EFFECTS OF MANAGEMENT PRACTICE ON THE COMMUNITY COMPOSITION AND SPECIES DIVERSITY OF SAL (*Shorea robusta* GAERTN.) FOREST AT COMILLA

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Abstract

The effect of management practice on the community composition, phytosociological characters and species diversity of Comilla Sal forest at two different locations, viz. Kotbari and Rajeshpur Eco-parks were studied from June 2014 to May 2015. Three visits were made during the work and quadrat-methods were followed. The phytosociological data were qualitatively and quantitatively analyzed to work out the important value index (IVI), diversity, species richness and evenness. The Kotbari Sal forest was represented by 65 species among them 18 were trees, 10 shrubs, 31 herbs and six climbers. The species belonged to 63 genera under 29 families. Dioscoreaceae was the dominant family consisting of five spp. On the other hand, 21 species of trees, eight shrubs, 23 herbs and seven climbers, i.e. 59 species under 49 genera and 26 families were recorded in the Rajeshpur Sal forest. In the Kotbari location, the maximum IVI was 62.77 in *Microcos paniculata* L. The IVI of *Shorea robusta* (Gaertn.) was 17.22, 14.62 and 8.57 during June, December 2014 and May 2015, respectively. In the Rajeshpur, the maximum IVI was 48.58 also in *M. paniculata* which is till now forming a middle canopy and *S. robusta* is only the dominating canopy cover. The Rajeshpur Sal forest exhibited highest overall Shannon-Weaver diversity index (H=4.219) during second visit (winter). The species richness index (D) showed quadratwise differences in both the locations during first visit. The overall D-value was much higher in Rajeshpur (12.333) than that of Kotbari area (9.152) during the first visit, but the overall D-value of Kotbari was higher (18.461) than that of Rajeshpur (15.464) during the third visit. The analysis revealed that the Sal forest of Rajeshpur is important ecosystem by virtue of high species diversity due to adequately managed as Eco-park and the Kotbari area needs management attention to protect its diversity.

Key words: Management practice, species diversity, Kotbari, Rajeshpur Eco-park, Sal forest.

INTRODUCTION

The rich deciduous forest dominated by Sal is now represented by a secondary formation in small to medium patches in the districts of Comilla, Gazipur, Tangail, Sherpur, Jamalpur, Rajshahi, Naogaon, Dinajpur and Rangpur of Bangladesh. The Sal forests of Rajshahi, Naogaon, Dinajpur and Rangpur are considered as dry deciduous forest and the rest as wet deciduous forest. The structure and composition of forests are strongly related to the climate and topography (Schall and Pinaka 1978, Currie 1991). Phytosociological analysis helps in understanding the structure and composition of plant communities (Braun-Blanquet 1965). Quantitative inventories also help in the identification of the species of special concern, i.e. rare, endangered, endemic, threatened or vulnerable species (Keel *et al*. 1993) and thus have enormous implications in the conservation and management of tropical forests (Campbell 1994).

Species diversity consists of two related components, viz. species richness and relative abundance/dominance/equitability. Species richness is easy to measure but it is important to state the area sampled (Wratten and Fry 1980, Krebs 1972). However, the knowledge on the structure, composition or dynamics of tropical forests is still inadequate (Hubbell and Foster 1992). The effect of different management practices on the species composition, richness have not been studied in the context of Bangladesh although the Forest Department has been protecting the forests of the country in different ways, such as declaring different forests as Eco Park, National Park, Wild Life Sanctuary etc.

In the present work, the effect of management practice on the phytosociological characters and seasonal variations of the plant species of wet deciduous forest of Comilla district from two selected places at Kotbari and Rajeshpur situated in Sadar south thana has been described. The work also focused on the species richness, species diversity and evenness of the forests.

