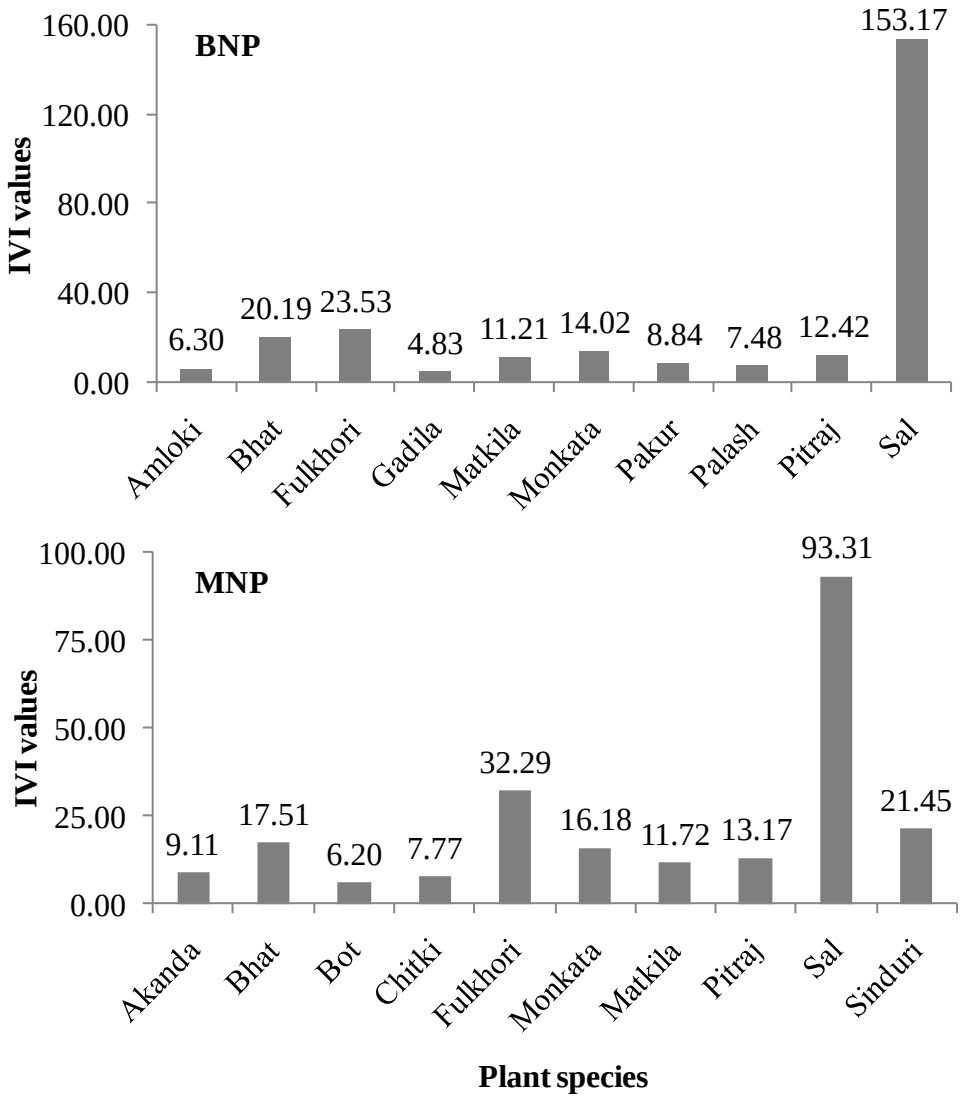

Figure 2. Top 10 plant species on the basis IVI values of BNP and MNP forest.

(*Rauvolfia serpentina*) as 0.005 m^2 ha^{-1} (0.02%; Table 7) which also indicates the dominancy of Sal tree in this forest.

