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# Comparison of Plant Diversity of Natural Forest and Plantations of Rema-Kalenga Wildlife Sanctuary of Bangladesh

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**ABSTRACT :** The purpose of the study was to assess and compare the diversity of plant species (trees, shrubs, herbs) of natural forest and plantations. A total of 52 plant species were recorded in the natural forest, of which 16 were trees, 15 were shrubs and 21 were herbs. On the contrary, 31 species of plants including 11 trees, 8 shrubs and 12 herbs were identified in plantation forest. Shannon-Wiener diversity index were 2.70, 2.72 and 3.12 for trees, shrubs and herbs respectively in the natural forest. However, it was 2.35 for tree species, 2.31 for shrub species and 2.81 for herb species in the plantation forest. Jaccard's similarity index showed that 71% species of trees, 44% species of shrubs and 43% species of herbs were same in plantations and natural forest.

**Keywords :** Shannon-Wiener diversity index, Jaccard's similarity index, Natural forest, Plantation forest, Plant diversity

## INTRODUCTION

Biodiversity is the relationship between species and their pattern of richness (Young and Swiacki, 2006). The preservation of biodiversity is now a central issue of world conservation strategies. Bangladesh is a part of the Indo-Burma region which is one of the ten global hot spot areas for biodiversity and supposed to have 7000 endemic plant species (Mittermeier *et al*., 1998). Due to its unique geo-physical location Bangladesh is a heritage of rich biological diversity (Chowdhury, 2001; Nishat *et al*., 2002). About 5,700 species of angiosperms alone, including 68 woody legumes, 130 fiber yielding plants, 500 medicinal plants, 29 orchids, three species of gymnosperms and 1700 pteridophytes have been recorded from Bangladesh (Troup, 1975; Khan, 1977; Firoz *et al*., 2004).

In Bangladesh, plantation establishment was started in the Chittagong Hill Tracts with Teak (*Tectona Grandis*) at its high value since 1871. In 1921 it was expanded to other hilly regions but total annual plantation area never exceeded 400 ha/year (GoB, 1992). After 1950, even though Teak continued to predominate, other species (*Dipterocarpus* spp., *Lagerstroemea* spp., *Artocarpus* spp., *Cedrela* sp., *Gmelina* sp. ect.) were planted on a sizable scale (GoB, 1992). The main objectives were to meet the demand of timber, increase the productivity and financial profit, supply industrial raw material and timber, and achieve self reliance of forest products (Pant, 1990). Plantations exceed natural forests any time in stumpage, the usual means of evaluating timber value. But natural forests produce a much wider range of goods beyond timber. Beyond that the natural forest provides environmental services more effectively than plantations. The services include ecological stability, watershed protection, genetic resources conservation, recreation and tourism (Panayatou and Ashton, 1992).

The Rema-kalenga Wildlife Sanctuary is a tropical evergreen and semi-evergreen forest (Mountfort and Poore, 1968; Sarker and Haq, 1985,) and much of it is primary forest (Uddin *et al*., 2002). A floristic survey conducted by BCAS (1997) in Rema-kalenga Wildlife Sanctuary and recorded 72 species of vascular plants.

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Natural forests of the sanctuary were converted by raising long rotation plantations (of *Tectona grandis*, *Swietenia mahagoni*, *Dipterocarpus turbinatus*, *Albizia procera*, *Shorea robusta*, *Gmelina arborea*, *Dalbergia sissoo*, *Toona ciliata*, *Aquilaria malacensis*, *Lagerstroemia speciosa*, *Artocarpus chaplasha*, *Syzygium grande*, etc) taken up from late twenties for production forestry. From ecological and conservation view point, assessment of biodiversity of any habitat or locality has been regarded as one of the vital issue for careful preservation, promotion and management of the variety of life-forms (Alam and Masum, 2005). The objective of this paper is to compare the diversity of plant species (trees, shrubs, herbs) of natural forest and plantation forest of the study site. Therefore, adequate measures would be taken to conserve and enrich its diversity according to forest types.

