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Composition and Diversity of Tree Species in Kamalachari Natural Forest of Chittagong South Forest Division, Bangladesh

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Abstract

Information on plant diversity and community structure are required to chalk out necessary actions for conservation management. The present study assessed the composition and diversity of tree species in Kamalachari Natural Forest of Chittagong South Forest Division, Bangladesh, during April 2010 to November 2011. A total of 107 tree species belonging to 72 genera and 37 families were recorded, where Moraceae family was represented by maximum (11) species. Density, Basal area and volume of tree species were 418±20.09 stem/ha, 21.10±2.62 m^2/ha and 417.4±79.8 m^3/ha respectively. Diameter and height class distribution of tree species revealed an almost reverse J-shaped curve. Both the number of species and percentage of tree individuals were maximum in the lower DBH and height ranges. Anthropogenic disturbances like illegal tree cutting, over extraction, settlement inside forest area etc. were noticed during the study, which are supposed to cause gradual decrease of both tree species and individuals in the higher DBH and height classes. However, *Artocarpus chama* was found dominant showing maximum IVI followed by *Schima wallichii*, *Aporosa wallichii*, and *Lithocarpus acuminata*. The quantitative structure of the tree species of Kamalachari natural forest is comparable to other tree species rich tropical natural forests. The findings of the study may help in monitoring future plant population changes of the identified species and adopting species specific conservation programs in Kamalachari natural forest.

Key Words: composition and diversity, importance value index, Kamalachari, structural composition, diameter class

Introduction

Natural forests of Bangladesh covering an area of 1.204 mha (Altrell et al. 2007) is classified into hill forests, sal forests and mangrove forests of Sundarban according to their distribution. Undisturbed natural hill forests of Bangladesh are generally uneven-aged and multi-storied (Alam 2008). During last few decades the whole natural forest structure of Bangladesh is negatively changed by both biotic and abiotic disturbances which ultimately affect the regeneration and population dynamics (Shaforth et al. 2002; Kwit and Platt 2003). Diameter distribution of trees has been often used to represent forest structure (Khan et al. 1987; Newton and Smith 1988). A clear understanding of forest stand parameters, i.e. DBH class distribution, height class distribution, stocking etc. are important for modeling future wood production of a forest. A description of the number of species, tree density, basal area and stock (volume) per hectare in a forest stand is important in order to compare it with a desired level for balanced forest health and growth. Conservation of the forest biodiversity is essential in Bangladesh as they are undergoing through severe deg-

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radation countrywide due to rapid population growth, poverty, inappropriate forest management system, over exploitation, energy deficit and lack of motivation regarding biodiversity conservation (Hassan 1995). In Bangladesh, the rapid loss and degradation of forests has brought about an alarming rate of forest biodiversity depletion (Rahman et al. 2000; Hossain 2001). Conservation of biological diversity to ensure their sustainable use, the fair and equitable sharing of benefits arising from the use of genetic resources and existence of complex ecosystem function is major aim of convention of biological diversity. Moreover, information on floristic composition, their quantitative structure and diversity is a vital for understanding the functioning and dynamics of forest ecosystems (Reddy et al. 2008).

Kamalachari Forest consists of naturally regenerated forests under Kamalachari beat (small administrative unit of Bangladesh Forest Department). The forest is of tropical evergreen and semi-evergreen type. Most of its forest patch is originated naturally; hence it is a natural forest according to the definitions of forests reported by FAO (2012). The Kamalachari natural forest in combination with two other forest beats of Chittagong South Forest Division is declared as Wildlife Sanctuary in 2010 (BFD 2014). As a part of a Wildlife Sanctuary its floral composition, structure and diversity is needed to be known for managerial decision making and development planning. In Bangladesh many researcher investigated plant species diversity and forest stand structure (Hossain et al. 1997; Rahman and Hossain 2003; Alamgir and Al-Amin 2005; Motaleb and Hossain 2011; Rahman et al. 2011; Hossain et al. 2012; Hossain et al. 2013). But, Kamalachari forest lacks information regarding structural composition, stocking and conservation issues of Kamalachari natural forests. Hence, the present study is conducted in Kamalachari natural forest of Bangladesh aiming to assess tree species composition, diversity, and structural composition based on DBH and height class distribution.

