

Title page

(1) Title:

Species composition and forest structure in tropical moist deciduous forest of Bangladesh- a case study in Thakurgaon.

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(5) Article type, subject area and field - Original article; Socioeconomics, planning, & management; Menstruation and monitoring

(6) Total page- 22

(7) Number of tables- 4

(8) Number of figures- 2

Abstract

This study was conducted in the tropical moist deciduous forest to describe the species composition, diversity and the forest structure. There were three plots established in Ranishonkoil, Ruhia and Baliadangi forest beat in Thakurgaon. A total 126 tree species, 1991 stems (663 ha^{-1}) of ≥ 10 cm girth were listed. Tree communities in these forest region differed in dominance, composition, diversity and structure and tree stand density varied from 651 to 685 ha^{-1} . Species diversity (H^1) ranges from 3.11 to 3.48. Meliaceae, Myrtaceae and Rubiaceae were the most abundant families within the 3 plot area. Study site 2 is more diverse at spatial scale and taxonomic levels due to high rainfall and favorable edaphic condition. This study will help to the foresters as baseline information for monitoring and sustaining diversity of tropical moist deciduous forests in Bangladesh.

Key words: Species composition, diversity, structure, dominance, Thakurgaon.

1. INTRODUCTION

Bangladesh is one of the most densely populated countries of the world with a population of 133.4 million and the density is about 904 per square kilometer and population growth is the most serious problem of the country (Anon 2003). The majority of land is flat and formed by river alluvium from the Ganges and the Brahmaputra and their tributaries. The eastern and northeastern parts of the country consist of hills alternating with broad valleys (Das 1990). The total area of the country is 14.4 million ha of which 2.46 million ha covered by forests distributed all over the country (Table 1). The natural forests of Bangladesh consist of three major vegetation types occurring on three distinctly different land types (Hassan 1994). Species diversity is the number of different species in a particular area weighted by some measure of abundance such as number of individuals or biomass. It differs from place to place. Bangladesh is rich in biodiversity, due to anthropogenic activities and replaced by inferior species and change of land use pattern the primary forest area are disappearing. Studies from forest survey of Bangladesh showed an average more than 70% of forest is affected by over population and their activities (BBS, 2004). Forest ecosystem dynamics and conservation depends on the understanding of species composition and diversity. It works as a tool to estimate the level of adaptation to the environment and

their ecological significance (Nath et. al., 1998). Tropical moist deciduous forests are enrich with economically important multi purposes tree species such as fruit, timber etc. Vegetation composition, diversity of species and their habitats are well understood for other tropical forest types compared to moist deciduous forests.

The floristic composition of the forests of Bangladesh is rich and has been described by several authors, *e.g.* Khan and Afza (1968) briefly gave the preliminary floristic report on Teknaf forest. Alam (1988) about Sylhet forests and Alam (1995) about moist deciduous forests area. In comparison to the moist deciduous and evergreen and semi-evergreen hill forests, the flora of the Sundarban mangroves did not show much heterogeneity in floral composition (Chaffey *et al.* 1985). However, altogether about 5 700 species of angiosperms and 1 500 species of fauna be available in the country but recent findings show that the populations of some of the species have declined to about a half (Khan 1996). The tropical moist deciduous forests in Thakurgaon, the Northern part of Bangladesh, also known as “inland sal forests”, cover relatively small areas distributed over the inland plain area (Alam, 1995). They are predominantly composed of sal (*Shorea robusta*) occurring in pure patches, sometimes associated with korai (*Albizia* spp.) in the canopy and mahogany (*Swietenia mahagon*), neem (*Azadirachta indica*) and other MPTS. More than half of these forests are located in the Dhaka,

Mymensingh and Dinajpur forest division. They have been subjected to considerable illicit fellings and encroachments due to their location in densely populated area.

<Table 1>

2. MATERIALS AND METHODS

2.1. Study area

The study area was located between 25° 57' to 25° 57' N and 88° 15' to 88° 25' E (Fig 1) in northern part of Bangladesh and about 2,497.92 sq. km. It is bordered by India on its west and north sides, it is a part of the Himalayan plain land. Thakurgaon district is located in a long distance from the divisional towns as well as central part of Bangladesh. The climate is mainly drought and the monsoon that usually begins in June and ends in September. The mean annual rainfall range is between 1500-1800 mm (BBS, 2007). The temperature varies on an average from 37°C & 26°C in summer, 28°C & 10°C in winter. There are 5 forest beats (lowest administrative units) in Thakurgaon forest range (Ranishonkoil, Baliadangi, Horipur, Pirgonj and Ruhia) (Fig 1). Three 1 ha plots area was selected at three different beats/sites: Site 1 is located in Horipur beat, site 2 is located in Ruhia beat and site 3 is located in Baliadangi beat in Thakuragon forest ranges (administrative units).

