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STRUCTURAL COMPOSITION AND DIVERSITY OF TREE SPECIES IN MADHUPUR SAL AND LAWACHARA FORESTS OF BANGLADESH

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ABSTRACT

Malaker JC, Rahman MM, Prodhon AKMA, Malaker SK (2011) Structural composition and diversity of tree species in Madhupur Sal and Lawachara forests of Bangladesh. *J. Innov. Dev. Strategy* 5(2), 41-47.

The study describes the community structure and diversity of tree plant species in two national forests of Bangladesh based on a random stratified circular sampling method. A total of 102 tree species (tree, sapling and seedling) was recorded in Madhupur sal forest and 78 tree species (tree, sapling and seedling) in Lawachara forest. Moraceae was the largest tree family in both the forests. The species *Shorea robusta* had the highest density (306.38 trees/ha), frequency (100%), abundance (7200 plants/ha), A/F ratio (72), IVI (54.51), H (0.1568), TBC (93.78 m²/ha), EC (173.76) and Cd (0.195) in Madhupur sal forest. In Lawachara forest, *Artocarpus chama* was the dominant tree species having the highest density (100 trees/ha), frequency (95.46%), IVI (30.17), H (0.1352), TBC (109.75 m²/ha), EC (36.28) and Cd (0.0338), and the highest A/F ratio (22) in the species *Michelia champaca*. On the other hand, the species *Elaeocarpus floribundus* represented the highest abundance rate (116.667 plants/ha). About 27 tree species were recorded as endangered in Madhupur sal forest, which had minimum or no regeneration. The species *Bridelia retusa*, *Diospyros cordifolia*, *Leea macrophylla*, *Pterospermum acerifolium*, *Spaeranthus indicus*, *Stereospermum suaveolens*, *Erythrina variegata*, and *Hopea odorata* had no regeneration and that area was seriously depleted in the Madhupur sal forest. Some 25 tree's species were recorded as endangered in Lawachara forest which had minimum or no regeneration. The species *Hydnocarpus kurzii*, *Ilex godajam*, *Elaeis guineensis*, *Castanopsis tribuloides* and *Litsea glutinosa* had no regeneration and that area was seriously depleted in the Lawachara forest.

Keywords: community structure, diversity, importance value index, total basal cover

INTRODUCTION

Bangladesh being situated in a sub-tropical zone constitutes a larger part of South-Asian centre of plant genetic diversity, sharing with India. About 5700 species of higher plants have been recorded (Hossain 1995), of which some 160 species are used as crops (Mondal 1990). The rest of the species are virtually left on growing in natural vegetation in forests and village thickets which have been an important source of numerous wild resource species like fruits, nuts, fuel, fodder, medicine, bamboo, rattans, palms, ornamentals and aromatics.

The flora of Bangladesh varies considerably in different parts of the country both in species identity and in number of species. Some species occur throughout, whilst other are restricted to quite small areas, such as *Cycas pectinata* in Chittagong Division (Champion 1965). Floristic composition of Sinharajan– A rain forest in Srilanka was studied by Gunatilleke and Gunatilleke (1980, 1981) with reference to endemics and *Dipterocarpus*.

Alam (1995) studied the diversity in the woody flora of Sal forests of Bangladesh. The woody taxa enumerated a total of number about 260 species under 160 genera comprising of 56 families including three monocotyledonous families (Gramineae, Liliaceae and Palmae). Out of these 260 taxa trees, shrubs and woody climbers were represented by about 133, 77 and 50 species, respectively. Leguminosae ranked top of the list. Euphorbiaceae and Rubiaceae occupied the next positions. About 17 families were represented by single woody taxa only.

The Lawachara forest is semi-evergreen. The canopy height varies from 10 to 30 m. The top canopy comprises *Tectona* sp., *Artocarpus chaplasha*, *Tetrameles* sp., *Hopea* sp., *Pygeum* sp., *Ficus* sp., etc. The second storey comprises *Syzygium* sp., *Gmelina* sp., *Dillenia* sp., *Grewia* sp. and *Ficus* sp. The under growth includes *Bambusa*, *Geodorum* sp. and several ferns and epiphytes (Craig 1991).

Correct inventory and assessment of forest biodiversity is necessary for evolving a long term strategy for rehabilitation of endangered species in similar to alternate habitats when original habitats get destroyed. Study of the components of any ecosystem is essential not only for understanding and assessing the richness of biodiversity but also for conservation of biodiversity. So, the present study has been aimed to evaluate the structural diversity, species composition of the study area which is necessary for biodiversity conservation and future planning and management.

MATERIALS AND METHODS

Bangladesh, a very densely populated country, lies between 20°34' and 26°38' North latitudes and between 88°01' and 92°41' East longitudes with a forested land of approximately 2.41 million hectares (Reza *et al.* 1992). Out of this, 1.37 million ha (9.5%) is managed by the Forest Department and 0.74 million ha (5%) is under the jurisdiction of the district administration (Das and Siddiqi, 1985; Reza *et al.* 1992). But these forest areas are decreasing day by day. It is recently estimated that this forest area has decreased drastically to 5.4% of the total land area of Bangladesh due to over exploitation, illicit felling, shifting cultivation, encroachment, overgrazing, migration of plain land people to forest land, etc. (ADB 1993). The sal forest areas are situated

within the Forest Division of Tangail district. The forest lies approximately 24°45' North latitude and 90°05' East longitude and located at 160 km north of the city of Dhaka, and 32 km south-east of Mymensingh district town. Lawachara forest (in Kamalganj Upazila of Maulvi Bazar District) is located nearly 160 km northeast of Dhaka and approximately 60 km south of Sylhet city. It lies between 24°30' – 24°32' N and 91°37' – 91°47' E and is nearly eight km east of Srimongal, on way to Kamalganj.