Maximum abundance value was recorded for Sal *(Shorea robusta)* tree as 19.5 followed by *Fulkhuri* (*Ageratum conyzoiodes;* 12.7), *Bhat* (*Clerodendrum infortunatum*; 9.2), Sinduri (*Mallotus philippenses*; 7.3), *Motkila* (*Glycosmis pentaphyla;* 6.9), *Monkata* (*Randia dumetorum;* 6.1), *Pitraj* (*Aphanamixis polystachya*) and Sarpagandha (*Rauvolfia serpentine*) 3.00 each. Twenty seven species, had abundance only 1 in MNP (Table 7).

IVI of plant community in the MNP areas ranges from 93.31 to 0.24 (Table 7). Highest IVI value was found in *Shorea robusta* (Sal; 93.31), followed by *Ageratum conyzoiodes* (Fulkhori; 32.29), Sinduri (*Mallotus philippenses*; 21.45), *Clerodendrum infortunatum* (Bhat; 17.51), *Randia dumetorum* (Monkata; 16.18), *Aphanamixis polystachya*(Pitraj; 13.17), *Glycosmis pentaphyla* (Mouhati; 11.72), Akanda (*Calotropis gigantean*; 9.12) and Chitki (*Phyllanthus reticulatus*; 7.77; Figure 2). And the lowest IVI was found in Chokka kola (*Bauhinia malabarica*) and Guava (*Psidium guajava*) 0.24 each, followed by Kaika/Haldu (*Adina cordifolia*), Koil/Kharajora (*Litsea monopetala*) and Ulat-kambal (*Abroma augusta*) 0.26 each.

DISCUSSION AND CONCLUSIONS

Knowing species diversity is a useful tool in plant ecology and forestry to compare the composition of different species. Tree species diversity in tropical forests differs greatly from location to location mainly due to variation in

Table 7. Structural composition of trees and shrubs species in Madhupur National Park (MNP) area of Bangladesh.

