Natural Regeneration Potential of Native Tree Species in Dudhpukuria-Dhopachori Wildlife Sanctuary of Chittagong, Bangladesh

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Abstract

Natural regeneration status of native tree species in Dudhpukuria-Dhopachori Wildlife Sanctuary (DDWS) in Chittagong South Forest Division, Bangladesh was assessed through stratified random sampling method. A total of 120 tree species belonging to 36 families were recorded from 125 plots of 5 m x 5 m in size. Moraceae and Euphorbiaceae families were represented by maximum number (11) of species, where maximum individuals (378) no. were recorded for Dipterocarpaceae family from the sampled area (0.3125 ha). Family Relative Density (FRD), Family Relative Diversity (FRDI) and Family Importance Value (FIV) index of the regenerating tree species were highest for Dipterocarpaceae (15.59%), Moraceae (9.17%) and Euphorbiaceae (20.5) family respectively. *Dipterocarpus turbinatus* was represented by maximum seedlings per hectare (1078) followed by *Grewia nervosa* (464) and *Aporosa wallichii* (464). Seven biological diversity indices were also calculated which ensures promising regeneration status of DDWS. Percentage distribution of seedlings of all species was maximum (80.62%) for the height range of 0-50 cm. Number of seedlings were found to reduce proportionately with height growth that indicates poor recruitment of the seedlings in the Wildlife Sanctuary area. However, *Artocarpus chama* was found to show maximum (8.91%) seedling recruitment percentage. Considering the findings, it is emphasized the need of a management plan based on natural regeneration potential for the effective functioning of Dudhpukuria-Dhopachori Wildlife Sanctuary.

সারসংক্ষেপ

বাংলাদেশের চট্টগ্রাম দক্ষিণ বন বিভাগের দুধপুকুরিয়া-ধোপাছড়ি বন্যপ্রাণী অভয়ারণ্যের দেশীয় বৃক্ষ প্রজাতির প্রাকৃতিকভাবে জন্মানো চারাসমূহের অবস্থান (Status) স্তরভিত্তিক (Stratified) দৈবচয়ন পদ্ধতিতে গণনা করা হয়েছে। ৫ মি. x ৫ মি. আয়তনের ১২৫টি প্লটে ৩৬ পরিবারের মোট ১২০টি বৃক্ষ প্রজাতি সনাক্তকরণ করা হয়। মোরেসি এবং ইউফরবিয়েসি পরিবার সবচেয়ে বেশী প্রজাতি (১১টি প্রজাতি) প্রদর্শন করে, যেখানে সার্ভেকৃত এলাকায় (০.৩১২৫ হে.) ডিপটেরোকারপেসি পরিবারে চারার সংখ্যা ছিল সবচেয়ে বেশি (৩৭৮)। দুধপুকুরিয়া-ধোপাছড়ি বন্যপ্রাণী অভয়ারণ্যে ডিপটেরোকারপেসি (১৫.৫৯%), মোরেসি (৯.১৭%) এবং ইউফরবিয়েসি (২০.৫%) পরিবারে প্রাকৃতিকভাবে জন্মানো বৃক্ষ প্রজাতিসমূহের যথাক্রমে পরিবার আপেক্ষিক ঘনত্ব (FRD), পরিবার আপেক্ষিক বৈচিত্র্য (FRD) এবং পরিবার গুরুত্ব নির্দেশক মান (FIV) সবচেয়ে বেশী পাওয়া গেছে। *Dipterocarpus turbinatus* এ চারা পাওয়া গেছে হেক্টর প্রতি সবচেয়ে বেশি সংখ্যক (১০৭৮), পরবর্তী অবস্থানে রয়েছে *Grewia nervosa* (৪৬৪) এবং *Aporosa wallichii* (৪৬৪)। তাছাড়া, সাতটি জীববৈচিত্র্য নির্দেশক তালিকা হিসেব করা হয়েছিল যা দুধপুকুরিয়া-ধোপাছড়ি বন্যপ্রাণী অভয়ারণ্য এলাকায় বৃক্ষ