Data collection method

The phytosociological studies were carried out in the selected two forests in the Madhupur of Madhupur Upazila of Tangail district from February 2006 to March 2007 and Lawachara forest in the Kamalganj Upazila of Maulvi Bazar district from April 2007 to May 2008. For phytosociological analysis of the vegetation study on only trees we selected 100 circular plots of 300 m² each in the Madhupur sal forest and 50 circular plots of 300 m² areas each in the Lawachara forests. Plots were established randomly from different sites continuously at 100 m interval in any direction. The size of 300 m² and number of circular sampling were determined by the species area curve (Misra 1968). The total number of species in all the circular sampling was recorded and then the basal area of all the species was measured. The basal area i.e., the cross section area of a tree measured at 4.5 feet above the ground (cross section area of a tree at breast height). The trees more than 31.5 cm cbh (circumference at breast height i. e., 1.37 m above the ground) were individually measured for cbh. Individuals between 10.5 to 31.5 cm cbh were recorded either as saplings or shrubs and the individuals less than 10.5 cm cbh were considered as seedlings (Knight 1963). The existing plant species were identified on the site by the help of local people and my supervisor. The species were also identified with the help of different Journals and reference books.

RESULTS AND DISCUSSION

Species composition

A total of 102 tree species were recorded in Madhupur sal forest (Table 1). While in Lawachara forest a total of 78 tree species had been recorded (Table 2). Moraceae was the largest family in both the forests. Malaker *et al.* (2008) found Moraceae was the largest family in Jaus bits and Beribaid bits of Madhupur sal forest. Chowdhury *et al.* (2000) observed Leguminosae as largest family in Dulhazara garjan forest in Bangladesh.

Table 1. Phytosociological attributes with Species diversity (H) and Concentration of dominance (Cd), the equitability or species per log cycle index (EC) of tree species in Madhupur sal forest

Sl. No.	Botanical name	Den. (tree/ha)	Freq. (%)	A/F	IVI	TBC (m ² /ha)	Ec	Cd	H
1.	<i>Abroma augusta</i> L.f.	2.13	2.13	23.50	0.82	0.39	9.149	0.000009	0.0077
2.	<i>Acacia mangium</i> Willd.	4.26	12.77	7.83	2.37	1.27	9.540	0.000038	0.0136
3.	<i>Acacia moniliformis</i> Griseb.	1.42	4.26	7.83	1.04	0.35	13.174	0.000004	0.0055
4.	<i>Adina cordifolia</i> (Roxb.) H Hook.f.ex Brandis	4.26	8.51	11.75	1.76	0.78	9.540	0.000038	0.0136
5.	<i>Aegle marmelos</i> (L.) Corr.	2.13	6.38	7.83	1.12	0.24	9.149	0.000009	0.0077
6.	<i>Albizia chinensis</i> (Osbeck.) Merr.	1.42	4.26	7.83	1.55	0.79	13.174	0.000001	0.0031
7.	<i>Albizia lebbek</i> (L.) Benth	1.42	4.26	7.83	1.50	0.74	13.174	0.000004	0.0055
8.	<i>Albizia procera</i> (Roxb.) Benth.	0.71	2.13	7.83	0.46	0.06	-6.702	0.000001	0.0031
9.	<i>Alstonia scholaris</i> (L.) R.Br.	1.42	4.26	7.83	0.89	0.23	13.174	0.000004	0.0055
10.	<i>Annona squamosa</i> L.	1.42	4.26	7.83	0.80	0.15	13.174	0.000004	0.0055
11.	<i>Neolamarckia cadamba</i> (Roxb.) Basser	7.80	23.40	7.83	3.83	1.82	12.329	0.000126	0.0219
12.	<i>Antidesma acidum</i> Retz.	2.84	8.51	7.83	1.39	0.24	8.833	0.000017	0.0098
13.	<i>Aphanamixis polystachya</i> (Wall.) R.N. Parkar	4.97	10.64	10.97	2.22	1.35	10.059	0.000051	0.0153
14.	<i>Ardisia solanacea</i> (Pior.) Roxb	4.97	12.77	9.14	2.32	1.03	10.059	0.000051	0.0153
15.	<i>Artocarpus chama</i> Hamilton	4.26	10.64	9.40	24.45	57.99	9.540	0.000038	0.0136
16.	<i>Artocarpus heterophyllus</i> Lamk	2.84	8.51	7.83	1.72	0.80	8.833	0.000017	0.0098
17.	<i>Artocarpus lacucha</i> Buch-Ham	2.13	4.26	11.75	0.92	0.25	9.149	0.000009	0.0077
18.	<i>Azadirachta indica</i> A. Juss.	1.42	2.13	15.67	0.91	0.42	13.174	0.000004	0.0055
19.	<i>Baccaurea ramiflora</i> Lour.	2.13	6.38	7.83	1.25	0.40	9.149	0.000009	0.0077
20.	<i>Bauhinia variegata</i> L.	8.51	21.28	9.40	4.53	6.14	12.904	0.000150	0.0234
21.	<i>Barringtonia acutangula</i> (L.) Gaertn	4.26	10.64	9.40	2.16	1.27	9.540	0.000038	0.0136
22.	<i>Bombax ceiba</i> L.	9.93	25.53	9.14	5.02	6.34	14.043	0.000204	0.0264
23.	<i>Bridelia retusa</i> (L.) Spreng.	0.71	2.13	7.83	0.47	0.07	-6.702	0.000001	0.0031
24.	<i>Bursera serrata</i> Wall.ex Colebr.	8.51	19.15	10.44	3.93	4.12	12.904	0.000150	0.0234
25.	<i>Butea monosperma</i> (Lam.) Taub.	3.55	10.64	7.83	1.88	0.69	9.095	0.000026	0.0117
26.	<i>Careya arborea</i> Roxb.	2.84	8.51	7.83	1.42	0.29	8.833	0.000017	0.0098
27.	<i>Cassia fistula</i> L.	3.55	2.13	39.17	0.73	0.01	9.095	0.000026	0.0117
28.	<i>Cassia siamea</i> (Lam.)	5.67	12.77	10.44	3.36	4.34	10.612	0.000067	0.0171
29.	<i>Cordia dichotoma</i> Forst. f	0.71	2.13	7.83	0.52	0.09	-6.702	0.000001	0.0031
30.	<i>Crataeva magna</i> (Lour.) DC.	3.55	10.64	7.83	2.36	1.69	9.095	0.000026	0.0117
31.	<i>Dillenia pentagyna</i> Roxb.	8.51	23.40	1.55	5.53	10.14	11.120	0.000150	0.0234
32.	<i>Diospyros peregrina</i> (Gaertn.) Gurke.	4.97	12.77	9.14	2.21	0.71	10.059	0.000051	0.0153