MATERIAL AND METHODS

Three visits were done from June 2014 to May 2015 in two locations, viz. Kotbari (23º25′19.12"N and 91º08′3.78"E) and Rajeshpur (23º21′12.81"N and 91º16′32.17"E) of Comilla district of Bangladesh. The Sal forest of Rajeshpur is well managed as it has been declared an Eco Park by the Bangladesh Forest Department. The stratified random sampling approach was followed for phytosociological survey. The sampling was done in all the strata, i.e. trees, shrubs and herbs, following Kushwaha and Nandy (2012). The size of the quadrat for sampling was determined by species-area-curve method (Mueller-Dombois and Ellenberg 1974, Misra 1968). Two to three $20\times20m^2$ quadrats for trees (≥30cm cbh) was laid at each sample site. In each quadrat, the circumferences at breast height (cbh) of Sal trees with ≥30cm were measured. A total of 4-6 plots were randomly laid in the Kotbari and Rajeshpur Sal forests in every sampling occasion. Five $1\times1m^2$ quadrats were established in each $20\times20m^2$ quadrat to study the shrub and herb vegetation. The field data were quantitatively analyzed for abundance, density and frequency (Curtis and McIntosh 1950, Ahmed *et al*. 2011) and importance value index (IVI) (Curtis 1959) for the trees, shrubs and herbs species. The species diversity of each site was determined using Shannon–Weaver Index (1949). Species richness index (d) was calculated according to Margalef (1951). The equitability or evenness (e) was calculated according to Pielou (1966).

To study the change in vegetation cover, Land SAT MSS and Land SAT TM images were studied for the last 38 years from 1972 to 2010. Land SAT MSS images with 60m resolutions were taken in 1972 (Fig. 1) and 1980 (Fig. 2) and Land SAT TM images with 30m resolutions were taken during 2000 (Fig. 1) and 2010 (Fig. 4). ARC View 9.1 software was used for line drawing, ARC GIS 10.1 was used for drawing the lines to estimate the area of the forested lands and ERDA program was used for image processing and ARC INFO 3.5 program was employed for editing the photos.

RESULTS AND DISCUSSION

The important value index (IVI) of two locations, viz. Kotbari and Rajeshpur Sal forests were studied in three seasons, i.e. rainy season (20th June 2014), winter (10th December 2014) and summer (29th May 2015). Kotbari location consisted of 65 species and Rajeshpur 59 species. Maximum IVI in case of both the locations was found in *Microcos paniculata* during winter season at the location of Kotbari and Rajeshpur and the values were 62.77 and 48.58, respectively (Table 1). On the other hand, the minimum IVI of both locations was found in *Eragrostis tennella*, *Glycosmis pentaphylla*, *Phyllanthus virgatus*, *Dioscorea glabra* and *Desmodium triflora* during summer at the same location (Kotbari) and the value was 1.397.

Phytosociology of Kotbari location

Shorea robusta trees and seedlings were found in all the seasons (Table 1). In June 2014, the maximum IVI was 41.89 in *M. paniculata* and minimum was 3.49 in *Careya arborea*. The IVI of *S. robusta* was 17.22. Intermediate IVI carrying species were Goli (28.1, local name), *Breynia retusa* (23.02), *Tabernaemontana divaricata* (23.47) and *Curcuma zedoaria* (14.31). In December 2014, the maximum IVI was 62.771 in *M. paniculata* and minimum 3.604 in *Commelina benghalensis*, *Aporosa* sp. and *Alstonia scholaris*. The IVI of *S. robusta* was 14.62. In May 2015, the maximum IVI was 49.40

in an unknown legume plant species and minimum 1.397 in *E. tennella, D. pentaphylla, P. virgatus, D. glabra,*and *D. triflora*. The IVI of *S. robusta* was 8.57.

Phytosociology of Rajeshpur location

Shorea robusta trees and more seedlings were also found to be present in all the seasons except one. The maximum IVI was 48.58 in *M. paniculata* and minimum was 2.12 which found in *Curcuma zedoaria* in respect to the three visits.