প্রজাতির প্রাকৃতিক পুনর্জন্মের ভাল অবস্থান নির্দেশ করে। অন্যদিকে, ০-৫০ সে.মি. উচ্চতার মধ্যে সকল প্রজাতির অনুপাতিক চারার সংখ্যা সবচেয়ে বেশী (৮০.৬২%) ছিল। উচ্চতা বৃদ্ধির সাথে সাথে চারা সংখ্যা আনুপাতিক হারে কমে গেছে যা কম সংখ্যক চারার পরবর্তী ধাপে উন্নীত হওয়া নির্দেশ করে। যাহোক, *Artocarpus chama* প্রজাতিতে সবচেয়ে বেশি সংখ্যক (৮.৯১%) প্রতিষ্ঠিত চারা পাওয়া গেছে। গবেষণা ফলাফল বিবেচনা করে বলা যায় যে, দুধপুকুরিয়া-ধোপাছড়ি বন্যপ্রাণী অভয়ারণ্যটির কার্যকর উন্নয়নের জন্যে প্রাকৃতিক পুনর্জন্মের সম্ভাবনার উপর গুরুত্বারোপ করে এর ব্যবস্থাপনা পরিকল্পনা (Management plan) প্রণয়ন করা প্রয়োজন।

Keywords: Biodiversity indices, Diversity indices, Dudhpukuria-Dhopachori, Natural regeneration, Wildlife Sanctuary.

Introduction

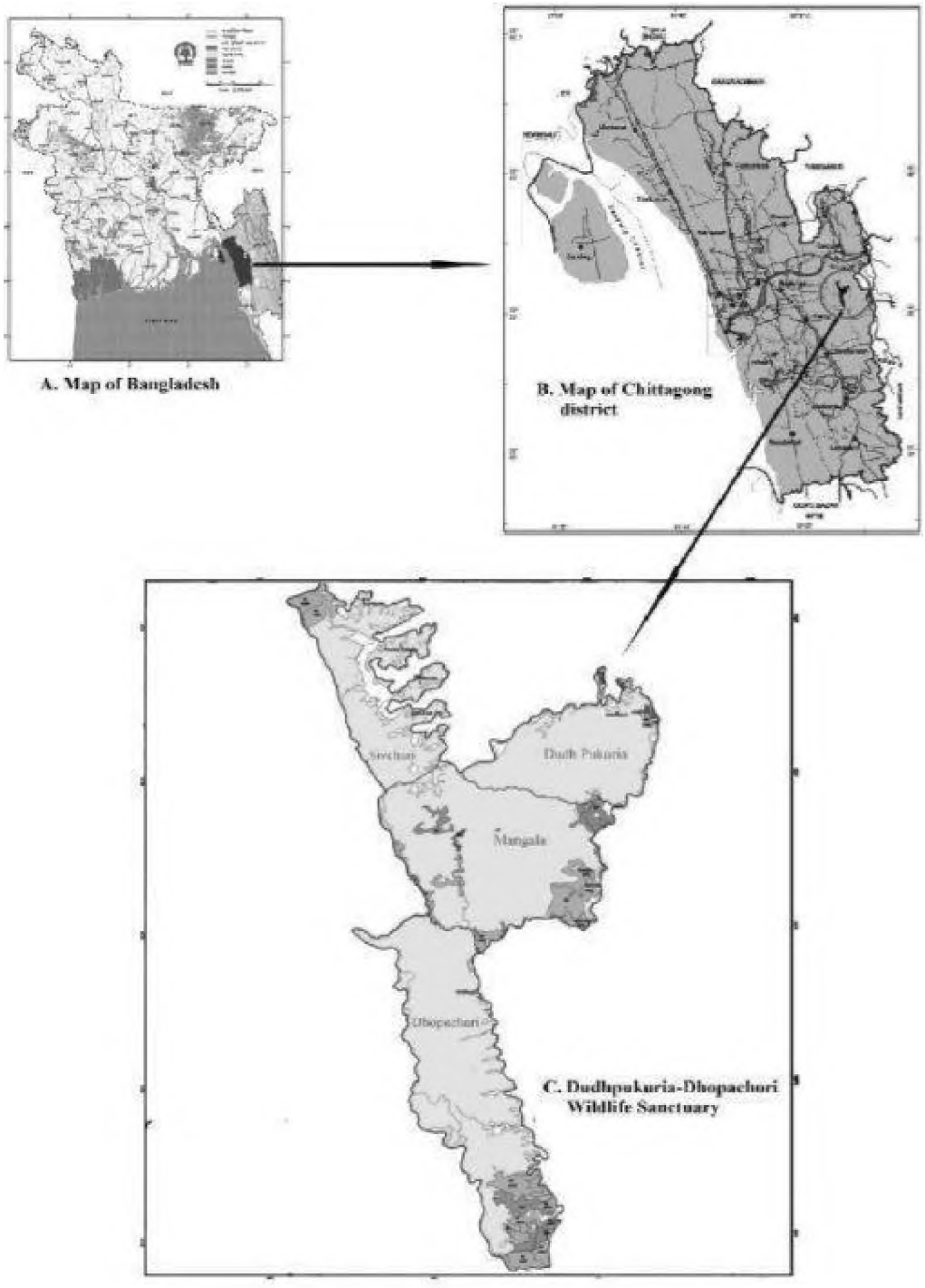
Natural regeneration of plant species is essential for preservation and maintenance of biodiversity (Hossain *et al.* 2004). Natural regeneration ensures maintenance and expansion of plant population of an area in time and space. It is a complex ecological process in an ecosystem involving dispersal of germs, reproduction and establishment of seedlings in relation to environmental factors (Barnes *et al.* 1998). Physical and biotic factors of regeneration along with disturbance regimes strongly influence regeneration process, species abundance and status of plant species. The dynamics of soil seed banks, seedlings of forest vegetation and population structure are most important parameters of natural regeneration. Knowledge of plant regeneration status helps in developing management strategies and setting priorities (Zegeye *et al.* 2011).