Sl. No.	Botanical name	Den. (tree/ha)	Freq. (%)	A/F	IVI	TBC (m ² /ha)	Ec	Cd	H
33.	<i>Elaeocarpus floribundus</i> Blume	4.26	12.77	7.83	2.11	0.60	9.540	0.000038	0.0136
34.	<i>Limonia acidissima</i> L.	1.42	4.26	7.83	0.88	0.22	13.174	0.000004	0.0055
35.	<i>Ficus benghalensis</i> L.	3.55	10.64	7.83	2.53	2.06	9.095	0.000026	0.0117
36.	<i>Ficus benamina</i> L. var. <i>comosa</i> (Roxb.) Kurz	4.26	12.77	7.83	2.90	2.61	9.540	0.000038	0.0136
37.	<i>Ficus carica</i> L.	0.71	2.13	7.83	7.02	2.84	-6.702	0.000001	0.0031
38.	<i>Ficus recemosa</i> L.	2.84	8.51	7.83	1.89	1.09	8.833	0.000017	0.0098
39.	<i>Ficus hispida</i> Lf.	17.73	46.81	8.90	7.34	1.76	20.020	0.000652	0.0407
40.	<i>Ficus lucescens</i> Blume	1.42	4.26	7.83	18.11	14.83	13.174	0.000004	0.0055
41.	<i>Ficus religiosa</i> L.	2.13	6.38	7.83	2.36	1.81	9.149	0.000009	0.0077
42.	<i>Ficus rumphii</i> Blume	2.84	8.51	7.83	1.52	0.46	8.833	0.000017	0.0098
43.	<i>Ficus hirta</i> Vahl.	2.13	6.38	7.83	1.49	0.71	9.149	0.000009	0.0077
44.	<i>Ficus scandens</i> Roxb.	1.42	4.26	7.83	0.89	0.23	13.174	0.000004	0.0055
45.	<i>Garuga pinnata</i> Roxb.	1.42	4.26	7.83	1.14	0.44	13.174	0.000004	0.0055
46.	<i>Gmelina arborea</i> Roxb.	4.26	12.77	7.83	2.25	0.95	9.540	0.000038	0.0136
47.	<i>Grewia asiatica</i> L.	2.84	8.51	7.83	2.32	1.82	8.833	0.000017	0.0098
48.	<i>Microcos paniculata</i> L.ex W.& A.	10.64	27.66	9.04	4.46	1.28	14.607	0.000235	0.0278
49.	<i>Hevea brasiliensis</i> (Wild.ex Juss) Muell. Arg.	1.42	2.13	15.67	0.60	0.16	13.174	0.000004	0.0055
50.	<i>Holarrhena pubescence</i> (Buch.-Ham.) Wall.	2.13	6.38	7.83	1.16	0.28	9.149	0.000009	0.0077
51.	<i>Hymenodicylen excelsum</i> Walp.	2.84	8.51	7.83	2.21	1.64	8.833	0.000017	0.0098
52.	<i>Lagerstroemia perviflora</i> Roxb. Var. <i>benghalensis</i> Clark.	0.71	2.13	7.83	2.81	1.06	-6.702	0.000001	0.0031
53.	<i>Lagerstroemia speciosa</i> (L.) Pers	2.13	2.13	23.50	0.75	0.30	9.149	0.000009	0.0077
54.	<i>Lannea coromandelica</i> (Houtt.)Merr.	17.73	29.79	13.99	6.00	5.30	20.020	0.000652	0.0407
55.	<i>Litsea glutinosa</i> (Lour) C.B. Roxb.	0.71	2.13	7.83	0.46	0.06	-6.702	0.000001	0.0031
56.	<i>Leucaena lencecephala</i> (Lamk.) de Wit.	5.67	10.64	12.53	2.07	0.67	10.612	0.000067	0.0171
57.	<i>Litsea monopetala</i> (Roxb.) Pers.	2.13	6.38	7.83	1.54	0.77	9.149	0.000009	0.0077
58.	<i>Madhuca longifolia</i> (L.) Macb.	1.42	4.26	7.83	0.88	0.22	13.174	0.000004	0.0055
59.	<i>Mallotus philippensis</i> (Lamk.) Muell. Arg.	41.14	53.19	18.17	11.50	7.84	35.931	0.003510	0.0727
60.	<i>Mangifera indica</i> L.	2.84	2.13	31.33	0.92	0.50	8.833	0.000017	0.0098
61.	<i>Melia sempervirens</i> (L.) All.	4.26	12.77	7.83	2.18	0.78	9.540	0.000038	0.0136
62.	<i>Milisia roxburghiana</i> . Hk.f &T.	2.84	8.51	7.83	2.43	2.00	8.833	0.000017	0.0098
63.	<i>Milisia velutina</i> . (Dunal) Hook.f et Th.	18.44	34.04	12.73	6.42	4.49	20.541	0.000705	0.0418
64.	<i>Phyllanthus emblica</i> L.	1.42	2.13	15.67	0.57	0.13	13.174	0.000004	0.0055
65.	<i>Polyalthia longifolia</i> (Sonn.) Thw.	4.97	14.89	7.83	2.64	1.34	10.059	0.000051	0.0153
66.	<i>Psidium guajava</i> (L.) Bat.	4.26	8.51	11.75	1.65	0.49	9.540	0.000038	0.0136
67.	<i>Saraca indica</i> L.	2.13	2.13	23.50	0.72	0.25	9.149	0.000009	0.0077
68.	<i>Schelichera oleosa</i> (Lour.) Oken.	2.84	8.51	7.83	1.72	0.80	8.833	0.000017	0.0098
69.	<i>Semecarpus anacardium</i> L.f.	4.26	12.77	7.83	2.01	0.35	9.540	0.000038	0.0136
70.	<i>Shorea robusta</i> Gaertn	306.38	100.00	72.00	54.51	93.78	173.755	0.194716	0.1568
71.	<i>Spondias pinnata</i> (L.f.) Kurz	2.84	2.13	31.33	0.75	0.22	8.833	0.000017	0.0098
72.	<i>Sterculia villosa</i> Roxb.	1.42	4.26	7.83	2.41	1.51	13.174	0.000004	0.0055
73.	<i>Stereospermum suaveolens</i> A. DC.	0.71	2.13	7.83	9.19	3.76	-6.702	0.000001	0.0031
74.	<i>Streblus asper</i> Lour.	7.09	12.77	13.06	2.48	0.85	11.754	0.000104	0.0203
75.	<i>Swietenia mahogoni</i> (L.) N.J. Jacquin	6.38	4.26	35.25	2.04	2.66	11.180	0.000085	0.0187
76.	<i>Syzygium cumini</i> (L.) Skeel.	2.13	6.38	7.83	1.57	0.80	9.149	0.000009	0.0077
77.	<i>Syzygium grandis</i> (Wt.) Wall.	2.13	4.26	11.75	1.07	0.43	9.149	0.000009	0.0077
78.	<i>Syzygium jambos</i> (L.) Alston	1.42	4.26	7.83	0.80	0.14	13.174	0.000004	0.0055
79.	<i>Syzygium operculatum</i> (Roxb.)	2.84	8.51	7.83	1.94	1.17	8.833	0.000017	0.0098
80.	<i>Tamarindus indica</i> L.	2.84	8.51	7.83	1.42	0.29	8.833	0.000017	0.0098
81.	<i>Tectona grandis</i> L.f.	5.67	17.02	7.83	2.82	1.10	10.612	0.000067	0.0171
82.	<i>Terminalia arjuna</i> (Roxb.) W&A.	2.13	6.38	7.83	1.40	0.59	9.149	0.000009	0.0077
83.	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	6.38	17.02	8.81	3.55	3.64	11.180	0.000085	0.0187
84.	<i>Terminalia chebula</i> (Gaertn.) Retz.	2.84	8.51	7.83	1.41	0.28	8.833	0.000017	0.0098
85.	<i>Toona ciliata</i> M. J. Roem	3.55	10.64	7.83	1.76	0.43	9.095	0.000026	0.0117
86.	<i>Trema orientalis</i> (L.) Blume	5.67	17.02	7.83	2.76	0.89	10.612	0.000067	0.0171
87.	<i>Trewia nudiflora</i> L.	8.51	21.28	9.40	3.75	2.15	12.904	0.000150	0.0234
88.	<i>Vitex glabrata</i> Br. (Verbena.)	0.71	2.13	7.83	0.82	0.21	-6.702	0.000001	0.0031
89.	<i>Vitex peduncularis</i> Wall.	2.84	8.51	7.83	1.57	0.55	8.833	0.000017	0.0098
90.	<i>Wringhtia arborea</i> (Dennst.) Mabb.	1.42	4.26	7.83	1.17	0.46	13.174	0.000004	0.0055
91.	<i>Xylia kerrii</i> Craib & Hutch.	1.42	2.13	15.67	0.45	0.03	13.174	0.000004	0.0055
92.	<i>Zanthoxylum rhetsa</i> (Roxb.) DC.	0.71	2.13	7.83	0.62	0.13	-6.702	0.000001	0.0031
93.	<i>Zizyphus oenoplea</i> (L.) Mill.	4.26	12.77	7.83	2.45	1.46	9.540	0.000038	0.0136
94.	<i>Zizyphus rugosa</i> Lamk.	2.84	8.51	7.83	1.44	0.32	8.833	0.000017	0.0098