Sl.	Scientific Name	Local Name	Total Plants	No. of quadrats occur	Density (trees ha^{-1})	ABA (m^2 $tree^{-1}$)	TBC (m^2 ha^{-1})	Frequency (%)	Abundance	RD (%)	RF (%)	R Dom (%)	IVI
1	*Dillenia pentagyna*	Ajuli	24	17	48	0.014	0.66	34	1.4	0.78	3.13	2.08	6.00
2	*Calotropis gigantean*	Akanda	67	36	134	0.001	0.09	72	1.9	2.19	6.63	0.30	9.12
3	*Mangifera indica*	Am/Mango	5	4	10	0.034	0.34	8	1.3	0.16	0.74	1.07	1.97
4	*Phyllanthus emblica*	Amloki	18	7	36	0.004	0.13	14	2.6	0.59	1.29	0.42	2.30
5	*Terminalia Arjuna*	Arjun	3	2	6	0.014	0.08	4	1.5	0.10	0.37	0.25	0.72
6	*Withania somnifera*	Ashhwagandha	1	1	2	0.023	0.05	2	1.0	0.03	0.18	0.14	0.36
7	*Clerodendrum inerme*	Bath/Bathraj	4	4	8	0.007	0.06	8	1.0	0.13	0.74	0.18	1.05
8	*Aegle marmelos*	Bel	6	3	12	0.007	0.08	6	2.0	0.20	0.55	0.26	1.01
9	*Clerodendrum infortunatum*	Bhat	314	34	628	0.001	0.31	68	9.2	10.26	6.26	0.99	17.51
10	*Hymenodiclyen excelsum*	Bhutum	2	2	4	0.005	0.02	4	1.0	0.07	0.37	0.06	0.49
11	*Terminalia bellirica*	Bohera	7	4	14	0.021	0.29	8	1.8	0.23	0.74	0.92	1.89
12	*Ziziphus mauritiana*	Boroi/Jujube	2	2	4	0.009	0.04	4	1.0	0.07	0.37	0.12	0.55
13	*Ficus benghalensis*	Bot	2	2	4	0.458	1.83	4	1.0	0.07	0.37	5.77	6.20
14	*Spaeranthus indicus*	Chagalnadi	11	8	22	0.008	0.18	16	1.4	0.36	1.47	0.57	2.41
15	*Albizia chinensis*	Chechra	5	3	10	0.013	0.13	6	1.7	0.16	0.55	0.42	1.13
16	*Artocarpus chapalasha*	Chapalish	2	2	4	0.033	0.13	4	1.0	0.07	0.37	0.42	0.85
17	*Alstonia scholaris*	Chatim	7	5	14	0.008	0.11	10	1.4	0.23	0.92	0.33	1.48
18	*Phyllanthus reticulates*	Chitki	49	32	98	0.001	0.09	64	1.5	1.60	5.89	0.28	7.77
19	*Bauhinia malabarica*	Chokka kola	1	1	2	0.004	0.01	2	1.0	0.03	0.18	0.03	0.24
20	*Antidesma acidum*	Chutki/Anaigota	3	3	6	0.008	0.05	6	1.0	0.10	0.55	0.15	0.80
21	*Microcos paniculata*	Datai	16	13	32	0.004	0.12	26	1.2	0.52	2.39	0.36	3.28
22	*Polyalthia longifolia*	Debdaru	2	2	4	0.013	0.05	4	1.0	0.07	0.37	0.17	0.60
23	*Wringhtia arborea*	Dudh-Kuruch	4	3	8	0.012	0.10	6	1.3	0.13	0.55	0.30	0.99
24	*Ficus carica*	Dumur	3	3	6	0.020	0.12	6	1.0	0.10	0.55	0.39	1.04
25	*Ageratum conyzoiodes*	Fulkhori	633	50	1266	0.001	0.76	100	12.7	20.69	9.21	2.39	32.29
26	*Careya arborea*	Gadila/Kumbi	13	7	26	0.007	0.19	14	1.9	0.42	1.29	0.61	2.32
27	*Gmelina arborea*	Gamari	1	1	2	0.023	0.05	2	1.0	0.03	0.18	0.14	0.36
28	*Paederia foetida*	Gandha vadali	35	16	70	0.001	0.08	32	2.2	1.14	2.95	0.26	4.36
29	*Milisua velutina*	Gandhagajari	2	2	4	0.009	0.03	4	1.0	0.07	0.37	0.11	0.54
30	*Terminalia chebula*	Haritaki	2	2	4	0.008	0.03	4	1.0	0.07	0.37	0.11	0.54
31	*Syzygium cumini*	Jam/Kalojam/Berry	5	2	10	0.008	0.08	4	2.5	0.16	0.37	0.24	0.77
32	*Citrus grandis*	Jambura	1	1	2	0.014	0.03	2	1.0	0.03	0.18	0.08	0.30
33	*Ziziphus rugosa*	Jangliboroi	3	3	6	0.008	0.05	6	1.0	0.10	0.55	0.14	0.79
34	*Lagerstroemia speciosa*	Jarul	7	3	14	0.022	0.31	6	2.3	0.23	0.55	0.97	1.75
35	*Lannea coromandelica*	Jiga/Bhadi/Jeol	12	8	24	0.004	0.09	16	1.5	0.39	1.47	0.29	2.16
36	*Schelichera oleosa*	Joina	5	5	10	0.023	0.23	10	1.0	0.16	0.92	0.72	1.81
37	*Anthocephalus cadamba*	Kadam	3	2	6	0.042	0.25	4	1.5	0.10	0.37	0.79	1.26
38	*Adina cordifolia*	Kaika/Haldu	1	1	2	0.007	0.01	2	1.0	0.03	0.18	0.05	0.26
39	*Averrhoa carambola*	Kamranga	1	1	2	0.021	0.04	2	1.0	0.03	0.18	0.13	0.35
40	*Oroxylum indicum*	Kanaidinga	2	2	4	0.008	0.03	4	1.0	0.07	0.37	0.11	0.54

Table 7. Cont.