Materials and Methods

Study area

Kamalachari natural forest composed of reserve forests of Kamalachari beat under Dudhpukuria-Dhopachori Wildlife Sanctuary of Chittagong (South) Forest Division. The forest lies at south-eastern side of Bangladesh between 22°09' to 22°22' north latitude and 92°05' to 92°10' east longitudes along the borderline of Chittagong, Rangamati and Bandarban districts (Fig. 1). It covers an area of 891 ha (Feeroz et al. 2012). Major part of the forest is covered by natural forest. During the field data collection it was found that major plantation patches were composed of *Acacia auriculiformis*, *Gmelina arborea*, and *Tectona grandis*. These plantations were established in 2003 to 2007. Some valley and low laying areas were being encroached by surrounding inhabitants and are using the area for agro-faming. The whole forest area criss-crossed by numerous creeks, and is comprised of hills and hillocks (about 80% of total area) and plain lands (about 20% of total area) covered with forests and grasses (IRG 2012).

Field methods and data analysis

The field data collection was done during April 2010 to November 2011. Simple random sampling method was applied with the sample plot size of 20x20 m in the study area following Caratti (2006). A total of 31 sample plots were studied in order to survey 0.14% of the total forest area. The

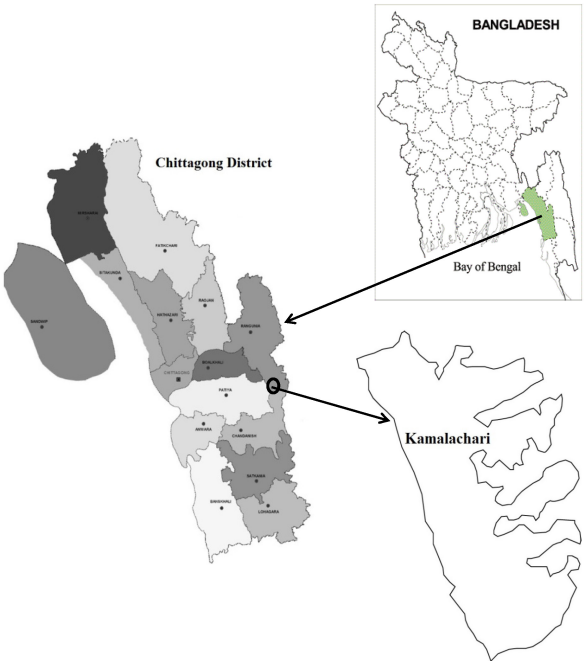

Fig. 1. Location map of Kamalachari natural forest in Chittagong district of Bangladesh.

tree species available in the plots were identified at species level in the field and herbarium specimens were prepared to identify the unknown plants. The unknown specimens were identified consulting with plant taxonomist and comparing with the authentic herbarium samples of Bangladesh Forest Research Institute (BFRI). Diameter at breast height (DBH), total height of the trees, number of tree individuals of each species in each sample plot were recorded. The data were then documented and analyzed to estimate tree diversity indices (i.e. Shannon's diversity index, Simpson's diversity index, Margalef's diversity index), stocking, structural composition and Importance Value Index (IVI) of the tree species of this area following Margalef (1958), Shannon and Wiener (1963), Shukla and Chandal (2000) and Simpson (1949). The following formulas were used to find out the Importance Value Index (IVI).

$$\text{Relative density} = \frac{Total\ No.\ of\ individuals\ of\ the\ species}{Total\ No.\ of\ individuals\ of\ all\ the\ species} \times 100$$

$$\text{Relative frequency} = \frac{Frequancy\ of\ one\ species}{Total\ frequency} \times 100$$

$$\text{Relative abundance} = \frac{Abundance\ of\ one\ species}{Total\ abundance} \times 100$$

$$\text{Relative dominance} = \frac{Basal\ area\ of\ one\ species}{Total\ basal\ area} \times 100$$

IVI=Relative density+Relative frequency+Relative dominance

Results

Tree species composition and density

The results revealed a total of 107 tree species belonging to 72 genera and 37 families were recorded from Kamalachari natural forests. Moraceae family was represented by maximum (11 species) number of species followed by Euphorbiaceae (9 species) and Meliaceae (6 species). Most common tree species were *Artocarpus chama*, *Schima wallichii*, *Lithocarpus acuminata*, *Dipterocarpus turbinatus*, *Aporosa wallichii* etc (Table 1). Stem density per hectare was found to be 418±20.09 stem/ha. Total Basal area and volume of all the recorded tree species were calculated as 21.10±2.62 m^2 and 417.4±79.8 m^3 respectively.