In June 2014, the maximum IVI was 48.58 in *M. paniculata* and minimum 3.21 in *Flemingia* sp. The IVI in *S. robusta* was 16.31. Intermediate IVI carrying species were *Melastoma malabathricum* (20.64), *T. divaricata* (17.94) and *Smilax macrophylla* (17.94). In December 2014, the maximum IVI was 31.23 in *Melastoma malabathricum* and minimum 2.579 in *Hopea odorata, Smilax* sp. and *Elaeocarpus sphaericus*. The IVI of *S. robusta* was 27.57. In May 2015, the maximum IVI was 27.41 in *M. paniculata* and minimum 2.208 in *Flemingia* sp., *Begonia* sp., *Acacia auriculiformis, Chukrasia tabularis, Phaseolus* sp. and *Butea monosperma* in the Rajeshpur location. The IVI in *S. robusta* was 18.78.

It is interesting to note that *M. paniculata* was found to be dominant in two locations in all the sampling occasions except May 2015 at Kotbari. Although it was found to be dominant, it is till now forming a middle canopy in the Sal forest of Comilla, and *S. robusta* is the only dominant canopy cover in all quadrats except one quadrat near the forest office of Rajeshpur where some planted tree species, viz. *Dipterocarpus turbinatus, Anacardium occidantale, Chukrasia tabularis* and *Acacia mangium* formed the higher canopy. Yousuf (1996) recorded almost similar IVI values of *S. robusta* in Chandra, Mouchak and Baraipara where the values were 14.787, 17.972 and 22.21, respectively. This area is included in the wet deciduous forest as the current forest. Kushwaha and Nandy (2012) found that *S. robusta* had highest IVI (150.31), followed by *Schima wallichii* (18.44) and *Terminalia bellirica* (10.12) in the moist Sal forests of West Bengal, India whereas in dry Sal forest *S. robusta* had an IVI value of 221.78.

Through the study of the Land SAT MSS and Land SAT TM images, it has been found that the forest land was 0.631 sq. km during 1972 (Fig. 1) and has been increased to 0.922 sq. km in 1980 (Fig. 2) 1.399 sq. km in 1989. But, area decreased afterward to 0.742 sq. km in 2000 (Fig. 3) and subsequently increased to 3.011 sq. km in 2010 (Fig. 4). It seems that the Sal forests of these locations need special management and conservation policy to maintain the current status.

The study revealed interesting information on the community structure and diversity in Kotbari and Rajeshpur Sal forests of Comilla. The Shannon-Weaver index of diversity showed higher values in Rajeshpur location than in Kotbari Sal forests (Tables 1 and 2). Rajeshpur Sal forests exhibited the highest overall Shannon-Weaver diversity index (H=4.219) during second visit (winter) (Table 2). However, quadrat 3 of Rajeshpur location also showed the lowest Shannon-Weaver diversity index (H=0.65) (Table 2) during third visit (summer). This is a planted area with some naturally growing species.

During the first visit, Shannon-Weaver diversity index was 3.68 in Kotbari location at quadrat one and the value was 3.63 in quadrat two where the overall H was 3.16 (Table 2). Relatively lower H value was observed during winter (second visit) with H=3.08 in quadrat one and H=3.46 in quadrat two. But, the overall value was high, H=3.85 (Table 2).

Although the number of species was higher during the third visit among the three visits in Kotbari location, the Shannon-Weaver diversity index values were not so high in the three quadrats studied. The H value for quadrat one was 3.59 whereas the values were 2.97 and 3.29 in quadrat two and three, respectively. The overall H was 3.89 (Table 2).

Table 1. Phytosociological analysis (Importance Value Index, IVI) of Comilla Sal forest (- =not present).