The total forest area of Bangladesh is 1.442 mha and natural forests cover 1.204 mha (Altrell *et al.* 2007). The natural forests passed through severe biotic and abiotic interferences in the last decades due to population pressure, inappropriate and inadequate management practices and land use changes (Khan *et al.* 2008). Till now the vegetation resources, including forests, are being destroyed at an alarming rate (Muhammed *et al.* 2008). In such circumstances, regeneration of forest crops by appropriate artificial or natural process is of prime importance in protecting forests flora and maintaining sustainability of yield of forest goods and services (Haque and Alam 1988). In Bangladesh, studies that focused on the natural regeneration status in different natural forests provide potential information on regeneration status of many native plant species, which are important for management and conservation programs (Hossain *et al.* 1999, Miah *et al.* 1999, Hossain *et al.* 2004, Motaleb and Hossain 2007, Rahman *et al.* 2011). But, there is no such information about the newly declared Dudhpukuria-Dhopachori Wildlife Sanctuary which is essential for its improvement and sustainable management. Hence, the present study was conducted to assess the regeneration composition, status and diversity of dominant tree species occuring in the natural ecosystem of Dudhpukuria-Dhopachori Wildlife Sanctuary.

Materials and Methods

Study area

Dudhpukuria-Dhopachori Wildlife Sanctuary (DDWS) covering 4,716.57 ha area is situated at the south of Rangunia upazila in Chittagong district and in the border of Chittagong, Bandarban and Rangamati districts. It lies between 22°09' to 22°22' north



Map 1 : Map showing the location of the study area

latitude and 92°05′ to 92°10′ east longitudes and divided into three beats namely Dudhpukuria (830 ha), Kamalachori (891 ha) and Dhopachori (2996 ha). The Wildlife Sanctuary is comprised of hill and hillocks (about 80% of total area) and plain lands (about 20% of total area) covered with forests and grasses and crisscrossed by numerous creeks (Map 1). The climate of this area is typically subtropical. The average annual rainfall is 2200-3400 mm and maximum rainfall occurs in June to September. Soil of the area is sandy loam and mostly suitable for regeneration and plant growth. Previously the forest possessed rich, well stratified and dense vegetation, but the forest is depleted continuously as a result of illegal and overexploitation of forest resources. Till now it inhibits a better patch of forest vegetation and wildlife in comparison to other Protected Areas (PAs) of Bangladesh.

Field survey methods

A stratified random quadrate method was used to determine the regeneration status of the tree species of Dudhpukuria-Dhopachori Wildlife Sanctuary. Sample plots were selected for all the aspects and slopes of the hills in the three beats. 125 sample plots of size 5 m x 5 m (31 from Dudhpukuria, 31 from Kamalachori and 63 sample plots from Dhopachori beat) were taken for the regeneration survey during January 2011 to May 2012. The seedlings were identified by local people in the field and authenticated with the help of taxonomists in the Department of Botany, Chittagong University and Bangladesh Forest Research Institute (BFRI). The seedlings were counted by species and their height was measured.