## MATERIALS AND METHODS

### Study site

Rema-Kalenga Wildlife Sanctuary is located at Chunarughat upazila (sub-district; administrative entity) of Habigonj district in Sylhet division. It is about 130 km east-north east of Dhaka and about 80 km south south-west of Sylhet city. With an area of 1795 ha, the Wildlife Sanctuary was established in 1996. Previously it was Tarap Hill Reserve Forest (NSP, 2007). The sanctuary encompasses several hills of different elevations and the low-laying valleys. The highest peak of the hills is about 67 m from the sea level (Rizvi, 1970). The hills are composed of Upper Tertiary rocks in which sandstone largely predominates (Ahmad, 1970) along with siltstones and mudstones, locally altered to slates and shales. Soil of the sanctuary varies from clay to sandy loam exceedingly fertile and show low pH. In some cases, soils texture consists of yellowish red sandy clay mixed with granules of magniferous iron ore (Ahmed, 1970). The sanctuary enjoys a most tropical climate characterized by a period of high precipitation from April to September and five months of relatively dry period from November to March.

### Methods

The study was carried out through stratified random quadrate method. Data were collected from both the plantations and natural forest of the sanctuary. The vegetation analysis was carried out by 24, 20 m × 20 m sample plots placed randomly for tree layer. From each forest site equal 12 sample plots were taken. For herb and shrub species 5, 2 m × 2 m sample plots were nested within each plot of tree layer (Total 120 plots, 60 from natural forest and 60 from plantation forest). After collection of field data, they were analyzed for richness, Shannon- Wiener diversity index and Jaccard's similarity index.

### Species richness

At its simplest level, diversity can be defined as the number of species found in a community, a measure known as Species Richness. Species richness was determined following Whittaker (1976) by tabulating the number of tree, shrub and herb species in the natural and plantation forest of the study area.

### The Shannon- Wiener diversity index

One of the most commonly used measures of species diversity is the Shannon- Wiener diversity index. It combines two quantifiable measures; 1. the species richness (the number of species in the community) and 2. species equitability (how even are the numbers of individuals of each species). The higher the number, the higher is the species diversity. The index equals zero when there is only a single species, increases with richness and evenness, and commonly has a value between 1.5 and 3.5 for many sampled ecological communities (Legendre and Legendre, 1998). The Shannon- wiener index for diversity was calculated according to Michael (1990) and it is as follows:

$$H = - \sum PiLnPi$$

Where, H = Index of species diversity

Pi = Number of individuals of one species / Total number of individuals in the samples

### Jaccard's similarity index

The Jaccard's (1912) index is a valuable tool because it allows one to determine whether two communities are composed of similar species.

The Jaccard's Index is calculated as

Jaccard's Index = A/ (A+B+C)

Where, A = total number of species present in both communities

B = the number of species present in community 1 but not 2

C = the number of species present in community 2 but not 1

If the Jaccard's Index is equal to one (B=0 & C=0), all species are shared between the two communities. If the Jaccard's Index is near 0, few if any species are shared.

## RESULTS

### Composition of tree species in the study area

A total of 16 species of trees distributed into 13 families were recorded from the natural forest of the study site. The dominant families were Dipterocarpaceae, Moraceae and Myrtaceae containing 2 species each. The remaining families were represented by single species. On the contrary, there were 11 tree species belonged to 9 families found in the plantation forest of the study area. It was found that family Dipterocarpaceae and Verbenaceae comprised the highest number of species (2 species each). Rest of the families occupied one species each. In the present study, 10 species were common occurred both in the plantations and natural forest. These were *Terminalia belerica, Crataeva nervosa, Artocarpus chaplasha, Syzygium*