Species names ↓ / Visit →	Kotbari No. of individuals			Rajeshpur No. of individuals			Kotbari IVI			Rajeshpur IVI		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Acacia auriculiformis A.Cunn. *ex* Benth & Hook.	8		5	1	2	1	10.799	-	2.492	3.211	3.196	2.208
Acacia mangium Wild.	-	-	-	-	-	4	-	-	-	-	-	3.994
Albizia procera (Roxb.) Benth.	-	-	-	5	4	-	-	-	-	5.242	4.432	-
Alstonia scholaris (L.) R. Br.	-	1	1	-	-	-	-	3.604	1.397	-	-	-
Amen (local name)	-	-	-	-	6	-	-	-	-	-	6.501	-
Angelonia grandiflora Morr.	-	-	-	5	5	4	-	-	-	5.242	5.05	3.994
Aphanamixis polystachya (Wall.) R. N. Parker	5	-	-	-	-	-	7.696	-	-	-	-	-
Aporosa dioicai Muell. Arg.	-	-	1	-	-	-	-	-	1.397	-	-	-
Aporosa sp.	-	-	3	-	-	-	-	3.604	1.944	-	-	-
Axonopus compresus P. Beauv.	-	30	10	-	-	4	-	22.55	3.859	-	-	3.994
Axonopus sp.	-	2	10	-	-	-	-	4.43	4.078	-	-	-
Begonia sp.	-	-	8	-	-	1	-	-	3.712	-	-	2.208
Bonnogach (local name)	-	-	-	20	-	-	-	-	-	12.86	-	-
Breynia retusa (Dennst.) Alston	25	-	-	11	32	-	23.020	-	-	10.99	21.73	-
Butea monosperma (Lamk.) Taub.	-	-	-	-	-	1	-	-	-	-	-	2.208
Canscora diffusa G. Don.	-	-	1	-	-	-	-	-	1.397	-	-	-
Careya arborea Roxb.	1	-	1	8	4	8	3.490	-	1.397	9.468	5.641	6.374
Cassia fistula L.	1	-	-	-	-	-	3.490	-	-	-	-	-
Chukrasia tabularis A. Juss.	3	-	-	-	-	1	5.593	-	-	-	-	2.208
Clerodendrum viscoum Vent.	-	2	8	-	-	-	-	4.43	4.594	-	-	-
Clynogyne dichotoma (Roxb.) Salis ex Benth.	-	-	-	-	5	-	-	-	-	-	6.071	-
Commelina benghalensis L.	-	1	5	-	-	-	-	3.604	3.163	-	-	-
Curcuma zedoaria (Christm.) Rosc.	13	5	10	10	26	44	14.310	8.388	4.078	7.781	15.1	20.12
Curculigo orchioides Gaertn.	-	-	1	-	-	-	-	-	1.397	-	-	-
Cyperus articulatus L.	-	-	3	-	-	-	-	-	2.796	-	-	-
Desmodium gangeticum (L.) DC.	1	-	2	-	-	50	3.490	-	1.671	-	-	23.69
Desmodium pulchelum (L.) Benth.	3	-	-	7	5	4	7.055	-	-	8.961	7.719	6.228
Desmoidium triflorum (L.) DC.	-	-	1	-	-	-	-	-	1.397	-	-	-
Dioscorea alata L.	-	15	7	-	-	16	-	14.05	3.039	-	-	9.773
Dioscorea belophylla Voigt *ex* Haines	5	11	7	15	-	-	8.507	11.79	3.529	10.32	-	-
Dioscorea bulbifera L.	1	-	-	14	25	30	3.490	-	-	9.813	17.41	19.47
Dioscorea glabra Roxb.	-	-	1	-	-	-	-	-	1.397	-	-	-
Dioscorea pentaphylla L.	-	-	16	12	-	-	-	-	5.501	8.797	-	-
Dipterocarpus turbinatus Roxb.	-	-	-	3	4	4	-	-	-	4.226	5.641	3.994