Table 1. List of the tree species recorded from Kamalachari natural forest

Sl. No.	Botanical Name Vernacular Name	Stem/ha
1	*Acronychia pedunculata* Jair-gola	3.23
2	*Actinodaphne angustifolia* Modonmesta, Chagolnadi	2.42
3	*Aglaia chittagonga* Thitpasing	1.61
4	*Alangium chinense* Marleza Gachh	2.42
5	*Albizia chinensis* Chakua Koroi	13.71
6	*Albizia odoratissima* Tetoya Koroi	1.61
7	*Albizia procera* Sada Koroi	4.84
8	*Alstonia scholaris* Chatim	2.42
9	*Anogeissus acuminata* Seori, Chakwa	1.61
10	*Aphanamixis polystachya* Pitraj, Royna	3.23
11	*Aporosa dioica* Harula	4.84
12	*Aporosa wallichii* Kokra, Castoma	16.94
13	*Artocarpous heterophyllus* Kanthal	0.81
14	*Artocarpus chama* Chapalish	33.87
15	*Artocarpus lacucha* Borta	8.06
16	*Bombax insigne* Bon shimul, Bon tula	1.61
17	*Bridelia retusa* Kata Kushui, Kata Koi	0.81
18	*Callicarpa arborea* Bormala, Khoja	12.1
19	*Carallia brachiata* Roscao	0.81
20	*Caryota mitis* -	1.61
21	*Chisocheton cumingianus* Kalikora, Rata	3.23
22	*Chukrasia tabularis* Chickrassi	0.81
23	*Cinnamomum iners* Tez-bohu	1.61

Table 1. Continued

Sl. No.	Botanical Name Vernacular Name	Stem/ha
24	*Cocos nucifera* Narikel	0.81
25	*Cryptocarya amygdalina* Oirga, Bhuiya Gachh	10.48
26	*Derris robusta* Jangaria, Jhamurja	0.81
27	*Dillenia scabrella* Hargeza	3.23
28	*Diospyros malabarica* Deshi gab	0.81
29	*Dipterocarpus alatus* Sada Garjan	1.61
30	*Dipterocarpus costatus* Baitta Garjan	0.81
31	*Dipterocarpus turbinatus* Tellia gorjon	14.52
32	*Duabanga grandiflora* Bandarhola	1.61
33	*Engelhardtia spicata* Jhumka bhadi	0.81
34	*Erythrina fusca* Panya Mandar	1.61
35	*Ficus auriculata* Baradumur, Battomeza	0.81
36	*Ficus benghalensis* Bot	1.61
37	*Ficus hispida* Dumur	8.06
38	*Ficus lamponga* Jig bot, Katgularia	2.42
39	*Ficus nervosa* Battrella, Panidumur	1.61
40	*Ficus racemosa* Jagyadumur	4.03
41	*Ficus semicordata* Chokorgola	1.61
42	*Ficus variegata* -	1.61
43	*Garcinia cowa* Kao	1.61
44	*Garcinia speciosa* Moigga Kao	0.81
45	*Garuga pinnata* Bhadi, Silbhadi, Jeolbhadi	7.26
46	*Glochidion multiloculare* Pannya Turi, Paniatori	2.42