**Table 1.** Tree species composition in natural and plantation forest of the study area

| Local name | Scientific name | Family | Natural forest | Plantation forest |
|---|---|---|---|---|
| Bohera | *Terminalia belerica* | Combretaceae | √ | √ |
| Bonak | *Crataeva nervosa* | Capparidaceae | √ | √ |
| Belphoi | *Elaeocarpus tectorius* | Elaeocarpaceae | √ | × |
| Botijam | *Syzygium operculatum* | Myrtaceae | √ | × |
| Chapalish | *Artocarpus chaplasha* | Moraceae | √ | √ |
| Chattim | *Alstonia scholaris* | Apocynaceae | √ | × |
| Dhaki Jam | *Syzygium grande* | Myrtaceae | √ | √ |
| Dumur | *Ficus roxburghii* | Moraceae | √ | × |
| Gamar | *Gmelina arborea* | Verbanaceae | √ | √ |
| Garjan | *Dipterocarpus turbinatus* | Dipterocarpaceae | √ | √ |
| Hargoza | *Dillenia pentagyna* | Dilleniaceae | √ | √ |
| Jarul | *Lagerstroemia speciosa* | Lythraceae | √ | √ |
| Jialbhadi | *Garuga pinnata* | Rubiaceae | √ | √ |
| Pichlagota | *Cordia myza* | Boraginaceae | √ | × |
| Sal | *Shorea robusta* | Dipterocarpaceae | √ | √ |
| Sheora | *Streblus asper* | Urticaceae | √ | × |
| Teak | *Tectona grandis* | Verbenaceae | × | √ |

Note: √ = presence; × = absence

*grande, Gmelina arborea, Dipterocarpus turbinatus, Dillenia pentagyna, Lagerstroemia speciosa, Garuga pinnata and Cordia myza.* However, there were 6 species namely, *Elaeocarpus tectorius, Syzygium operculatum, Alstonia scholaris, Ficus roxburghii, Cordia myza* and *Streblus asper* recorded only from natural forest. On the other hand, one species named *Tectona grandis* was confined to plantation site only (Table 1).

### Composition of shrub species in the study area

During the present study, 15 species of shrubs under 10 families were identified in the natural forest. The highest number of species were belonged to Compositae and Verbenaceae families (3 species each) followed by Malvaceae (2 species). Rest of the families contained one species each. In contrast, 8 species of shrubs of 7 families were recorded from the plantation sites. Most of the species was represented by Verbenaceae contained 2 species, while the remaining 6 families had one species each. There were 7 species namely, *Asclepias curassaviaca, Heliotropium indicum, Eupatorium odoratum, Calamus guruba, Firmiana colorata, Clerodendrum viscosum* and *Lippia geminate* found in the both types of forests. However, eight of the total recorded species were limited to natural forest. These were *Centipeda orbicularis*, *Mikania cordata, Ipomoea fistulosa, Desmodium polycarpum, Abutilon hybridum, Urena lobata, Ochna kirkii and Lantana camara.* But, *Cnesmone javanica* was the only species found no where of natural forest (Table 2).

### Composition of herb species in the study area

Herb species inventory of the natural forest of the study area yielded a total of 21 species belonged to 17 families. It was found that the family Gramineae occupied the highest number of species (3 species) followed by Compositae and Leguminosae (2 species each). The remaining families contained one species each. On the other hand, 12 species of herbs of 11 families were identified in the plantation forest. The family Gramineae dominated containing two species, whereas the remaining