Table 2. Phytosociological attributes with Species diversity (H) and Concentration of dominance (Cd), the equitability or species per log cycle index (EC) of tree species in Lawachara forest

Sl. No.	Botanical name	Den (tree/ha)	Freq (%)	A/F	IVI	TBC (m ² /ha)	Ec	Cd	H
1.	<i>Acacia chinensis</i> (Osborne) Merr.	4.55	13.64	2.44	3.03	1.55	1.6488	0.00007	0.0174
2.	<i>Adina cordifolia</i> (Roxburgh) Hook.f. ex Brandis	3.03	4.55	14.67	2.03	1.17	1.0995	0.00003	0.0126
3.	<i>Albizia moluccana</i> Miq.	4.55	13.64	2.44	2.81	1.19	1.6488	0.00007	0.0174
4.	<i>Alstonia scholaris</i> Br.	3.03	9.09	3.67	1.93	0.60	1.0995	0.00003	0.0126
5.	<i>Neolamarckia cadamba</i> (Roxburgh) Bassler	22.73	50.00	0.91	9.53	6.18	8.2463	0.00175	0.0576
6.	<i>Aphanamixis polystachya</i> (Wall.) R.N. Parkar	4.55	9.09	5.50	2.46	1.31	1.6488	0.00007	0.0174
7.	<i>Aquilaria agallocha</i> Roxburgh.	1.52	4.55	7.33	1.23	0.30	0.5496	0.00001	0.0071
8.	<i>Ardisia solanacea</i> (Poir.) Roxburgh	1.52	4.55	7.33	5.53	2.68	0.5496	0.00001	0.0071
9.	<i>Artocarpus chama</i> Hamilton	100.00	95.46	1.10	30.17	109.75	36.2837	0.03380	0.1352
10.	<i>Artocarpus lacucha</i> Roxburgh.	16.67	40.91	1.00	7.90	6.49	6.0473	0.00094	0.0464
11.	<i>Baccaurea ramiflora</i> Lour.	4.55	13.64	2.44	2.28	0.32	1.6493	0.00007	0.0174
12.	<i>Bombax ceiba</i> L.	4.55	13.64	2.44	5.01	4.86	1.6488	0.00007	0.0174
13.	<i>Bursera serrata</i> Wall. ex Colebr.	4.55	13.64	2.44	3.15	1.77	1.6493	0.00007	0.0174
14.	<i>Caryota urens</i> L.	10.61	18.18	3.21	4.18	2.14	3.8483	0.00038	0.0333
15.	<i>Cassia fistula</i> L.	3.03	4.55	14.67	1.51	0.60	1.0995	0.00003	0.0126
16.	<i>Chickrassia tabularis</i> Juss. A. Juss.	7.58	9.09	9.17	12.62	28.78	2.7488	0.00019	0.0259
17.	<i>Cinnamomum cecidodaphne</i> Meisn.	13.64	31.82	1.35	6.96	7.59	4.9478	0.00063	0.0401
18.	<i>Citrus grandis</i> (L.) Osbeck.	1.52	4.55	7.33	1.47	0.43	0.5498	0.00001	0.0071
19.	<i>Diospyros peregrina</i> (Gaertn.) Gurke	3.03	4.55	14.67	1.67	0.77	1.0995	0.00003	0.0126
20.	<i>Diptocarpus turbinatus</i> Gaertn.	4.55	13.64	2.44	2.40	0.51	1.6488	0.00007	0.0174
21.	<i>Elaeis guineensis</i> Jacq.	3.03	9.09	3.67	2.32	1.02	1.0992	0.00003	0.0126
22.	<i>Elaeocarpus floribundus</i> Blume	10.61	9.09	12.83	3.48	2.71	3.8471	0.00038	0.0333
23.	<i>Engelhardtia spicata</i> Lesch. Ex Blume	1.52	4.55	7.33	0.90	0.11	0.5498	0.00001	0.0071
24.	<i>Erythrina variegata</i> L. var. <i>Orientalis</i> Merr.	4.55	13.64	2.44	3.78	2.81	1.6488	0.00007	0.0174
25.	<i>Ficus benghalensis</i> L.	1.52	4.55	7.33	20.02	10.71	0.5498	0.00001	0.0071
26.	<i>Ficus benjamina</i> L. var. <i>comosa</i> (Roxburgh.) Kurz	4.55	13.64	2.44	3.47	2.28	1.6488	0.00007	0.0174
27.	<i>Ficus hispida</i> Lf.	1.52	4.55	7.33	1.28	0.32	0.5498	0.00001	0.0071
28.	<i>Ficus nervosa</i> Heyne ex Roth.	4.55	13.64	2.44	2.69	1.00	1.6488	0.00007	0.0174