<Fig 1>

2.2. Field Sampling

Phytosociological data were collected in three 100x100 m plots which were divided into 20x20 m subplots and were systematically surveyed for all trees ≥ 10 cm girth at breast height and the gbh-above 130 cm from the ground. The collection period was April 2008 to June 2008 in Horipur-Ruhia-Baliadangi in Thakurgaon, Bangladesh. Thus data were obtained from a total of 60 subplots (total=3 ha). All plots sampled were representative of the most common vegetation types in Thakurgaon. The species were identified with the help of DAE (Department of Agricultural Extension).

2.3. Data Analysis

The vegetation data were quantitatively analyzed for basal area, relative density, relative frequency and relative dominance (Philips, 1959). The importance Value Index (IVI) for the tree species was determined as the sum of the relative frequency, relative density and relative dominance (Cottam and Curtis, 1956).

Basal area (m^2) = Area occupied at breast height (1.3 m) = $C^2/4p$ or $0.0796 \times C^2$ (where C is the circumference).

Relative density = No. of the trees of species/total number of trees of all species $\times 100$

Relative frequency = No. of time species occurs/total number of species x 100

Relative dominance = Total basal area of a species/total basal area for all species x 100

Importance Value Index (IVI) = Sum of relative density+ relative frequency + relative dominance

Species diversity of each forest types was determined using Shanon-Weiner Index (H^1)

= -Sum $\{(ni/N) \ln (ni/N)\}$ (Shannon and Wiener, 1949; Odum, 1971).

Where: ni = IVI of individual species; N = IVI of all species.

Local diversity was defined as the number of species found in a hectare. Regional diversity of each area derived independently of plot data.

3. RESULTS AND DISCUSSIONS

3.1. Species composition

A total 126 tree species were recorded within 3 ha plots area, responding 89 genera in 40 families. The mean stem density of 663 stems ha^{-1} and range of 651 to 685 stems ha^{-1} in the forests of Northern part of Bangladesh. The tree diversity assessed by the Shannon-Weiner index (H^1) which was 3.19, 3.48 and 3.11 for the site 1, 2 and 3 respectively. Plot-wise tree species richness was 59 for site 1, 64 for site 2 and 57 for site 3 with major differences between the plots (Table 2). Site 2 forests are more diverse

at spatial scale and all taxonomic levels than their counterparts followed by 1 and 3 (Table 2). Within the 3 plot area the most abundant families were Meliaceae, Myrtaceae and Rubiaceae. An obvious variation in representation of tree species and the proportion of dominant species in the three sites can directly be attributed to rainfall distribution and favorable edaphic conditions. The study results were similar in comparison with the study of Alam (1995) in diversity in the woody flora of Sal forest of Bangladesh. The most frequently occurring species in three sites was *Swietenia mahagoni*, *Magnifera indica* and *Artocarpus heterophyllus*. In site 1 and 2 some of moisture indicating species is prevalent i.e., *Dalbergia sissoo*, *Azadirachta indica*, *Pterocarpus marsupium*, and *Anthocephallus chinensis*. Where as in site 3 species composition possesses comparatively indicating dry habitats and *Cassia fistula*, *Terminalia arjuna*, *Albizia chinensis* and *Gmelina aroba* were predominant (Table 3).

There were total 1991 individuals representing 40 families in the 3 plots area. The common tree species in the three sites was *Swietenia mahagoni*, *Magnifera indica* and *Artocarpus heterophyllus* which commonly found in all over in the moist deciduous forest for their multipurpose value. These three species had the most individuals in all plots also. Species similarity between different sites was using presence/absence data. 58% of the species recorded was found similar between site 1 and site 2. Site 1 and site