Table 1. Continued

Sl. No.	Botanical Name Vernacular Name	Stem/ha
47	*Gluta elegans* Kabita	0.81
48	*Gmelina arborea* Gamar	2.42
49	*Grewia nervosa* Assar	12.1
50	*Grewia tiliifolia* Pholsa, Dhomoni	0.81
51	*Holarrhena antidysenterica* Kurchi, Kuruj	2.42
52	*Hopea odorata* Telsur	0.81
53	*Hydnocarpus laurifolius* Hiddigach	4.03
54	*Ilex godajam* Jangligewa, Raktim	0.81
55	*Lagerstroemia macrocarpa* Bansua Jarul, Mon Jarul	4.84
56	*Lagerstromia speciosa* Painna Jarul	3.23
57	*Licuala peltata* Chhata Pat, Kurud	5.65
58	*Lithocarpus acuminata* Kali Batna	16.94
59	*Lithocarpus elegans* Tal batna, Ramkota	2.42
60	*Lithocarpus pachyphylla* Kanta Batna, Gurja batna	2.42
61	*Lithocarpus polystachya* Sada Batna	4.84
62	*Macaranga denticulata* Bura	6.45
63	*Macaranga indica*	0.81
64	*Maesa indica* Romjani	1.61
65	*Magifera sylvatica* Uri-Am	0.81
66	*Mangifera indica* Am	0.81
67	*Mitragyna diversifolia* Phul Kadom	5.65
68	*Mitragyna parvifolia* Tobba, Phuti Kadom	5.65
69	*Mitragyna rotundifolia* Dakurum	1.61

Table 1. Continued

Sl. No.	Botanical Name Vernacular Name	Stem/ha
70	*Myristica linifolia* Am Barela	0.81
71	*Neolamarckia cadamba* Kadam	10.48
72	*Oroxylum indicum* Khona, Kanaidingi	1.61
73	*Persea bombycina* Sada modonmossol	0.81
74	*Phoenix sylvestris* Khejur	0.81
75	*Phyllanthus emblica* Amloki	2.42
76	*Phyllanthus reticulatus* Pankushi	0.81
77	*Protium serratum* Gotgutia	5.65
78	*Pterospermum acerifolium* Muli Udal	8.06
79	*Pterospermum semisagittatum* Lana-assar	4.03
80	*Sapium baccatum* Cham phata	5.65
81	*Schima wallichii* Konak	19.35
82	*Senna siamea* Minjiri	3.23
83	*Spondias pinnata* Bon-Amra	3.23
84	*Sterculia foetida* Baro Udal	2.42
85	*Sterculia hamiltonii* -	0.81
86	*Sterculia villosa* Chandul	1.61
87	*Stereospermum colais* Dharmara	4.03
88	*Steteospermum suaveolens* Silana	3.23
89	*Swintonia floribunda* Civit	2.42
90	*Syzygium cumini* Kalo Jam	1.61
91	*Syzygium firmum* Dhaki jam	0.81
92	*Syzygium syzygioides* Kharijam, Jonkijam	1.61

Table 1. Continued

Sl. No.	Botanical Name Vernacular Name	Stem/ha
93	*Syzygium tetragonum* Pholda jam	3.23
94	*Terminalia alata* Asal, Asma, Hasna	0.81
95	*Terminalia arjuna* Arjun	2.42
96	*Terminalia bellirica* Bohera	8.06
97	*Terminalia chebula* Haritaki	1.61
98	*Tetrameles nudiflora* Chandul	2.42
99	*Toona ciliata* Chondon Suruj	4.84
100	*Trema orientalis* Jiban, Naricha	0.81
101	*Trewia nudiflora* Pitali	1.61
102	*Vitex glabrata* Goda Arsol	2.42
103	*Vitex peduncularis* Goda	9.68
104	*Vitex pinnata* Goda Horina	7.26
105	*Walsura robusta* Bon Litchi	0.81
106	*Wrightia arborea* Dudhi, Dudh kurus	0.81
107	*Zanthoxylum rhetsa* Bajna, Bazinali	2.42

Structural composition based on DBH (cm) classes

Distribution of tree individuals among different DBH classes (Fig. 2) showed a reverse J-shaped curve, typical for most undisturbed tropical and temperate forests (Campbell et al. 1986; Rankin-de-Merona et al. 1992). It depicts progressive decline of tree individuals in larger tree size classes. The number of species and tree individuals was found to decrease continuously in the higher DBH classes with very little exception. The number of species, tree individuals and their percentage were maximum (88 species; 345 individuals and 66.02%) in 10.1-20 cm DBH range and minimum (7 species, 11 individuals and 2.12%) in >70 cm DBH range (Fig. 2). Number of species and tree in-