41	*Bauhinia variegate*	Kanchan	5	2	10	0.009	0.09	4	2.5	0.16	0.37	0.28	0.81
42	*Stereospermum suaveolens*	Kan-Sonalu	17	9	34	0.007	0.25	18	1.9	0.56	1.66	0.79	3.00
43	*Artocarpus heterophyllus*	Kanthal	1	1	2	0.032	0.06	2	1.0	0.03	0.18	0.20	0.42
44	*Ficus hirta*	Khandadumur	3	2	6	0.037	0.22	4	1.5	0.10	0.37	0.70	1.16
45	*Litsea monopetala*	Koil/Kharajora	1	1	2	0.007	0.01	2	1.0	0.03	0.18	0.05	0.26
46	*Albizia procera*	Koroi/Sil Koroi	2	1	4	0.008	0.03	2	2.0	0.07	0.18	0.10	0.35
47	*Holarrhena pubescence*	Kurch/Kuruj	17	12	34	0.005	0.16	24	1.4	0.56	2.21	0.49	3.26
48	*Citrus aurantifolia*	Lebu	3	2	6	0.003	0.02	4	1.5	0.10	0.37	0.06	0.52
49	*Xylia kerrii*	Lohakat	1	1	2	0.013	0.03	2	1.0	0.03	0.18	0.08	0.30
50	*Erythrina variegate*	Mandar	9	4	18	0.005	0.08	8	2.3	0.29	0.74	0.25	1.29
51	*Randia dumetorum*	Monkata/Mainkata	212	35	424	0.002	0.89	70	6.1	6.93	6.45	2.80	16.18
52	*Glycosmis pentaphyla*	Mouhati/Matkila	185	27	370	0.001	0.22	54	6.9	6.05	4.97	0.70	11.72
53	*Ptereospermum acerifolium*	Muchibanda	2	1	4	0.004	0.02	2	2.0	0.07	0.18	0.05	0.30
54	*Azadirachta indica*	Neem	5	3	10	0.004	0.04	6	1.7	0.16	0.55	0.14	0.85
55	*Bursera serrata*	Neul/Neur	9	4	18	0.005	0.09	8	2.3	0.29	0.74	0.29	1.33
56	*Milisua roxburghiana*	Oza	6	5	12	0.009	0.11	10	1.2	0.20	0.92	0.35	1.47
57	*Ficus infectoria*	Pakur	1	1	2	0.078	0.16	2	1.0	0.03	0.18	0.49	0.71
58	*Butea monosperma*	Palash	3	2	6	0.013	0.08	4	1.5	0.10	0.37	0.25	0.71
59	*Psidium guajava*	Peyara/Guava	1	1	2	0.003	0.01	2	1.0	0.03	0.18	0.02	0.24
60	*Aphanamixis polystachya*	Pitraj/Raina	87	29	174	0.009	1.58	58	3.0	2.84	5.34	4.98	13.17
61	*Shorea robusta*	Sal	976	50	1952	0.009	16.59	100	19.5	31.91	9.21	52.20	93.31
62	*Rauvolfia serpentine*	Sarpagandha	3	1	6	0.001	0.005	2	3.0	0.10	0.18	0.02	0.30
63	*Streblus asper*	Sheora	15	11	30	0.007	0.22	22	1.4	0.49	2.03	0.69	3.21
64	*Lagerstroemia perviflera*	Sidha	4	4	8	0.013	0.11	8	1.0	0.13	0.74	0.33	1.20
65	*Mallotus philippenses*	Sinduri	197	27	394	0.008	3.19	54	7.3	6.44	4.97	10.04	21.45
66	*Diptocarpus turbinatus*	Tellya-garjan	1	1	2	0.014	0.03	2	1.0	0.03	0.18	0.09	0.31
67	*Tamarindus indica*	Tetul	6	5	12	0.008	0.09	10	1.2	0.20	0.92	0.28	1.40
68	*Abroma augusta*	Ulat-kambal	1	1	2	0.008	0.02	2	1.0	0.03	0.18	0.05	0.26
69	*Semecarpus anacardium*	Vela/Behula	2	1	4	0.009	0.04	2	2.0	0.07	0.18	0.12	0.37
	Total		**3059**	**–**	**6118**	**–**	**31.795**	**1086**	**–**	**100.0**	**100.0**	**100.0**	**300.0**