3 was having 37% common species. The top ten predominant species with relative dominance, relative density, relative frequency and IVI were given in Table 3. In this study it was found that the forest area of Thakurgaon was rich in plant diversity, specially the site 2. Most of the tree species were random distributed. The relative density of species per unit area was maximum for *magnifera indica* 19.2 in site 1, *Artocarpus heterophyllus* 21.2 and 21.46 in site 2 and 3 respectively. The relative dominance which is a coverage value of a species was found to be maximum for *Artocarpus heterophyllus* (20.78) followed by *Swietenia mahagoni* (17.1), *Magnifera indica* (14.7), *Azadiracha indica* (14.4), *Anthocephallus chinensis* (11.59) and *Embllica officinalis* (7.2). The most promising dominant species on the basis of IVI value were *Artocarpus heterophyllus* (56.57), *Swietenia mahagoni* (46.2), *Azadiracha indica* (46.2), *Magnifera indica* (41.1) and *Anthocephallus chinensis* (39.11). However, *Syzygium sumini*, *Eucalyptus tereticornis*, *Terminalia arjuna*, *Albizia chinensis*, *Gmelina aroba* and *Albizzia procera* with lower value may be considered as co-dominant species (Table 3). Basal area is also regarded as an index of dominant species, most basal area tree showed the most dominancy. By this reckoning, highly basal area was recorded for *Magnifera indica* (3.86), *Azadiracha indica* (3.83), *Swietenia mahagoni* (3.27), *Shorea robusta* (2.55) and *Artocarpus heterophyllus* (2.49).

<Table 2>

<Table 3>

3.2. Forest Structure

The northern districts of the country's forest land are bestowed with Tropical Moist Deciduous Forests. This forest is intermingled with the neighboring settlements and fragmented into smaller patches (Dinajpur Forest Division, 2007). The distribution of the total plot area across 1 ha plots, using gdb interval classes, reveal the dominance of small stemmed individuals in the plot. The mean diameter of top 10 dominant tree species covers 62% of ground cover. It means minority of species dominate the majority of the available resources. Stem density and species richness have consistently decreased with increasing girth class of tree species from 10 to 155cm girth. The highest numbers of species were encountered in the low gbh class (10-50 cm). Species number gradually decreases with the fall of stems in higher girth class category (Table 4). Tree distribution by height intervals is shown in Fig 2.

<Table 4>

<Fig 2>

Most of the economically valuable and indigenous forest tree belongs to height range of 15 - <25 m and dbh range of 20 – <30 cm and the less species belongs to height range of 10 - <15 m and 60 - <70 cm dbh range. The tallest individual tree was *Shorea robusta* (30 m) and *Swietenia macrophylla*. (25 m) in site 1. In site 2 *Shorea robusta* (27 m) and *Artocarpus heterophyllus* (24 m) is the tallest tree. In Baliadangi beat (site 3) *Dalbergia sissoo* (25 m) and *Magnifera indica* (22 m) was found as the tallest tree. Trees height in site 1 (35%) and site 2 (41%) show trends higher than the site 1 (45% of trees are less than 5 m). Tree heights are influenced by the abundance of saplings, richness of nutrients and management practices.

4. CONCLUSION

It may be concluded from the study that the forest of Thakurgaon is in a remnant condition due to the destruction done by the local people and lack of co-operation of Forest department with the local people and is heterogeneous nature and composition. However, till now this forest is extremely rich in plant diversity, even after disturbance occurrence by grazing, extraction of economical or medicinal species and lack of management practice. Therefore, priority should be given to conserve these forests which are facing pressure from increasing population and their demand. Calculation of IVI helped in understanding the ecological significance of the species in tropical moist

deciduous forest type. Species diversity and stem density is decreasing with the increasing of girth class. In order to maintain the complexity of this forest and its species diversity, an economically and ecologically sound management plan is desirable with minimum disturbance to the forest ecosystem. Long term research on the changing climate on the forest must be given priority for the protection, conservation and perpetuation of this forest region. The present study will help to monitoring and sustaining the diversity of tropical moist deciduous forest of Bangladesh.

ACKNOWLEDGEMENT

The authors showed their deep thanks and gratitude to the MONBUKAGAKSHU MEXT (Japanese education and cultural ministry) for the financial support. Also would like to thanks the respondents of the study area, the Department of Agricultural Extension and the Forest Department of Thakurgaon.

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Table-1: Forest types of Bangladesh

Forest Type	Location	Area (million ha)	Remarks
Tropical Moist Hill Forest	Eastern part (Chittagong Hill Tracts and Sylhet)	0.67	Managed under the control of Forest Department
Unclassed State Forest (USF)	Hill Tracts Districts	0.73	Once rich with Dipterocarps and associates but now degraded and under control of district administration
Tropical Moist Deciduous Forest	Central and Northwest	0.12	Indigenous Sal forest are converting to exotic short rotation plantations
Mangrove Forests	South-West	0.57	Well Known Sundarban Mangrove natural forests
Coastal Forest	All along the coast	0.10	Mangrove plantations mainly with <i>Sonneratia apetala</i>
Village Forests	All over the country	0.27	Homestead Forests of individual villagers all over the country

Table-2: Combined particulars of species inventory in the study sites.