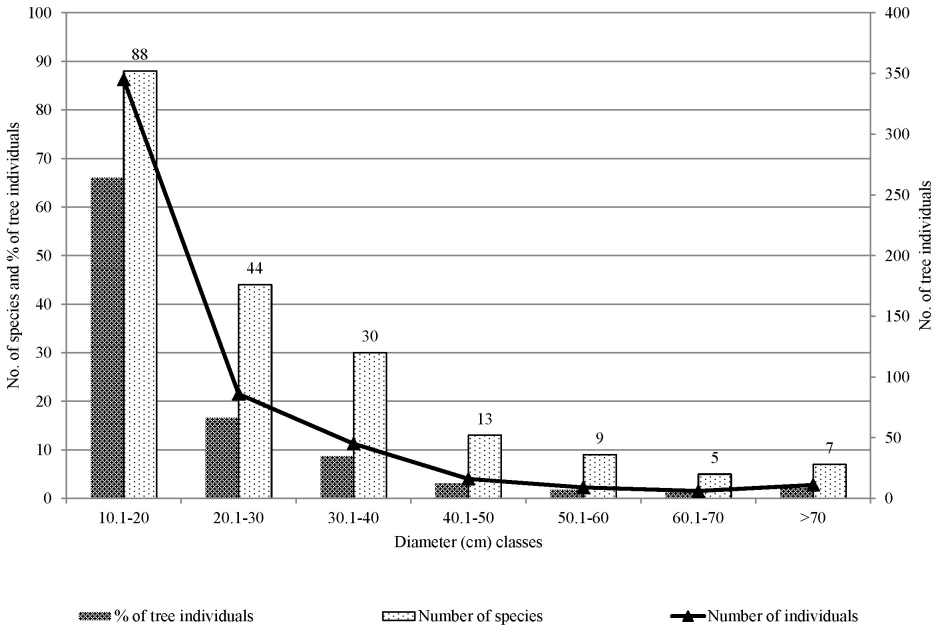

Fig. 2. Distribution of tree species, % of tree individuals and number of tree individual in different dbh (cm) classes of Kamalachari Natural Forest.

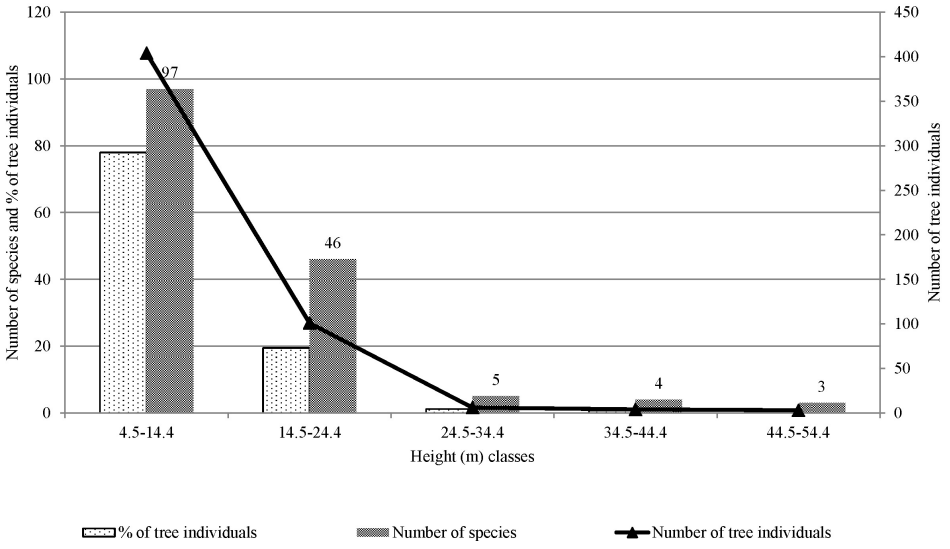

Fig. 3. Distribution of tree species, % of tree individuals and individual number in different height (m) classes of Dudhpukuria-Dhopachori wildlife sanctuary.

dividuals was decreased with the increase in DBH. It is because of the illegal felling of mature and economically important trees in the wildlife sanctuary area. The higher number of trees in lower size classes also indicates profuse natural regeneration and recruitment of the native tree species.