ABA = Average Basal Area, TBC = Total Basal Cover, RD = Relative Density, RF = Relative Frequency, R Dom = Relative Frequency, IVI = Important Value Index.

biogeography, habitat, and disturbance (Neumann and Starlinger 2001; Padalia et al. 2004). Plant diversity changes are compared in conjunction with human impacts (Naiduand Kumar 2016). Certain changes are easy to predict, at least qualitatively. Population sizes when reduced may have deleterious consequences (Gershoni and Pietrokovski 2014). According to Beard (1955), the annual rainfall and edaphic factors are responsible for the differences in forest structure among various tropical forest formations. Hence, the present investigation was aimed at assessing the tree and shrub diversity in the BNP and MNP range of Sal forest of Bangladesh.

The study indicated that there are considerable differences between BNP and MNP Sal forests of Bangladesh in terms of diversity, composition, and the stand structure. The stand density of Sal forest represented maximum plant species diversity on MNP (69 species), followed by BNP (28 species) according to Shannon-Wiener diversity index (1.47 and 2.35 respectively). Based on species diversity and richness of BNP was richer even in two decades past (Husain and Haque 1977; 200 species). MNP was also rich in species than the present study which was reported by several scientists in their previous study on Sal forests (Gain 2006;Malakar and Rahman 2006;Rahman et al. 2007, 2008; Malakar et al. 2010). The number of tree species recorded in the present study was found to be lower than the number of species reported by several workers in other Sal forests, for example, Kushwahaand Nandy (2012) found 247 and 76 species in moist anddry

sal forest of India; however; Sukumar et al. (1992) found 71 species in semi-evergreen, moist Deciduous and dry Deciduous forest of India. While, Reddy et al. (2007), Sahu et al. (2007), Khera et al. (2001) and Attua and Pabi (2013) found 121, 187, 92 and 88 species in the mosit deciduous Sal forests respectively. . Species diversity was significantly influenced by forest structure and species composition (Huang et al 2003), human intervention and high species diversity is often connected to more complex vertical structures. So, it is clear from these studies that plant species diversity in the Sal forest area of Bangladesh is gradually decreasing. This declining pattern of species diversity in this forest may be due to monoculture of exotic species, desperate encroachment, more encouragement of horticultural crops cultivation inside forest, unplanned industrial approaches, etc. Sal (*Shorea robusta*) population inside the forest is largely decreasing over time due to different ill approaches by the local community.

Those species which have the strongest control over energy flow and the environment in a given habitat are known as ecological dominants. Ecological dominance can be measured through Simpson's index (D). This index is a scale ranging from 0 (high heterogeneity or lots of diversity) to a maximum close to 1 (no heterogeneity and no diversity). The study indicated that MNP (0.17) has higher heterogeneity in species than BNP (0.42). Besides this, according to Simpson index, number of effective species was higher in MNP (6 species) than BNP (2 species). According to Simpsons index and IVI, Effective species in BNP was Sal and fulkhori while Sal, Fulkhori, Sinduri, Bhat, Monkata and Pitraj was dominant in MNP. Similar result was found by Malaker and Rahman (2006) and Rahman et al. (2019).

The absolute species and population density were higher in MNP than BNP. From these statements, it is clear that species diversity, richness and density were more in MNP compared to BNP. But density of both of the study areas were lower compared with densities reported from the Kalarayan hills (Kadavul and Parthasarathy 1999), EG of northern Andhra Pradesh (Reddy et al. 2011). Plant density can be affected by natural calamities, anthropogenic activities, and soil properties. However, TBC of BNP range was little bit more (42.281 m^2/ha) compared to MNP range (38.3 m^2/ha) which indicate DBH or GBH (Diameter or Girth at breast height) of the plant species was greater in BNP region compared to MNP region of Sal forest. The differences in the basal area of tree layers among the study plots may be due to differences in altitude, species composition, age of trees, and extent of disturbances and successional strategies of the stands.