Elaeocarpus angustifolius Blume	-	-	-	1	-	-	-	-	-	3.211	-	-
Elaeocarpus sphaericus (Gaertn.) K. Schum.	-	-	-	-	1	-	-	-	-	-	2.579	-
Elephantopus scaber L.	-	-	6	-	-	-	-	-	3.346	-	-	-
Eragrostis tenella L.	-	-	1	-	-	-	-	-	1.397	-	-	-
Erythrina variegata L.	3	-	-	-	-	-	5.593	-	-	-	-	-
Eupatorium cannabinum auct. *non* L., Hook. f.	-	-	-	5	-	-	-	-	-	5.242	-	-
Eupatorium foeniculaceum Willd	-	-	2	10	-	-	-	-	1.671	7.781	-	-
Euphorbia sp.	-	-	1	-	-	-	-	-	1.397	-	-	-
Euphorbiaceae	-	-	-	-	-	1	-	-	-	-	-	2.208
Euphorbiaceae (Yellow flower)	-	-	2	-	-	-	-	-	1.671	-	-	-
Flemingia sp.	-	-	-	1	3	1	-	-	-	3.211	5.212	2.208
Fodickila (Local name)	20	15	-	-	-	-	19.390	15.17	-	-	-	-
Gentaniaceae (herb)	-	-	10	-	-	-	-	-	3.859	-	-	-
Glycosmis pentaphylla A. DC.	-	-	1	-	-	-	-	-	1.397	-	-	-
Goli (Local name)	32	-	-	-	-	-	28.100	-	-	-	-	-
Poaceae	-	-	1	-	-	-	-	-	1.397	-	-	-
Hemidesmus indicus (L.) R. Br.	-	-	-	-	-	3	-	-	-	-	-	3.398
Holarrhena pubescens Wall. *ex* G. Don.	-	-	3	-	-	-	-	-	2.796	-	-	-
Hopea odorata Roxb.	-	-	1	2	1	2	-	-	1.397	3.718	2.579	2.803
Hordeum vulgare L.	-	-	-	4	3	-	-	-	-	4.734	3.814	-
Asclepiadaceae	-	-	1	-	-	-	-	-	1.397	-	-	-
Ixora coccinea L.	7	-	-	-	-	9	9.958	-	-	-	-	6.97
Justicia gendarussa Burm. f.	-	3	6	-	-	-	-	7.255	3.346	-	-	-
Murraya sp.	-	-	-	-	-	1	-	-	-	-	-	2.208
Leea crispa L.	-	-	2	2	10	12	-	-	1.671	3.718	8.139	8.755
Lygodium sp.	-	10	18	-	-	14	-	11.22	5.543	-	-	9.7
Macaranga peltata (Roxb.) Muell.-Arg.	-	28	177	-	-	-	-	21.42	30.44	-	-	-
Mallotus philippensis Muell.-Arg.	-	-	-	-	-	5	-	-	-	-	-	4.589
Mangifera sylvatica Roxb.	-	-	-	-	1	1	-	-	-	-	3.706	2.208
Melastoma malabathricum L.	5	5	2	30	69	9	8.507	6.909	1.671	20.64	31.23	7.964
Meliaceae	-	-	1	-	-	-	-	-	1.397	-	-	-
Microcos paniculata L.	51	101	88	85	16	65	41.890	62.77	16.83	48.58	10.8	27.41
Microcos sp.	-	-	25	-	-	-	-	-	7.963	-	-	-
Morinda angustifolia Roxb.	9	23	45	-	10	24	11.410	18.58	10.25	-	8.221	13.05
Mycnia (local name)	-	-	4	-	-	-	-	-	2.218	-	-	-
Norcha (local name)	4	-	-	-	-	-	6.645	-	-	-	-	-
Phaseolus sp.	-	-	-	-	-	1	-	-	-	-	-	2.208
Phaulopsis imbricata (Forssk.) Sweet	-	-	120	-	-	-	-	-	33.95	-	-	-
Phyllanthus reticulatus Poir.	-	-	-	-	-	10	-	-	-	-	-	7.565
Phyllanthus emblica L.	-	-	-	12	-	-	-	-	-	8.797	-	-