Data analysis

The Relative Density, Relative Frequency, Relative Abundance and Importance Value Index (IVI) were calculated according to the methods of Shukla and Chandal (2000), Odum (1971), Michael (1990), Kent and Coker (1992), Pielou (1966) and Magurran (1988). The following equations were considered for calculation of the diversity indices.

Species diversity index, $S_{Di} = S/N$

Margalef's index, $R = (S-1)/Ln(N)$

Shannon-Wiener's diversity index, $H = \sum_{i}^{n=1} P_i \ln P_i$

Shannon's maximum diversity index, $H_{max} = Ln(S)$

Species evenness index, $E = H/Ln(S)$

Simpson's diversity index, $D = \sum_{i}^{n=1} P^2$

Dominance of Simpson index, $D' = 1-D$

Family relative density, $F_d(\%) = N_f/T_i \times 100$

Family relative diversity, $F_r(\%) = N_s/T_s \times 100$

Here, S = Total number of species,

N = Total number of individuals of all the species,

H = Shannon-Wieneris diversity index,

P_i = No. of individuals of one species ÷ Total no. of individuals in all the samples

N_f = No. of individuals in a family

T_i = Total No. of individuals

N_s = No. of species

T_s = Total number of species

Results and Discussion

Natural regeneration status

A total of 2,425 seedlings of 120 species belonging to 36 families were recorded from the 125 sample plots of Dudhpukuria-Dhopachori Wildlife Sanctuary. 36% families were represented by only one species and 42% by more than three species. Euphorbiaceae and Moraceae families were represented by maximum 11 species. Highest Family relative density (FRD) was found for

Table 1. Species and seedlings number, FRD (%), FRDI (%) and FIV index of different family for regeneration in Dudhpukuria-Dhopachori Wildlife Sanctuary

Family	Species (No.)	Seedlings (No.)	FRD (%)	FRDI (%)	FIV
Alangiaceae	1	4	0.16	0.83	1.00
Anacardiaceae	5	28	1.13	4.17	5.32
Apocynaceae	3	55	2.27	2.50	4.77
Arecaceae	3	17	0.70	2.50	3.20
Bignoniaceae	3	44	1.81	2.50	4.31
Bombacaceae	1	7	0.29	0.83	1.12
Burseraceae	2	111	4.58	1.67	6.24
Caesalpiniaceae	4	20	0.82	3.33	4.16
Clusiaceae	1	80	3.30	0.83	4.13
Combretaceae	2	49	2.02	1.67	3.69
Datiscaceae	1	2	0.08	0.83	0.92
Dilleniaceae	1	24	0.99	0.83	1.82
Dipterocarpaceae	5	378	15.59	4.17	19.8
Ebenaceae	1	2	0.08	0.83	0.92
Elaeocarpaceae	3	22	0.91	2.50	3.41
Euphorbiaceae	11	264	10.89	9.16	20.1
Fabaceae	2	4	0.16	1.67	1.83
Fagaceae	4	154	6.35	3.33	9.68
Flacourtiaceae	1	46	1.90	0.83	2.73
Lauraceae	5	141	5.81	4.17	9.98
Lythraceae	2	16	0.66	1.67	2.33
Meliaceae	4	34	1.40	3.33	4.74
Mimosaceae	5	48	1.98	4.17	6.15
Moraceae	11	206	8.49	9.17	17.7
Myristacaceae	1	3	0.12	0.83	0.96
Myrsinaceae	1	8	0.33	0.83	1.16
Myrtaceae	6	51	2.10	5.00	7.10
Rhizophoraceae	1	1	0.04	0.83	0.87
Rubiaceae	8	80	3.30	6.67	9.97
Rutaceae	4	63	2.60	3.33	5.93
Sapindaceae	1	15	0.62	0.83	1.45
Sonneratiaceae	1	1	0.04	0.83	0.87
Sterculiaceae	4	105	4.33	3.33	7.66
Tiliaceae	4	159	6.56	3.33	9.89
Ulmaceae	1	1	0.04	0.83	0.87
Verbenaceae	7	182	7.51	5.83	13.3

Dipterocarpaceae (15.59%) followed by Euphorbiaceae (10.89%), Moraceae (8.49%) and Verbenaceae (7.51%) family. Moraceae (9.17%) showed highest family relative diversity index (FRDI) followed by Euphorbiaceae (9.16%), Rubiaceae (6.67%) and Verbenaceae (5.83%). Maximum Family Importance Value (FIV) index was found for Euphorbiaceae (20.1%) followed by Dipterocarpaceae (19.8%), Moraceae (17.7%) and Verbenaceae (13.3%). Rhizophoraceae, Sonneratiaceae, and Ulmaceae showed the lowest (0.67) FIV index. Species and seedlings number FRD, FRDI and FIV value of the 36 families found in Dudhpukuria-Dhopachori Wildlife Sanctuary are presented in Table 1.