29.	<i>Ficus racemosa</i> Roxburgh.	6.06	18.18	1.83	3.71	2.04	2.1990	0.00012	0.0218
30.	<i>Ficus religioisa</i> L.	3.03	9.09	3.67	2.21	0.90	1.0992	0.00003	0.0126
31.	<i>Ficus rumphii</i> Blume	3.03	9.09	3.67	2.42	1.13	1.0992	0.00003	0.0126
32.	<i>Firminia colorata</i> (Roxburgh.) R. Br.	1.52	4.55	7.33	2.44	0.96	1.6488	0.00001	0.0071
33.	<i>Flacourtia jangomas</i> (Lour.) Raeusch.	1.52	4.55	7.33	1.23	0.30	0.5498	0.00001	0.0071
34.	<i>Garcinia cowa</i> Roxburgh.	7.58	18.18	2.29	3.57	1.39	2.7488	0.00019	0.0259
35.	<i>Garcinia xanthochymus</i> Hook.f.	1.52	4.55	7.33	0.90	0.11	0.5498	0.00001	0.0071
36.	<i>Gmelina arborea</i> Roxburgh.	25.76	31.82	2.54	8.30	6.00	9.3458	0.00003	0.0126
37.	<i>Holigarna caustica</i> (Dennst) Oken.	1.52	4.55	7.33	1.04	0.19	0.5496	0.00001	0.0071
38.	<i>Hopea odorata</i> Roxburgh.	4.55	13.64	2.44	2.57	0.79	1.6488	0.00007	0.0174
39.	<i>Hyndocarpus kurzii</i> (King.) Warb.	1.52	4.55	7.33	1.37	0.37	0.5496	0.00001	0.0071
40.	<i>Illex godajam</i> Coleb.	1.52	4.55	7.33	9.29	4.76	0.5498	0.00001	0.0071
41.	<i>Lagerstroemia speciosa</i> (L.) Pers.	36.36	54.55	1.22	12.42	9.52	13.1941	0.00447	0.0785
42.	<i>Lophopetalum fimbriatum</i> Wight.	1.52	4.55	7.33	1.47	0.43	0.5496	0.00001	0.0071
43.	<i>Macaranga denticulata</i> (Bl.) Muell. Ang.	6.06	9.09	7.33	2.33	0.83	2.1990	0.00012	0.0218
44.	<i>Mangifera indica</i> L.	1.52	4.55	7.33	0.98	0.15	0.5498	0.00001	0.0071
45.	<i>Melastoma malabathricum</i> L.	1.52	4.55	7.33	1.04	0.19	0.5496	0.00001	0.0071
46.	<i>Michelia champaca</i> L.	4.55	4.55	22.00	2.99	2.89	1.6493	0.00007	0.0174
47.	<i>Microcos paniculata</i> L.	12.12	31.82	1.20	5.46	1.32	4.3967	0.00050	0.0368
48.	<i>Naravelia zeylanica</i> DC.	1.52	4.55	7.33	0.90	0.11	0.5496	0.00001	0.0071
49.	<i>Paraserianthes falcataria</i> (L.) Nielson.	4.55	13.64	2.44	2.71	1.03	1.6488	0.00007	0.0174
50.	<i>Phyllanthus embelica</i> L.	1.52	4.55	7.33	1.04	0.19	0.5496	0.00001	0.0071
51.	<i>Pterospermum acerifolium</i> (L.) Wild	7.58	22.73	1.47	4.01	1.45	2.7488	0.00019	0.0259
52.	<i>Schima wallichii</i> (DC.) Korth.	15.15	40.91	0.91	8.70	11.89	5.4959	0.00078	0.0433
53.	<i>Shorea robusta</i> Gaertn. f.	3.03	9.09	3.67	2.45	1.17	1.0992	0.00003	0.0126
54.	<i>Spondias pinnata</i> (L.f.) Kurz.	3.03	9.09	3.67	1.95	0.62	1.0995	0.00003	0.0126
55.	<i>Streblus aspera</i> Lour.	3.03	9.09	3.67	2.12	0.80	1.0992	0.00003	0.0126
56.	<i>Swietenia mahogoni</i> (L.) N.J. Jacquin	3.03	9.09	3.67	1.90	0.56	1.0992	0.00003	0.0126
57.	<i>Syzygium cumini</i> (L.) Skeel.	16.67	40.91	1.00	8.32	9.05	6.0473	0.00094	0.0464
58.	<i>Syzygium fruticosum</i> (Roxburgh.) DC.	4.55	13.64	2.44	2.87	1.30	1.6493	0.00007	0.0174
59.	<i>Syzygium grandis</i> (Wt.) Wal.	4.55	13.64	2.44	3.06	1.60	1.6488	0.00007	0.0174
60.	<i>Syzygium jambos</i> (L.) Alston.	1.52	4.55	7.33	1.23	0.30	0.5498	0.00001	0.0071