Phyllanthus virgatus Forst. f.	6	-	1	-	15	6	9.232	-	1.397	-	10.37	5.681
Randia dumetorum (Retz.) Lam.	1	-	-	5	22	7	3.490	-	-	5.242	13.38	5.779
Rubiaceae	-	-	1		-	-	-	-	1.397	-	-	-
Rutaceae	-	-	4	-	-	-	-	-	2.218	-	-	-
Samanea saman (Jack.) Merr.	1	4	-	-	-	-	3.490	6.083	-	-	-	-
Shorea robusta Roxb. *ex* Gaertn.f.	17	16	34	18	55	38	17.220	14.62	8.570	16.31	27.57	18.78
Smilex macrophylla Roxb.	5	8	5	30	1	5	7.696	10.09	3.163	17.94	2.579	5.272
Solka (local name)	-		-	15	10	-	-	-	-	10.32	8.139	-
Stephania glabra Miers.	-	13	18	-	-	-	-	12.92	6.123	-	-	-
Stephania japonica (Thunb.) Miers	-	-	-	-	4	11	-	-	-	-	4.432	7.727
Syzygium balsameum Walp.	-	-	-	-	2	-	-	-	-	-	4.782	-
Syzygium fruticosum DC.	1	4	5	-	2	5	3.490	5.044	3.163	-	3.196	4.589
Tabernaemontana divericata (L.) R. Br. ex Roem. & Schult.	20	15	12	30	16	12	23.470	15.17	4.444	17.94	10.8	8.136
Terminalia catappa L.	-	-	-	1	-	-	-	-	-	3.211	-	-
Tiliaceae	-	-	-	-	-	7	-	-	-	-	-	5.779
Triumfetta rhomboidea Jacq.	-	8	20	10	17	7	-	9.388	6.429	7.781	11.23	5.779
Unknown 1	-	-	-	-	-	4	-	-	-	-	-	4.863
Unknown 2	-	-	-	-	-	2	-	-	-	-	-	2.803
Unknown 3	-	5	-	-	-	-	-	6.909	-	-	-	-
Unknown 4	-	-	5	-	-	-	-	-	3.163	-	-	-
Unknown 5	-	-	-	-	29	-	-	-	-	-	19.88	-
Unknown 6	-	-	23	-	-	-	-	-	6.888	-	-	-
Unknown 7	-	-	301	-	-	-	-	-	49.40	-	-	-
Unknown 8	-	--	30	-	-	-	-	-	9.331	-	-	-
Verbinaceae	-	-	2	-	-	3	-	-	1.671	-	-	3.398
Vitaceae	-	-	1	-	-	-	-	-	1.397	-	-	-
Ziziphus sp.	-	-	-	6	-	-	-	-	-	8.453	-	-
Ziziphus rugosa Lamk.	1	-	-	7	4	11	3.490	-	-	6.258	4.432	7.727

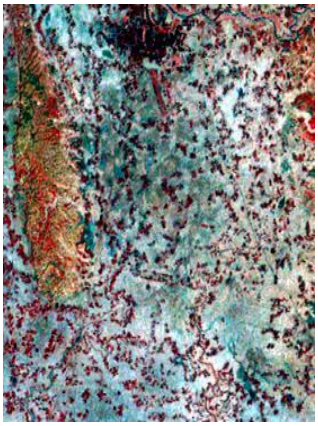

Fig. 1. LAND SAT MSS image (28 December 1972)

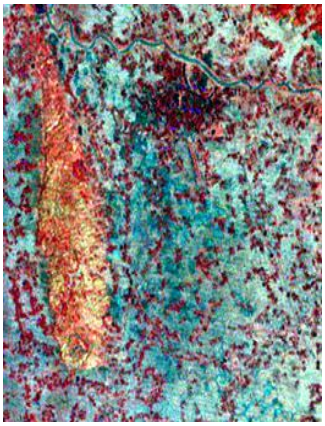

Fig 2. LAND SAT MSS image (15 January 1980)

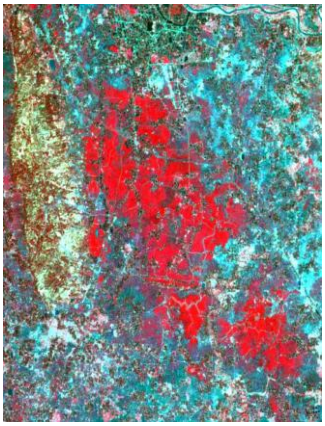

Fig. 3. LAND SAT TM image (28 February 2000)