Number of naturally regenerating species

Among the 120 regenerating plant specis the highest number of seedlings per hectare were found 1078 for *Dipterocarpus turbinatus* followed by *Grewia nervosa* (464), *Aporosa wallichii* (464) and *Lithocarpus acuminata* (445). The lowest number of seedlings per hectare (3.2 seedlings/ha) was found for *Anisoptera scaphula*, *Carallia brachiata*, *Duabanga grandiflora*, and *Trema orientalis*. Maximum relative density (13.90%) was calculated for *Dipterocarpus turbinatus* followed by *Aporosa wallichii* (5.98%), *Grewia nervosa* (5.98%) and *Lithocarpus acuminata* (5.73%). Maximum relative frequency (5.30%) was found for *Grewia nervosa* and *Aporosa wallichii* followed

Table 2. Seedling per hectare, relative density (RD), relative frequency (RF), relative abundance (RA) and Importance Value Index (IVI) of 30 dominant regenerating plants in DDWS.

Scientific Name	Seedling/ha	RD (%)	RF (%)	RA (%)	IVI
Acronychia pedunculata	154	1.98	2.55	0.74	5.28
Actinodaphne angustifolia	198	2.56	2.74	0.89	6.19
Antidesma bunius	58	0.74	0.95	0.75	2.44
Aphanamixis polystachya	58	0.74	1.14	0.63	2.50
Aporosa wallichii	464	5.98	5.30	1.08	12.36
Artocarpus chama	202	2.60	2.74	0.91	6.25
Artocarpus lacucha	157	2.02	2.46	0.79	5.27
Callicarpa arborea	61	0.78	0.95	0.79	2.52
Cryptocarya amygdalina	99	1.28	1.61	0.76	3.65
Dillenia scabrella	77	0.99	1.61	0.59	3.19
Dipterocarpus costatus	122	1.57	0.57	2.64	4.78
Dipterocarpus turbinatus	1,078	13.90	1.23	10.81	25.94
Ficus hispida	96	1.24	1.32	0.89	3.46
Garcinia cowa	256	3.30	3.12	1.01	7.43
Garuga pinnata	58	0.74	1.04	0.68	2.47
Glochidion multiloculare	99	1.28	1.89	0.65	3.82
Grewia nervosa	464	5.98	5.30	1.08	12.36
Holarrhena antidysenterica	138	1.77	1.89	0.9	4.56
Hydnocarpus laurifolius	147	1.90	1.70	1.07	4.67
Lithocarpus acuminata	445	5.73	5.01	1.09	11.84

Scientific Name	Seedling/ha	RD (%)	RF (%)	RA (%)	IVI
Litsea glutinosa	131	1.69	2.37	0.68	4.74
Protium serratum	298	3.84	3.22	1.14	8.19
Pterospermum semisagittatum	198	2.56	2.08	1.18	5.81
Sterculia foetida	90	1.15	1.32	0.83	3.31
Stereospermum colais	102	1.32	1.61	0.78	3.71
Tarenna campaniflora	118	1.53	1.80	0.81	4.14
Terminalia bellirica	112	1.44	2.27	0.61	4.32
Trewia nudiflora	51	0.66	0.66	0.95	2.28
Vitex peduncularis	362	4.66	3.60	1.24	9.49
Vitex pinnata	93	1.20	1.04	1.10	3.34

by *Lithocarpus acuminata* (5.01%) and *Vitex peduncularis* (3.60%). The highest relative abundance was found for *Dipterocarpus turbinatus* (10.81%) followed by *Syzygium tetragonum* (2.71%) and *Dipterocarpus costatus* (2.64%). The maximum Importance Value Index (IVI) was calculated for *Dipterocarpus turbinatus* (25.94) followed by *Aporosa wallichii* (12.36), *Grewia nervosa* (12.36), *Lithocarpus acuminata* (11.84) and *Vitex peduncularis* (9.49). Seedlings per hectare, RD, RF, RA, Importance Value Index (IVI) of 30 dominant regenerating plants in DDWS are given in Table 2.