Sl. No.	Botanical name	Den (tree/ha)	Freq (%)	A/F	IVI	TBC (m ² /ha)	Ec	Cd	H
61.	<i>Syzygium romosissimum</i> (Wall. ex Duth.) Balak.	4.55	13.64	2.44	2.90	1.34	2.4981	0.00007	0.0174
62.	<i>Syzygium syzygioides</i> (Miq.) Merr. & Parry.	6.06	18.18	1.83	3.24	1.01	2.1984	0.00012	0.0218
63.	<i>Syzygium walltchi</i> (Wt.) Walp.	4.55	13.64	2.44	2.58	0.81	1.6488	0.00007	0.0174
64.	<i>Tamarindus indica</i> L.	1.52	4.55	7.33	1.13	0.24	0.5496	0.00001	0.0071
65.	<i>Tectona grandis</i> L.	31.82	36.36	2.41	10.84	19.07	11.5414	0.00342	0.0721
66.	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn.	6.06	18.18	1.83	3.25	1.02	2.1984	0.00012	0.0218
67.	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	7.58	18.18	2.29	4.21	3.17	2.7479	0.00019	0.0259
68.	<i>Terminalia catappa</i> L.	21.21	40.91	1.27	8.46	6.20	7.6965	0.00152	0.0549
69.	<i>Terminalia chebula</i> (Gaertn.) Retz.	1.52	4.55	7.33	1.04	0.19	0.5498	0.00001	0.0071
70.	<i>Tricalysia singularis</i> K. schum.	1.52	4.55	7.33	1.47	0.43	0.5496	0.00001	0.0071
71.	<i>Vitex peduncularis</i> Wall.	12.12	27.27	1.63	6.03	5.72	4.3967	0.00050	0.0368
72.	<i>Xylia kerrii</i> Craib & Hutch.	1.52	4.55	7.33	2.07	0.76	0.5498	0.00001	0.0071