Biodiversity indices are generated to bring the diversity and abundance of species in different habitats to a similar scale for comparison and the higher the value, the greater the species richness. The higher values of the diversity indices revealed a forest with high tree species diversity and abundance (Adekunle et al. 2013). Shannone-Weiner values for species diversity in the present study (1.47-2.35) ranged between 0.81 and 4.1 (Sahu et al 2012; Sundarapandian and Swamy 2000; Naidu and Kumar 2016). The extent of dominance (Simpson's index) in the present study is within a range of 0.21-1.34 in other forests (Lalfakwma et al. 2009; Naidu and Kumar 2016). The Margalef index within the range of 4.54-23.41 for tropical forests was reported by earlier workers (Mishra et al 2005; Kumar et al. 2010; Sathish et al. 2013). The Sorensen index for BNP and MNP is 0.557 (Table 1). This index value indicates that 55.7% plant species of BNP and MNP ranges of Sal forest was similar and 44.3% large community was dissimilar.

The species Sal and Fulkhori was found with 100% frequency in both BNP and MNP (Table 6 and 7). Similar results were found in MNP by Malakar et al. (2008) but density of these species was relatively higher compared to the present study. This phenomenon supports the species diversity losses in the Sal forest area of Bangladesh. TBC of plant species is the measure of basal compactness of vegetation which is directly related to the density of plant species within the forest. The more TBC indicates the more dense or dark forest ecosystem. In the present study, TBC ranges from 0.02-35.63 m^2 ha^{-1} in BNP and 0.005-16.59 m^2 ha^{-1} in MNP; similar results were recorded by Malakar et al. (2008) in MNP (0.114-19.753 m^2 ha^{-1}). In each study, maximum TBC was for *Shorea robusta* including Rahman et al. (2019). Abundance indicates the relative importance of a species in the community which is directly related to basal coverage estimated as percent of total coverage. Estimated values of abundance also identify the dominant species of any plant community. *Shorea robusta* scores maximum abundance in both BNP and MNP (47.5 and 19.5 respectively). Based on TBC and abundance of the species it was found that the most dominant species in the BNP and MNP area is Sal which is also supported by the findings of Malaker and Rahman (2006); Rahman et al. (2019); Islam et al. (2016) and Rahman et al. (2020). Besides these, *Shorea robusta* constituted 78.83% and 52.2% basal area in BNP and MNP respectively which also indicates Sal plant as the dominant species. Previously the forests were covered more than 80% area by Sal tree now gradually decreased due to Illegal and unplanned felling of *Sal* coppice and overpopulation and poverty (Gain 2002, 2006).

In order to have an overall picture of ecological importance of a species with respect to the community structure, IVI is most reliable measurement (Hossain et al. 1997). Considering the IVI value of the plant species of BNP and MNP, Sal is the most important and dominant species followed by Fulkhori, Bhat, Monkata, Pitraj and Mouhati. Not exactly same but near similar dominant species was recorded considering the IVI value byMalakar et al. (2008) and Malaker and Rahman (2006) inMNP forest.

Biodiversity is necessary to assess ecosystem health because it affects key ecological processes. Woody plant species are key components of the forest ecosystem and are responsible for forest architecture and influences the overall composition of forest communities. Documenting the patterns of tree diversity and their distribution provides a good database, useful for management measures in these forests. A comprehensive approach to forest management is needed for the conservation of dominant tree species that are necessary for the canopy formation as well as maintaining the ecological balance of the forests. Tree species density, distribution, and population structure analyzed in this study should be useful to the conservation researchers and scientists and also to the forest managers for effective management of the forest conservation. The preservation of these forests is crucial not only for conservation of their rich biodiversity but also for meeting the basic needs of the local population. Therefore, this paper calls for an urgent conservation plan to conserve biological diversity.

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