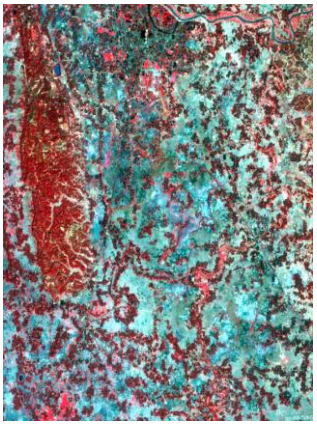

Fig. 4. LAND SAT TM image (20 January 2010)

On the other hand, during the first visit the H value for quadrat one and two (Planted area) in the Rajeshpur location were 3.88 and 2.33, respectively with an overall value at 4.21 (Table 2). During the second visit, the H value for quadrat one, two and three in Rajeshpur location was 4.006, 1.99 and 2.608 (Planted area), respectively with an overall value at 4.219 (Table 2). During the third visit, relatively lower value of the H values were found in quadrat one, two and three in Rajeshpur location, 2.45, 2.26 and 0.65 (Planted area), respectively with an overall value at 2.19 (Table 2).

Table 2. The Shannon-Weaver diversity index (H), the species richness index (d) and the evenness index (Equitability index, e) of the two Sal forest of Kotbari and Rajeshpur.

Visits	Stands	Quadrats	H	d	e
1st	Kotbari	1	3.675	8.828	2.825
		2	3.63	9.836	2.745
		overall	3.16	11.677	2.6869
	Rajeshpur	1	3.883	9.06	2.852
		2	2.329	6.286	2.329
		overall	4.214	11.603	2.8256
2nd	Kotbari	1	3.083	8.346	2.37
		2	3.461	7.488	2.813
		overall	3.849	9.152	2.789
	Rajeshpur	1	4.006	10.34	2.831
		2	1.995	7.362	1.657
		3	2.608	4.928	2.733
		overall	4.219	12.233	2.779
3rd	Kotbari	1	3.59	12.682	2.407
		2	2.97	9.301	2.181
		3	3.29	12.857	2.131
		overall	3.892	18.461	2.217
	Rajeshpur	1	2.45	9.986	1.775
		2	2.26	13.444	1.767
		3	0.651	9.046	0.509
		overall	2.194	15.464	1.352

On the other hand, during the first visit the H value for quadrat one and two (Planted area) in the Rajeshpur location were 3.88 and 2.33, respectively with an overall value at 4.21 (Table 2). During the second visit, the H value for quadrat one, two and three in Rajeshpur location was 4.006, 1.99 and 2.608

(Planted area), respectively with an overall value at 4.219 (Table 2). During the third visit, relatively lower value of the H values were found in quadrat one, two and three in Rajeshpur location, 2.45, 2.26 and 0.65 (Planted area), respectively with an overall value at 2.19 (Table 2).

The species richness index (d) showed quadrat wise differences in both the locations during first visit although overall values in the two locations were almost the same (Table 2). Although lower value of species richness index (d) in different quadrats was found in Rajeshpur area during second visit, the overall d-value was much higher in Rajeshpur (12.333) than that of Kotbari area (9.152). Overall d-value of Kotbari was higher (18.461) than that of Rajeshpur (15.464) during the third visit with the different values of quadrats were also comparably higher than the Kotbari area. The evenness index (Equitability index, e) was almost similar (1.657 to 2.825) (Table 7) during all visits in all quadrats in two locations except the value for Rajeshpur area. The e-value ranged from 0.509 to 1.775 in Rajeshpur location (Table 2).