Biological diversity indices

Different biological diversity indices, e.g. Species diversity index (S_{DI}), Margalef's index (R), Shannon-Winner diversity index (H), Shannon's maximum diversity index (H_{max}), Species evenness index (E), Simpson index (D) and Dominance of Simpson index

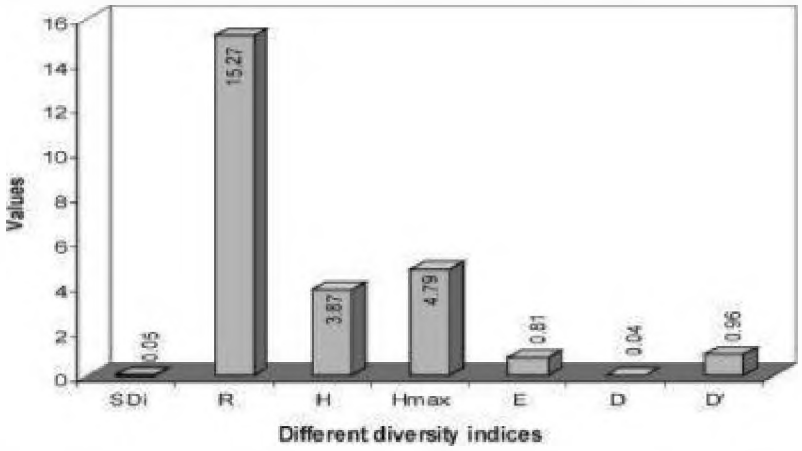


Figure 1. Different biological diversity indices for plant regeneration in DDWS

[Here, S_{DI} = Species diversity index, R = Margalef's index, H = Shannon-Winner diversity index, H_{max} = Shannon's maximum diversity index, E = Species evenness index, D = Simpson index and (D' = Dominance of Simpson index].

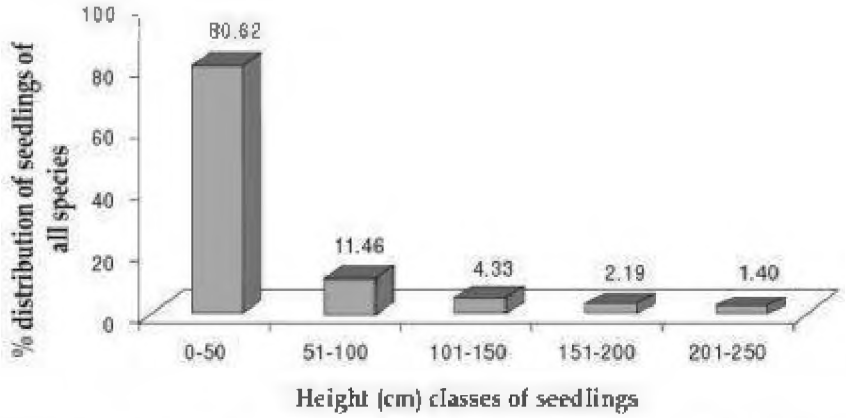


Figure 2. Percentage distribution of all the seedlings into different height (cm) classes

(D') were explored for Dudhpukuria-Dhopachari WS to depict natural regeneration status of recorded plant species (Figure 1). Margalef's index (15.269) for the regenerating species indicated higher species richness in DDWS (Margalef 1958). On the other side species diversity index (0.049) and Shannon-Winner's diversity index (3.865) revealed higher diversity in regenerating plant species. Less variation in the plant community was also revealed by higher value of species evenness index (0.807 out of 1). There were no single dominant regenerating plant species as represented by Simpson's dominance index (0.041). The different diversity indices of the regenerating plants are represented in figure 1.