Structural composition of the tree species based on height classes

Distribution of tree individuals among different height classes showed a more or less reverse J-shaped curve that indicates presence of more or less stable population structure or good regeneration status (Zegeye et al. 2011). Patterns of height (m) class distribution designate general trends of population dynamics and recruitment process to the maximum species in Dudhpukuria-Dhopachori wildlife sanctuary. It is found that both the number of species and number of individual stem decreased regularly with the increase of total height (Fig. 3). The number of tree species,

tree individual percentage and their number were highest (97 species, 77.99%, 404 individuals) in the height range of 4.5-14.4 m. Height range 44.5-54.4 m was represented by the lowest number of tree species, tree individual number and their percentage (3 species, 3 individuals and 0.58%).

Importance Value Index (IVI) of the tree species

Importance Value Index (IVI) of the tree species were calculated combining their relative density, relative dominance and relative frequency. The study revealed that *Schima wallichii* was represented by highest (2.36 m^2) basal area, and maximum (9.03%) relative dominance. Maximum tree density (33.87 stem/ha) was found for *Artocarpus chama* followed by *Schima wallichii* (19.35 stem/ha) and *Aporosa wallichii* (16.94 stem/ha). *Artocarpus chama* and *Dipterocarpus turbinatus* were represented by maximum Relative Frequency (4.53%) and maximum Relative Abundance (2.15%) respectively. *Artocarpus chama* was found to be mostly dominating species of that area as it showed maximum (20 out of 300) IVI followed by *Schima wallichii* (17.06 out of 300), *Aporosa wallichii* (11.19 out of 300), and *Lithocarpus acuminata* (9.99 out of 300) (Table 2).

Discussion

The present study revealed that Kamalachari natural forest as a diverse and well stratified one representing 107 tree species. The results may be influenced due to sampling methodology, geographical location, edaphic and climatic condition of the study area when compared with other tropical forests. The composition (107 tree species under 82 genera and 37 families) is quite greater than 85 tree species reported from Bamu reserve forest of Cox's Bazar (Hossain et al. 1997); 92 tree species from Chunati wildlife sanctuary (Rahman and Hossain 2003); 102 tree species from Boroitoli forest (Rahman et al. 2004); 62 tree species from Tankawati natural forest (Motaleb and Hossain 2011); 77 tree species from Dudhpukuria Natural forest (Hossain et al. 2012). But, it is quite lower in comparison to the 153 tree species reported from tropical forests of Eastern Ghats India (Reddy et al. 2011); 162 tree species from primary forests of Garo Hills, India (Kumar et al. 2006). Stem density of 418±20.09 stem/ha is higher than 369 stem/ha reported by Hossain et al. (1997); 376 stem/ha by Wale et al. (2012). The density is very close to Rahman

Table 2. Basal area (BA), relative density (RD), relative frequency (RF), relative abundance (RA), relative dominance (RDo) and Importance Value Index (IVI) of 20 most dominant tree species in Kamalachari Natural Forest

Local Name	BA (m)	RD (%)	RF (%)	RA (%)	RDo (%)	IVI
Albizia chinensis	0.27	3.28	1.70	2.03	1.04	6.02
Albizia procera	0.54	1.16	1.42	0.86	2.05	4.62
Aporosa wallichii	0.90	4.05	3.68	1.16	3.45	11.19
Artocarpus chama	1.93	8.11	4.53	1.89	7.36	20
Artocarpus lacucha	0.27	1.93	2.27	0.90	1.01	5.21
Callicarpa arborea	0.22	2.90	1.70	1.80	0.84	5.44
Cryptocarya amygdalina	1.19	2.51	1.98	1.33	4.53	9.02
Dipterocarpus alatus	2.08	0.39	0.57	0.72	7.94	8.89
Dipterocarpus turbinatus	0.47	3.47	1.70	2.15	1.81	6.99
Garuga pinnata	0.64	1.74	1.70	1.08	2.43	5.87
Grewia nervosa	0.61	2.90	3.12	0.98	2.32	8.33
Lithocarpus acuminata	0.66	4.05	3.40	1.26	2.54	9.99
Neolamarckia cadamba	0.23	2.51	1.42	1.87	0.88	4.80
Pterospermum acerifolium	0.20	1.93	2.55	0.80	0.77	5.25
Schima wallichii	2.36	4.63	3.40	1.44	9.03	17.06
Swintonia floribunda	1.37	0.58	0.57	1.08	5.24	6.39
Syzygium tetragonum	0.86	0.77	1.13	0.72	3.30	5.20
Terminalia bellirica	0.51	1.93	2.27	0.90	1.95	6.14
Vitex peduncularis	0.17	2.32	1.70	1.44	0.64	4.66
Vitex pinnata	0.33	1.74	1.70	1.08	1.26	4.70