Density and Frequency

The tree density range in Madhupur sal forest was observed from 0.71 trees/ha to 306.38 trees/ha (Table 1). The highest density was observed in *Shorea robusta* (306.38 trees/ha) followed by *Mallotus philippensis* (41.135 trees/ha) in Madhupur sal forest (Table 1). Malaker *et al.* (2008) found the species *Shorea robusta* had greater seedling density 273.33-226.67 (trees/ha) in Jaus bits and Beribaid bits respectively, of Madhupur sal forest.

In the Lawachara forest, the density of tree species ranged from 1.515 to 100 trees/ha (Table 2). *Artocarpus chama* was the dominant tree species (100 trees/ha) followed by *Lagerstroemia speciosa* (36.366 trees/ha). Malaker *et al.* (2008) found the species *Shorea robusta* had greater tree density 273.33- 226.67 (trees/ha) in Jaus bits and Beribaid bits respectively, of Madhupur sal forest.

The frequency of tree species ranged from 2.128 to 100 % in Madhupur sal forest and from 4.546 to 95.455 % in the Lawachara forest. The highest frequency was observed in *Shorea robusta* (100%) in the Madhupur sal forest followed by *Mallotus philippensis* (59.191%). In the Lawachara forest, the highest frequency was observed in *Artocarpus chama* (95.455%) followed by *Lagerstroemia speciosa* (54.546%) (Table 2).

From the above observations, it was found that the species *Shorea robusta* in Madhupur sal forest and *Artocarpus chama* in Lawachara forest were the dominant tree species. In terms of frequency rate *Shorea robusta* and *Artocarpus chama* species were uniformly distributed in both the forests. Akhter *et al.* (1997) found *Magnifera indica* as highest in number in the sampled villages of Chittagong, Bangladesh.

TBC and Abundance

In the Madhupur sal forest, the TBC values ranged from 0.014 m²/ha to 93.775 m²/ha and in Lawachara forest it varied from 0.114 m²/ha to 109.753 m²/ha (Table 1, 2). Semwal *et al.* (2002) reported the range of TBC from 27-191.5 m² in Garhawal Himalaya, India. (Table 1) showed that the maximum TBC value belonged to the species *Shorea robusta* (93.775 m²/ha) (Table 2) followed by *Artocarpus chama* (57.993m²/ha) in Madhupur sal forest while in Lawachara forest the species *Artocarpus chama* (109.753 m²/ha) represented maximum occurrence in terms of TBC value followed by the species *Chickrassia tabularis* Juss. (28.783 m²/ha) (Table 2).

According to total basal cover, it was revealed that *Shorea robusta* and *Artocarpus chama* were occupied the largest area than the other species in Madhupur sal forest and *Artocarpus chama* and *Chickrassia tabularis* in Lawachara forest. Al-Amin *et al.* (2005) found the highest TBC in *Tectona grandis* in degraded forest of Chittagong, Bangladesh. It was evident from the above mentioned values that the TBC ranges were greater on Lawachara forest than the values reported in Madhupur sal forest. The abundance rate was approximately same in both the forests.

A/F Ratio and Importance Value Index (IVI)

A/F ratio was used to assess the distribution pattern of the species. Distribution pattern indicated that the most of the species in circular sampling unit method were distributed contagiously (clumped) followed by randomly. The A/F ratio in Madhupur sal forest varied from 1.55 to 72 (Table 1) and in Lawachara forest from 0.91 to 22 (Table 2). The species *Shorea robusta* (72) represented the highest A/F ratio values in Madhupur sal forest (Table 1) and the greater A/F ratio was recorded in the species *Michelia champaca* (22) in Lawachara forest (Table 2).