Distribution of seedlings in different height classes

Plants below 251 cm in height were considered as seedling. The percentage (%) distribution of all seedlings of all species into five height (cm) classes is shown in Figure 2. It was found that maximum (80.62%) seedlings were within the height range of 0-50 cm, whereas, only 1.40% seedlings were

Table 3. Stock of 10 major dominating seedlings with their stems per hectare showing recruitment percentage at DDWS

Scientific Name	Tree stems/ha	Seedlings/ha	% Recruitment
Artocarpus chama	18	202	8.91
Lithocarpus acuminata	22	445	4.94
Aporosa wallichii	21	464	4.53
Grewia nervosa	19	464	4.09
Protium serratum	12	298	4.03
Vitex peduncularis	11	362	3.04
Pterospermum semisagittatum	5	198	2.53
Dipterocarpus turbinatus	26	1078	2.41
Actinodaphne angustifolia	4	198	2.02
Garcinia cowa	5	256	1.95

found in 201-250 cm height range (Fig. 2). Poor survival of seedlings is the result of both biotic and abiotic disturbances.

Seedlings Recruitment Percentage

All the height classes seedlings are considered as recruit for the respective species. A comparison between the major dominating seedlings with the corresponding tree stems per hectare showed that *Artocarpus chama* had maximum 8.91% seedlings recruitment percentage followed by *Lithocarpus acuminata* (4.94%) and *Aporosa wallichii* (4.53%). The stocking of the 10 major dominating seedlings with their stems per hectare is given in Table 3.

Information on regeneration potential leads to conservation measures of biological diversity (Verma *et al.* 1999). It is an important indicator for evaluating overall condition of forest ecosystem (Rahman *et al.* 2011). There is scarce information on the regeneration status of native species of DDWS. In the present study, 120 regenerating tree species belonging to 36 families were recorded and the number of species is much higher than earlier reports on similar natural forests of Bangladesh. Hossain *et al.* (2004) recorded 64 regenerating tree species in natural forests of Chittagong (South) Forest Division. Alamgir and Al-Amin (2007) reported 39 species under 18 families from a proposed biodiversity conservation area namely Bamerchara and Danerchara of Chunuti Wildlife Sanctuary, Chittagong, Bangladesh. Molaleb and Hossain (2007) reported 29 regenerating tree species under 16 families from a semi-evergreen forest of Chittagong (South) Forest Division. Rahman *et al.* (2011) found 55 regenerating plant species in Khadimnagar National Park and Tilagor Eco-Park. The higher regeneration status of DDWS may be the result of minimum human interferences and fire hazards as the Government strengthened conservation programs of the wildlife sanctuary in recent years. This may be the main reason of higher number of seedlings in the initial stages of seedling development.

Euphorbiaceae, Dipterocarpaceae, Moraceae and Verbenaceae showed higher regeneration potential due to maximum seed dispersal capability, and favorable conditions prevailing for natural regeneration. The forest was previously known as Dipterocarp forest because of the dominance of *Dipterocarpus alatus, D. costatus, D. turbinatus* and *Hopea odorata* in Dudhpukuria-Dhopachori Wildlife Sanctuary. The dominant regeneration of *D. turbinatus, Grewia nervosa, Aporosa wallichii, Lithocarpus acuminata* and *Vitex peduncularis* were found. This was due to their profuse seed production and convenient environmental conditions for regeneration success. Seedlings of *Acacia auriculiformis, Gmelina arborea* and coppice shoots of *Tectona grandis* were also recorded from the plantations raised by Forest Department.

The diversity indices of the present study show more promising regeneration in DDWS in comparison to the diversity indices reported by Rahman *et al.* (2011) from biodiversity conservation areas of northeastern Bangladesh. They reported 0.01 for Species diversity index, 4.92 for Species richness index, 3.62 for Shannon-Winner diversity index, 3.69 for Shannon's maximum diversity index, 0.98 for Shannon's equitability index, 2.26 for Species evenness index, 0.03 for Simpson index and Dominance of Simpson index was 0.97.

The DDWS forest is in a high risk of deforestation and degradation as many forest dependent local communities are residing around the forest. But recent co-management initiatives and conservation programs with the participation of local people are seems to be good initiatives in biodiversity conservation programs of the Wildlife Sanctuary. Results of the present study

acquaint an over-view of regeneration status of DDWS. It is obvious that the forest possess much higher regeneration potential for many economic and ecologically important tree species. But till now there are many causes prevailing that may be destructive to the occurrence and establishment of natural regeneration of DDWS. So, the Protected Area (PA) authority should be careful in implementing the conservation measures and should enhance more effective co-management and protection programs involving local people to ensure effective conservation of the Wildlife Sanctuary.

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