et al. (2000) 459 stem/ha; Shukla and Pandey (2000) 484 trees/ha. The basal area of Kamalachari is 21.10±2.62 per m^2/ha which is higher than 16.88 m^2 ha^{-1} Rahman et al. (2000), but it is lower than that of 47.02-62.16 m^2/ha (Motaleb and Hossain 2011).

Maximum number of species (88) and percentage of tree individuals (66.02%) was found in the DBH range of 10.1-20 cm, where DBH range of 20.1-<30 cm possess both highest (58 species) number of species and percentage (29.69 %) of tree individuals in Tankawati Natural Forest Reserve of Chittagong (South) Forest Division, Bangladesh (Motaleb and Hossain 2009). Ahmed and Haque (1993) reported number of stems (257 stems/ha) showing highest (30.53%) distribution in 30-39 cm DBH class from the natural forests of Bangladesh. Comparing to the above studies, Kamalachari natural forest possesses a regular trend of population dynamics and recruitment processes of the species. Some species having higher number of individuals in the lower DBH classes indicate that they have satisfactory regeneration potential. The plant species which possess either no or poor number of individuals in the lower DBH classes indicate that they have poor regeneration and recruitment.

Bhuju and Yonzon (2009) studied height classes of some tree species. They reported height class distribution of *Shorea robusta*, *Schima wallichii*, *Terminalia alata* in a dynamic landscape of the Churiya, eastern Nepal, where, all the three species were found in highest frequency within 4-10 m height range. The height class distribution of Kamalachari showed the natural forest is vertically well stratified. *Dipterocarpus alatus*, *D. costatus*, *Swintonia floribunda*, *Artocarpus chama*, and *Syzygium tetragonum* were dominated in the upper canopy. Below the upper canopy *Lithocarpus acuminata*, *Artocarpus lacucha*, *Grewia nervosa*, *Macaranga denticulata*, *Protium serratum*, *Schima wallichii*, *Vitex peduncularis* appeared as the pre-dominant tree species. The forest of this region was known as "Garjan (*Dipterocarpus* spp.) forest" because, several *Dipterocarpus* spp. were dominant in this forest. Severe deforestation, over-exploitation and human settlement at the adjacent forest areas in the past decades caused reduced population of dominant trees in the upper canopy. After declaring the area as Wildlife Sanctuary protection measures of this forest was enhanced.

The study showed that, the most dominant 10 species have 34.67% of the total IVI (104 out of 300). The dominant tree species of Kamalachari, i.e. *Artocarpus chama*, *Schima wallichii*, and *Aporosa wallichii* are similar to that of Dudhpukuria Natural Forests of Chittagong (Hossain et al. 2012); and Chunati Wildlife Sanctuary, Bangladesh (Rahman et al. 2000). Tree species composition with different IVI represent Kamalachari as a diversified natural forests of Chittagong South Forest Division.

Conclusion

The study revealed Kamalachari natural forest as a land of diverse tree species, moderately dense and stratified tree populations. The forest plays important role from both ecological and economic considerations. It provides food and habitat for the available wildlife (i.e. Asian elephant); fuel wood, construction material, bamboo, timber, farm implements, medicinal plants, animal fodder, bee forage, edible fruits etc. for the surrounding local people. Forests are degrading and shrinking day by day worldwide. Alike the world forest, flora of Kamalachari natural forests is under threat of over extraction and illegal cutting which in future may reduce their population density drastically. Such detrimental interferences must be stopped immediately otherwise those will make it more fragmented and reduce natural forest restoration capacity. The ecologically important plant species may be conserved through both *in situ* and *ex situ* conservation methods. The composition and quantitative information of the tree species will be helpful to the policy makers, conservationists and management planners in formulating and implementing future forest resource conservation of Kamalachari natural forest.

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