Description	Site 1	Site 2	Site 3	Total
No. of tree species	59	64	57	126
No. of genera	48	51	41	89
No. of families	22	24	19	40
Density (stems ha ⁻¹)	655	685	651	1991
Species diversity index (H ¹)	3.19	3.48	3.11	-
No. of shrub species	24	27	21	35
No. of herb species	61	56	63	103
No. of climber species	21	17	19	26

Table-3: The family name, relative density, dominance, frequency, basal area, IVI and species diversity of different species in the study sites.

Site 1	RD	RDo	RF	Basal area	IVI	Family	Diversity index
<i>Swietenia mahagoni</i>	18.7	17.1	7.3	3.18	42.4	Meliaceae	-0.131
<i>Magnifera indica</i>	19.2	14.7	7.2	3.43	41.1	Anacardiaceae	-0.156
<i>Artocarpus heterophyllus</i>	16.02	20.78	19.1	2.19	56.57	Moraceae	-0.120
<i>Shorea robusta</i>	1.5	2.5	3.0	2.55	7.0	Dipterocarpaceae	-0.090
<i>Dalbargia sissoo</i>	8.3	8.5	3.8	1.25	20.6	Fabaceae	-0.126
<i>Azadirachta indica</i>	14.6	14.4	17.2	3.83	46.2	Meliaceae	-0.065
<i>Pterocarpus marsupium</i>	1.9	4.8	5.0	0.21	11.7	Fabaceae	-0.037
<i>Anthocephallus chinensis</i>	4.7	2.4	2.8	2.13	9.9	Rubiaceae	-0.123
<i>Eucalyptus tereticornis</i>	1.7	2.0	3.4	0.36	7.1	Myrtaceae	-0.040
<i>Syzygium cumini</i>	7.88	6.29	5.1	1.95	19.3	Myrtaceae	-0.100
Site 2							
<i>Swietenia mahagoni</i>	19.4	16.3	8.9	3.27	44.5	Meliaceae	-0.139
<i>Magnifera indica</i>	16.7	5.3	6.1	3.86	28.1	Anacardiaceae	-0.128
<i>Artocarpus heterophyllus</i>	21.2	14.5	6.8	2.1	42.4	Moraceae	-0.138
<i>Shorea robusta</i>	2.6	2.5	3.1	2.9	8.3	Dipterocarpaceae	-0.089
<i>Dalbargia sissoo</i>	7.3	5.8	4.2	1.79	17.3	Fabaceae	-0.118
<i>Azadirachta indica</i>	8.1	8.1	9.7	2.65	25.9	Meliaceae	-0.082
<i>Pterocarpus marsupium</i>	1.4	2.3	3.4	0.42	7.0	Fabaceae	-0.065
<i>Anthocephallus chinensis</i>	12.35	11.59	15.16	1.95	39.11	Rubiaceae	-0.090
<i>Eucalyptus tereticornis</i>	4.8	2.4	2.2	0.27	9.5	Myrtaceae	-0.061
<i>Syzygium cumini</i>	5.61	5.21	7.24	1.55	18.07	Myrtaceae	-0.130
Site 3							
<i>Swietenia mahagoni</i>	14.6	14.4	17.2	3.12	46.2	Meliaceae	-0.145
<i>Magnifera indica</i>	17.1	8.2	9.7	3.42	35	Anacardiaceae	-0.132
<i>Artocarpus heterophyllus</i>	21.46	16.02	8.82	2.49	46.3	Moraceae	-0.141
<i>Cassia fistula</i>	7.86	5.4	7.24	0.67	20.51	Caesalpiniaceae	-0.078
<i>Psidium guajava</i>	0.99	0.29	10.0	0.39	11.28	Myrtaceae	-0.065
<i>Emblica officinalis</i>	7.2	7.2	4.2	1.25	18.6	Euphorbiaceae	-0.086
<i>Albizia procera</i>	1.12	0.31	1.44	0.031	2.88	Mimosaceae	-0.065
<i>Terminalia arjuna</i>	1.4	5.3	5.0	2.0	11.7	Combretaceae	-0.93
<i>Albizia chinensis</i>	1.2	1.01	4.6	0.32	6.81	Fabaceae	-0.071
<i>Gmelina aroba</i>	2.24	1.46	2.89	0.073	6.6	Verbenaceae	-0.068

Table-4: Different species and individual's distribution according to Girth class intervals in three study sites.