The IVI value varied between 0.448 and 54.512 in Madhupur sal forest (Table 1) and between 0.903 and 30.173 in Lawachara forest (Table 2). The species *Shorea robusta* (54.512) in Madhupur sal forest and the species *Artocarpus chama* (30.173) in Lawachara forest had a high IVI score due to the many species present in the forests (Table 2).

From the above observations, the high IVI scores of *Shorea robusta* (54.512), *Artocarpus chama* (24.450) and *Ficus hispida* (7.342) in Madhupur sal forest and the species *Artocarpus chama* (30.173), *Lagerstroemia speciosa* (12.422) and *Tectona grandis* (10.836) in Lawachara forest might have to be attributed due to the big diameters of individual trees. In Bamu Reserved Forest of Cox' Bazar, Bangladesh, Hossain *et al.* (1997) observed the highest IVI in *Bursera serata*.

Species Diversity (H), Concentration of Dominance (Cd) and the equitability or species per log cycle index (EC)

The tree species diversity (H) was observed from 0.0031 to 0.1568 in Madhupur sal forest (Table 1) and in Lawachara forest it varied from 0.0071 to 0.1352 (Table 2). Bhandari (2003) observed the Species diversity from 0.73 to 1.60 in Garhwal Himalaya of India. *Shorea robusta* (0.1568) ranked first with respect to species diversity in Madhupur sal forest and *Artocarpus chama* (0.1352) showed the greater diversity values in Lawachara forest. The second highest diversity was found in *Mallotus philippensis* (0.0727), *Bombax ceiba* (0.0264) and *Dillenia pentagyna* (0.0234) in Madhupur sal forest (Table 1) while in Lawachara forest *Lagerstroemia speciosa* (0.0785), *Tectona grandis* (0.0721) and *Neolamarckia cadamba* (0.0576) ranked the second highest species diversity (Table 2).

The concentration of dominance (Cd) was recorded from 0.000001 to 0.194716 in the Madhupur sal forest and in the Lawachara forest from 0.00001 to 0.03380. Su *et al.* (2001) observed the Cd from 0.6637 to 0.8119 in Guangzhou, China. The highest Cd was found in *Shorea robusta* (0.194716) and *Mallotus philippensis* (0.003510) in the Madhupur sal forest (Table 1) and the species *Artocarpus chama* (0.03380.) and *Lagerstroemia speciosa* (0.00447) had the highest Cd recorded in Lawachara forest (Table 2). Ashutosh *et al.* (2002) recorded maximum Cd in sal trees in Uttaranchal Pradesh of India.

From the above results it was observed that the species diversity of Madhupur sal forest is greater than Lawachara forest. The highest Cd was found in *Shorea robusta* (0.194716) in Madhupur sal forest and the species *Artocarpus chama* (0.03380.) in Lawachara forest were found as diversified tree species in both the forests and it might be due to the soil and geographic condition of the study area.

The equitability or species per log cycle index was recorded from -6.702 to 173.755 in the Madhupur sal forest (Table 1) and in the Lawachara forest from 0.5496 to 36.2847 (Table 2). The highest Ec was recorded in *Shorea robusta* (173.755) and *Mallotus philippensis* (35.931) in the Madhupur sal forest and the species *Artocarpus chama* (36.2847.) and *Lagerstroemia speciosa* (13.1941) had the highest Ec found in Lawachara forest (Table 2).

From the above results it was observed that the species per log cycle index of Madhupur sal forest is greater than Lawachara forest.

CONCLUSION

A total of 102 tree (tree, sapling and seedling) species was recorded in Madhupur sal forest. While in Lawachara forest about 78 tree (tree, sapling and seedling) species had been recorded. Moraceae was the largest tree family in both the forests. The species *Shorea robusta* had the highest density (306.38 trees/ha), frequency (100%), abundance (7200 plants/ha), A/F ratio values (72), IVI (54.51), H (0.1568), TBC (93.78 m²/ha), EC (173.76) and Cd (0.195) in Madhupur sal forest. In Lawachara forest, *Artocarpus chama* was the dominant tree species having the highest density (100 trees/ha), frequency (95.46%), IVI (30.17), H (0.1352), TBC (109.75 m²/ha), species EC (36.28) and Cd (0.0338), and the highest A/F ratio values (22) in the species *Michelia champaca*. On the other hand, and the species *Elaeocarpus floribundus* represented the highest abundance rate (116.667 plants/ha).

About 27 tree species were recorded as endangered in Madhupur sal forest, which had minimum or no regeneration. The species *Bridelia retusa*, *Diospyros cordifolia*, *Leea macrophylla*, *Pterospermum acerifolium*, *Spaeranthus indicus*, *Stereospermum suaveolens*, *Erythrina variegata*, and *Hopea odorata* had no any regeneration and that area was seriously depleted in the Madhupur sal forest. Some 25 tree's species were recorded as endangered in Lawachara forest which had minimum or no regeneration. The species *Hyndocarpus kurzii*, *Ilex godajam*, *Elaeis guieensis*, *Castanopsis tribuloides* and *Litsea glutinosa* had no regeneration and that area was seriously depleted in the Lawachara forest. From the above observations it was revealed that more number of endangered species were found in the Madhupur sal forest. So this forest is more vulnerable than Lawachara forest. A number of threats to plant species and their habitats in both the forests have also been identified, which are on the verge of extinction, demanding proper conservation measures to be taken.

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