**Table 2.** Shrub species composition in natural and plantation forest of the study area

| Local name | Scientific name | Family | Natural forest | Plantation forest |
|---|---|---|---|---|
| Dod agasa | *Asclepias curassaviaca* | Asclepiadaceae | √ | √ |
| Hatishore | *Heliotropium indicum* | Boraginaceae | √ | √ |
| Mechta | *Centipeda orbicularis* | Compositae | √ | × |
| Asam lata | *Eupatorium odoratum* | Compositae | √ | √ |
| Taralata | *Mikania cordata* | Compositae | √ | × |
| Dhulkolmi | *Ipomoea fistulosa* | Convolvulaceae | √ | × |
| Bishuti | *Cnesmone javanica* | Euphorbiaceae | × | √ |
| Banmethi | *Desmodium polycarpum* | Leguminosae | √ | × |
| Marichaphool | *Abutilon hybridum* | Malvaceae | √ | × |
| Ban Ukra | *Urena lobata* | Malvaceae | √ | × |
| Okana | *Ochna kirkii* | Ochnaceae | √ | × |
| Jali bet | *Calamus guruba* | Palmae | √ | √ |
| Uzaru | *Firmiana colorata* | Sterculiaceae | √ | √ |
| Bhat | *Clerodendrum viscosum* | Verbenaceae | √ | √ |
| Lantana | *Lantana camara* | Verbenaceae | √ | × |
| Vui Ukra | *Lippia geminate* | Verbenaceae | √ | √ |

Note: √ = presence; × = absence

**Table 3.** Herb species composition in natural and plantation forest of the study area

| Local name | Scientific name | Family | Natural forest | Plantation forest |
|---|---|---|---|---|
| Upathlenga | *Achyranthes aspera* | Amaranthaceae | √ | × |
| Kachu | *Colocasia esculenta* | Araceae | √ | × |
| Dudhilata | *Doemia extensa* | Asclepiadaceae | √ | × |
| Lehara | *Bothriospermum tenellum* | Boraginaceae | √ | × |
| Assampata | *Eupatorium odoratum* | Cimpositae | √ | × |
| Kasoni | *Cichorium endivia* | Compositae | √ | √ |
| Hati lata | *Argyreia splendens* | Convolvulaceae | √ | √ |
| Keumul | *Costus speciosus* | Costaceae | × | √ |
| Painna ghas | *Axonopus variegate* | Gramineae | √ | √ |
| Sungrass | *Imperata arundinaceae* | Graminae | √ | √ |
| Fuljhar | *Thysalonema maxima* | Gramineae | √ | × |
| Lazzaboti | *Mimosa pudica* | Leguminosae | √ | × |
| Kheri | *Phaseolus aconotifolius* | Leguminosae | √ | √ |
| Sapgas | *Sanseviera trifasciata* | Liliaceae | √ | √ |
| Bala | *Pavonia odorata* | Malvaceae | √ | √ |
| Alo ghas | *Mollugo hirta* | Molluginaceae | √ | √ |
| Afing | *Papaver somniferum* | Papaveraceae | √ | × |
| Marcha | *Rivinia humilis* | Phytolaccaeae | √ | × |
| Paporomia | *Peperomia pellucid* | Piperaceae | × | √ |
| Heru | *Protium sanguisorba* | Rosaceae | √ | × |
| Bon dhone | *Eryngium foeridum* | Umbelliferae | √ | √ |
| Haruta | *Oreocnide integrifolia* | Utricaceae | √ | × |
| Ban halud | *Curcuma aromatica* | Zingiberaceae | √ | √ |

Note: √ = presence; × = absence

families were represented by single species each. Study revealed that 10 species such as *Cichorium endivia, Argyreia splendens*, *Axonopus variegate*, *Imperata arundinaceae*, *Phaseolus aconotifolius, Sanseviera trifasciata*, *Pavonia odorata, Mollugo hirta, Eryngium foeridum* and *Curcuma aromatica* were common in both types of forests. But, 11 species namely, *Achyranthes aspera, Colocasia esculenta, Doemia extensa, Bothriospermum tenellum, Eupatorium odoratum, Thysalonema maxima, Mimosa pudica, Papaver somniferum, Rivinia humilis, Protium sanguisorba and Oreocnide integrifolia were* reported only in natural forest. *Costus speciosus* and *Peperomia pellucid* were identified in plantation forest only (Table 3).