Girth class (cm)	Site 1		Site 2		Site 3		Total Individuals	Percent of total individuals
	Species	Individuals	Species	Individuals	Species	Individuals		
<30	42	187	48	191	41	202	580	29.1
31-50	34	169	51	164	29	186	519	26
51-70	23	122	20	114	35	118	354	18
71-90	16	82	24	87	15	72	241	12.1
91-110	12	43	15	52	9	47	142	7.1
111-130	8	27	9	18	11	32	77	3.8
131-150	6	14	4	17	6	17	48	2.4
>151	5	11	3	8	3	11	30	1.5
	59	655	64	651	57	685	1991	100

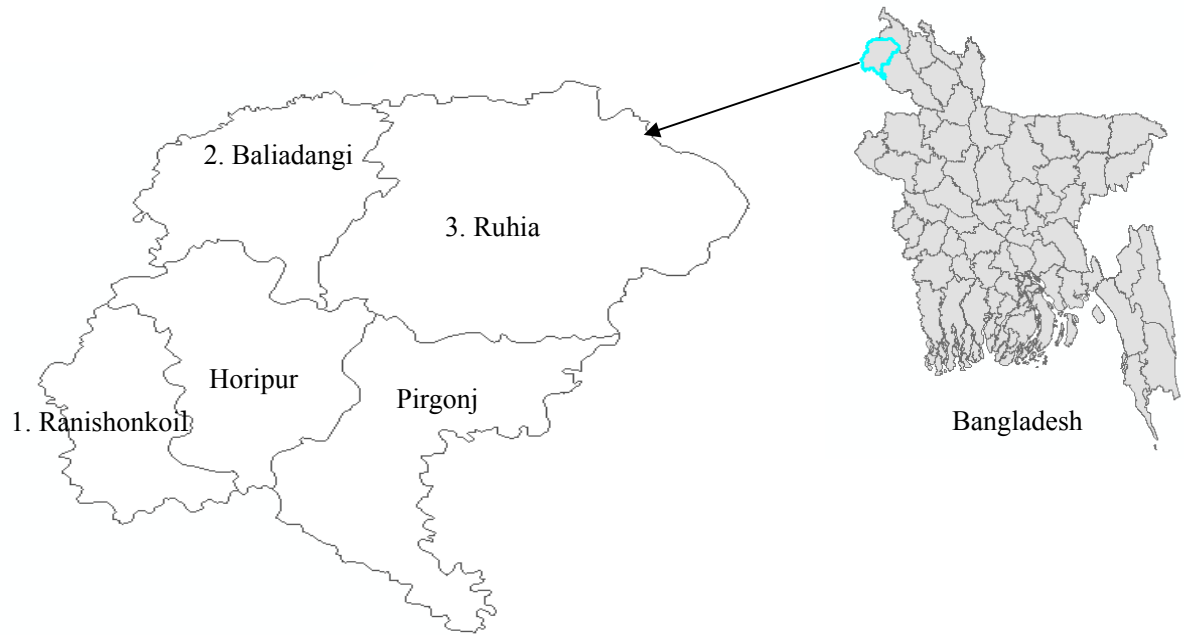


Fig-1: The study area: Ranishonkoil (1), Ruhia (2), Baliadangi (3), in Thakurgaon district, Bangladesh.
(GIS image, source: Bangladesh Weather Division)

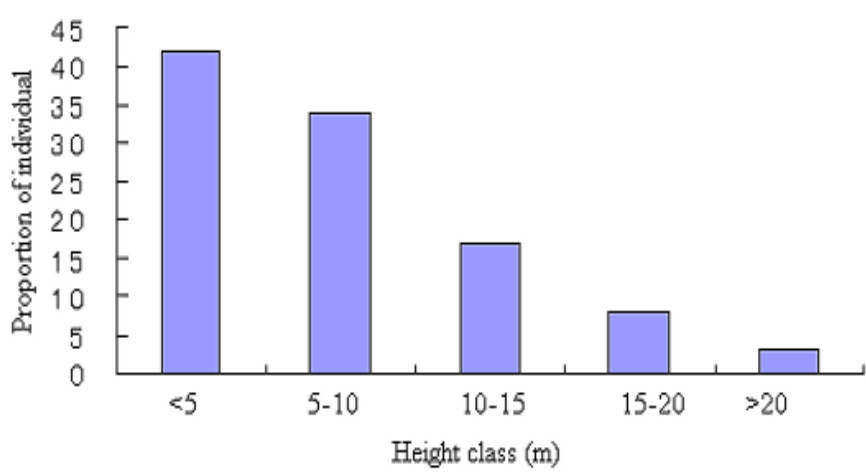


Fig-2: Hight class wise proportion of individuals in the study sites.