Taxonomic diversity

The Kotbari Sal forest is represented by 65 species among them 18 were trees, 10 shrubs, 31 herbs and 6 climbers, which belonged to 29 families and 63 genera. The family Dioscoreaceae was the dominant family consisting of 5 spp., followed by Fabaceae (4 spp.) and the rest of the families contained single genus represented by single species found in the location of Kotbari. On the other hand, 21 trees, 8 shrubs, 23 herbs and 7 climbers, i.e. 59 species belonging to 26 families and 49 genera were recorded in the Rajeshpur Sal forest. In the Rajeshpur Sal forest 49 genera consisted of single species each. Yousuf (1996) recorded only 22, 21 and 33 species in Chandra, Mouchak and Baraipara stand, respectively in the Chandra forest of Gazipur district. Kushwaha and Nandy (2012) showed that plant richness and diversity in the moist sal forests of the northern West Bengal of India were higher than the dry sal forests of south-west Bengal; a total of 134 tree (cbh C30 cm), 113 shrub and 230 herb species were recorded in the moist sal forest compared to 35 tree, 41 shrub and 96 herb species in the dry sal forest.

In the Kotbari location, 29 species of 26 genera belonging to 17 families were found in the month of June 2014. Euphorbiaceae (4 spp.) and Dioscoreaceae (3 spp.) were the dominant families, 8 genera consisted of single species (Table 1). During the second visit (December 2014), 24 species of 22 genera in 15 families were observed. Euphorbiaceae (2 spp.), Poaceae (2 spp.), Apocynaceae (2 spp.) and Dioscoreaceae (2 spp.) were found the dominant families and 10 genera consisted of single species each (Table 1). In May 2015, 57 species of 50 genera in 25 families were found. Euphorbiaceae (5 spp.) and Dioscoreaceae (4 spp.), Apocynaceae (3 spp.) and Asteraceae (3 spp.) were the dominant families, 14 genera consisted of single species in the Kotbari location (Table 1).

In the Rajeshpur location where 31 species of 27 genera under 20 families were found in the month of June 2014 where Fabaceae (5 spp.), Dipterocarpaceae (3 spp), Dioscoreaceae (2 spp.) and Tiliaceae (2 spp.) were the dominant families, 10 genera consisted of single species (Table 1). During the second visit (December 2014), 33 species of 31 genera in 18 families were observed. Fabaceae (4 spp.), Dioscoreaceae (2 spp.), Dipterocarpaceae (2 spp.), Tiliaceae (2 spp.) was the dominant families and 11 genera consisted of single species (Table 1). In May 2015, 42 species of 38 genera in the 22 families were found. Fabaceae (7 spp.) following Rubiaceae (3 spp.), Tiliaceae (3 spp.) and Dioscoreaceae (2 spp.) were the dominant families, 19 genera consisted of single species (Table 1).

Although the forests of both Chandra and Comilla of Bangladesh are considered as moist Sal forest, they exhibit a very low species richness and diversity than the wet, even than the dry sal forests of North Bengal of India. Changes in diversity and community pattern in relation to the degree of disturbance were studied by Pandey and Shukla (1999). Shankar (2001) studied phytosociological attributes in a sal-

dominated lowland forest of eastern Himalaya. In a recent study using remote sensing, GIS and field investigations, Nayak (2007) reported high biological richness in moist and low biological richness in dry sal forests in India. Shannon–Weaver index of diversity also showed higher values in moist sal than in dry sal forests (Kushwaha and Nandy 2012). Species diversity is an important attribute of a natural community that influences functioning of an ecosystem (Hengeveld 1996). High species content per unit area is largely due to the presence of synusiae in the forest (Richards 1996). Greater diversity leads to higher community stability (MacArthur 1955). Gentry (1995) has observed that the neotropical deciduous forests are dominated by the family Leguminosae followed by Bignoniaceae, as in Indian deciduous forests (Sukumar *et al.* 1992, Murali *et al.* 1996, Shankar *et al.* 1998).

The ever-increasing anthropogenic pressure continues to degrade the natural forest patches of the country in spite of the forest laws and some conservation and management policies. The analysis revealed that the Sal forest of Rajeshpur is important ecosystem by virtue of high species diversity. The same in the Kotbari sal forest is low due to high disturbance. As evident from the present study, the Sal forests in Kotbari need protection for recovery. In fact, the patches of Sal at Rajeshpur are adequately protected as Eco Park, have shown good diversity.

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