## Diversity indices of plant species of natural forest and plantations of the study area

Table 4 illustrates the Shannon-Wiener diversity index and the Jaccard's similarity index of plantation forest and natural forest of the study area. The Shannon-Wiener diversity index is the most widely used species diversity measure. A rich ecosystem with high species diversity has a large value for the Shannon-Wiener diversity index (H), whereas an ecosystem with little diversity has a low H. With regard to the tree species, Shannon-Wiener diversity index of natural forest was 2.70, while it was 2.35 for plantation forest. Regarding shrub species, Shannon-Wiener diversity index was 2.72 in natural forest and 2.31 in plantation forest. With respect to the

**Table 4.** Diversity indices of plant species of natural and plantation forest of the study area

| Diversity index | Tree | | Shrub | | Herb | |
|---|---|---|---|---|---|---|
| | Natural | Plantation | Natural | Plantation | Natural | Plantation |
| Shannon- Wiener index | 2.70 | 2.35 | 2.72 | 2.31 | 3.12 | 2.81 |
| Jaccard's similarity index | 0.71 | | 0.44 | | 0.43 | |

herb species, Shannon- Wiener diversity index were 3.12 and 2.81 in natural and plantation forest respectively. Therefore, natural forest of the study area was more diverse than plantation forest. Although the Shannon-Wiener diversity index provides us with method of quantifying the degree to which species in a community are represented, the Jaccard's similarity index allows us to quantify the degree of overlap between the species in the two communities. The lower the values of the similarity index, the higher the heterogeneity. Jaccard's similarity index were 0.71 for trees, 0.44 for shrubs, and 0.43 for herb species in the study site. Result demonstrated that 71% tree species was common between natural and plantation forest. In case of shrubs, 44% species were overlapped between plantation and natural forest. Concerning herbs, 43% species was similar to both types of forests. So, composition of plant species was varied between the two forests.

## DISCUSSION

Distinguishing plant communities has been at the centre of plant science for centuries, with a traditional focus on the distribution, composition and classification of plant communities (Kashian *et al*., 2003). Plant communities are differentiated from each other based on indicator species in combination with a distinctive floristic composition. The latter is considered as one of the major distinguishing characters of a community (Dansereau, 1960). In the study area, there were some species those occurred either in plantation forest or natural forest only and constituted different species composition. Plantation forest of the study site was comparatively undisturbed than natural forest. Natural forest was disturbed by illegal felling and cattle grassing. These disturbances may play a role to the higher richness of natural forest than plantations. Mishra *et al*. (2004) reported that moderately or slightly disturbed tropical forests tend to support more number of species in comparison with a forest which is dense and undisturbed. Though the diversity of trees was higher in natural forest but, density of tree species was higher in the plantation forest than natural forest. Plantation was carried out by 2 m × 2 m spacing, while natural forest represented irregular and scattered distribution of tree species. Light intensity is correlated with the tree density of any forest. Lower number of trees facilitate more open place in the forest area and forest ground receive more sunlight. Richness and abundance of understorey vegetation are dependent upon the amount of light available. Shrub and herb species diversity were higher in the natural forest than plantation forest. The reason behind this may be due to the availability of more light in natural site than plantations. Uemura (1994) reported that the species diversity of understorey vegetation in different environments vary with light condition. Dense shade creates a photosynthetically inactive light regime at the ground level (Fetcher *et al*., 1983; Turton and Duff, 1992). It was also found that the basic difference between the richest and poorer understorey communities at a wooded meadow site in Estonia is the degree of light penetration through the vegetation (Kull and Zobel, 1991).

## CONCLUSION

One of the most universal features of natural systems is that species richness, the number of different species co-occurring in a given area, varies enormously from place to place. Species richness may differ substantially between areas with comparable environments. In the

study site, differences were observed in the number of tree, shrub and herb species, families and vegetation composition between plantations and natural forest. In the plantation forest, richness of tree species is regulated by the management authority. They select the species according to their management objectives, site suitability and associate species. Lower density of tree species in the natural forest contributes to the higher richness of shrubs and herbs. Several herbs and shrubs were restricted only to natural forest of the study site. Management with care in the study area may lead one of the biodiversity richest areas of the country.

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