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Tree diversity and vegetation structure of the tropical evergreen forests of the southern slopes of Meghalaya, North East India

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Abstract. *Tynsong H, Dkhar M, Tiwari BK. 2022. Tree diversity and vegetation structure of the tropical evergreen forests of the southern slopes of Meghalaya, North East India. Asian J For 6: 22-33.* In the tropical evergreen forests of the southern slopes of Meghalaya, North East India, we examined the plant species diversity and community structure of woody plant species. The forests chosen for this study represent the area's primary vegetation. We counted a total number of 6016 individual trees belonging to 146 species, 95 genera, and 56 families from three 1-ha plots. The Shannon-Wiener Index (H') of the tree species in the three forest stands ranged from 3.74 to 3.95, the dominance of Simpson's index from 0.02 to 0.04, the evenness index from 0.68 to 0.83, and Margalef index range from 23.07 to 27.39. The density of woody species ranged from 1944 to 2100 trees ha^{-1} (mean 2005 ± 48.01). The dominant families based on Importance Value Index (IVI), number of species, genera and individuals were Fagaceae (IVI = 205.29, species= 11, genera= 4 and number of individuals= 1184), Lauraceae (IVI = 139.42, species= 22, genera= 9 and Individual= 882) and Euphorbiaceae (IVI = 68.39, species= 17, genera= 8 and Individual=478). Arecaceae represented by *Arenga pinnata* (Wurmb) Merr. and *Caryota* sp. and Pandanaceae, represented by *Pandanus odoratissimus* Blume, were the only monocot families, and Pinaceae, the sole gymnospermic family, represented by *Pinus kesiya* Royle ex Gordon. This study offers valuable knowledge about the species diversity and community structure of trees which is a prerequisite for efficient management and protection of the forests conserved by the local village communities primarily for ecosystem services.

Keywords: Diversity, species richness, tropical evergreen forests, village community forests

INTRODUCTION

The tropical forests cover an area of over seven percent of the total land surface (Gentry 1982; Richards 1996) and are often referred to be one of the highest species-rich terrestrial ecosystems harboring an enormous portion of the earth's biodiversity (Apguaua et al. 2015; Gandiwa et al. 2016). However, worldwide most tropical forests are highly threatened by anthropogenic activities (Curran et al. 2004; Sahu et al. 2010; Majumdar and Datta 2015). Large patches of forests are being deforested each year, resulting in rapid loss of biodiversity at an accelerated rate that may eventually end in the collapse of some ecosystems (Kharkwal et al., 2005; Panda et al., 2013; Mutiso et al., 2015). It is estimated that 177,000 km^2 of forests and woodlands are cleared annually to form space for farming or to reap timber trees for fuel and wood products and also believed that the earth has lost about half of its forests in 8,000 years and over 3% of forests have been clear-felled since the 1990s alone (WWF 2017). The natural forests are being converted into plantation forests, mainly timber, to meet the ever-increasing human population's needs (Pandey and Shukla 1999). The present generation largely depends on managed forests for wild plant resources, as few natural forests are left (Bhuyan et al. 2003).

Forest is an association of plants dominated by trees of various sizes and other components, such as shrubs and herbs, which occupy different strata (Zhang et al., 2017). The tree diversity determines the biodiversity of a forest as all resources, as well as habitats for almost all other forest plants, are provided by trees (Li et al. 2003 Armenteras et al. 2009; Neumann and Starlinger 2001). In forest ecosystems, the tree species diversity greatly varies from place to place, mainly because of variations in geographic space, geological time, surrounding ecosystems, and disturbance (Whitmore 1998; Sundarapandian and Karoor 2013). Vegetation analysis of the forest ecosystem helps ecologists/conservationists to understand the community structure (Sahu et al. 2019) and the regeneration potential of the species, which are useful in forest management, species conservation (Borogayary et al. 2017), and ecosystem services (Palit et al. 2012). Furthermore, understanding forest dynamics will help conserve the species composition, reduce financial inputs and control the growth, composition/structure, and quality of the forests (Bhat et al. 2000), and conserve plant diversity (Murali et al. 1996). Species diversity is a crucial component of forest ecosystems because it reflects the general health of a specific forest and provides useful information for conserving trees, shrubs, herbs, and other organisms within the forest ecosystem (Roy et al., 2004; Sharma and Kant, 2014).

Eastern Himalayas and Northeast India's forests are rich in plant species and estimated to harbor about 5000 endemic species (Olson et al. 1998). According to Takhtajan (1988), the region is the center of origin of some angiosperms. Meghalaya, a constituent of the Indo-Burma biodiversity hot spot, harbors 3128 species of angiosperms, including 1237 endemic species and fifty-three vulnerable plant species (Khan et al. 1997). The species richness of tropical forests in the Eastern Himalayas and Northeast India was first investigated by taxonomists like Hooker (1872-1897), Kanjilal et al. (1934-1940), Rao and Panigrahi (1961), Rao (1977), and Balakrishnan (1981-1983). Lately, several researchers like Rao et al. (1990), Bhuyan et al. (2003), Saikia et al. (2017), and others have also carried out various studies to understand the ecology of the forest communities and also to quantify plant diversity in the region. The biodiversity of the natural forests of Meghalaya has been studied by workers like Upadhaya et al. (2003), Jamir and Pandey (2003), Tripathi et al. (2006), Jamir et al. (2006), Kumar et al. (2006), Lakadong and Barik (2006), Tynsong (2009), Tynsong and Tiwari (2011) and Tripathi and Shanker (2014). Meghalaya has six principal forest types viz., tropical evergreen forest, tropical moist mixed deciduous forest, Sal forest, subtropical pine forest, sub-tropical mixed broadleaved forest, and sub-tropical oak-dominated forest (Tripathi and Shanker 2014). Through literature reviews, we found out that there is still a lack of research on the plant diversity of the tropical evergreen forest of Meghalaya. The objective of this study was to inventory the tree diversity and community structure of tropical evergreen forests of southern Meghalaya, which is necessary for the management and protection of the local Village Community Forests.

MATERIALS AND METHODS

Study area

The State of Meghalaya, India, lies between 24°02′ and 26°07′ N latitude and 89°48′ and 92°51′ E longitude, with a total geographic area of 22429 km^2 and an altitude ranging from 100 to 1965 m above sea level. It's bordered on the North-West, North, and East by Assam, while Bangladesh borders the South and South-West. The forests within the state of Meghalaya are broadly grouped into (i) government-managed forests comprising reserve forests, national parks, and wildlife sanctuaries controlled and managed by, and subject to, Indian union or state laws and (ii) Autonomous District Council forests which include what locally named as *Law Shnong* (village forest), *Law Adong* (restricted village forest), *Law Kyntang* (sacred forest), *Law Ri-Sumar* (private forest on community land), *Law Ri-Kynti* (private forest on private land), *Law Raid* (forests belonging to a bunch of villages) and *Law Kur* (clan forest) (Tiwari et al. 2010). The forests controlled and managed by the government are barely 1112 km^2 area or 12% of the recorded forest area, and the remaining 88% of the forest in the state (8372 km^2) is managed by the three Autonomous District Councils of the state (Tiwari et al. 2010).

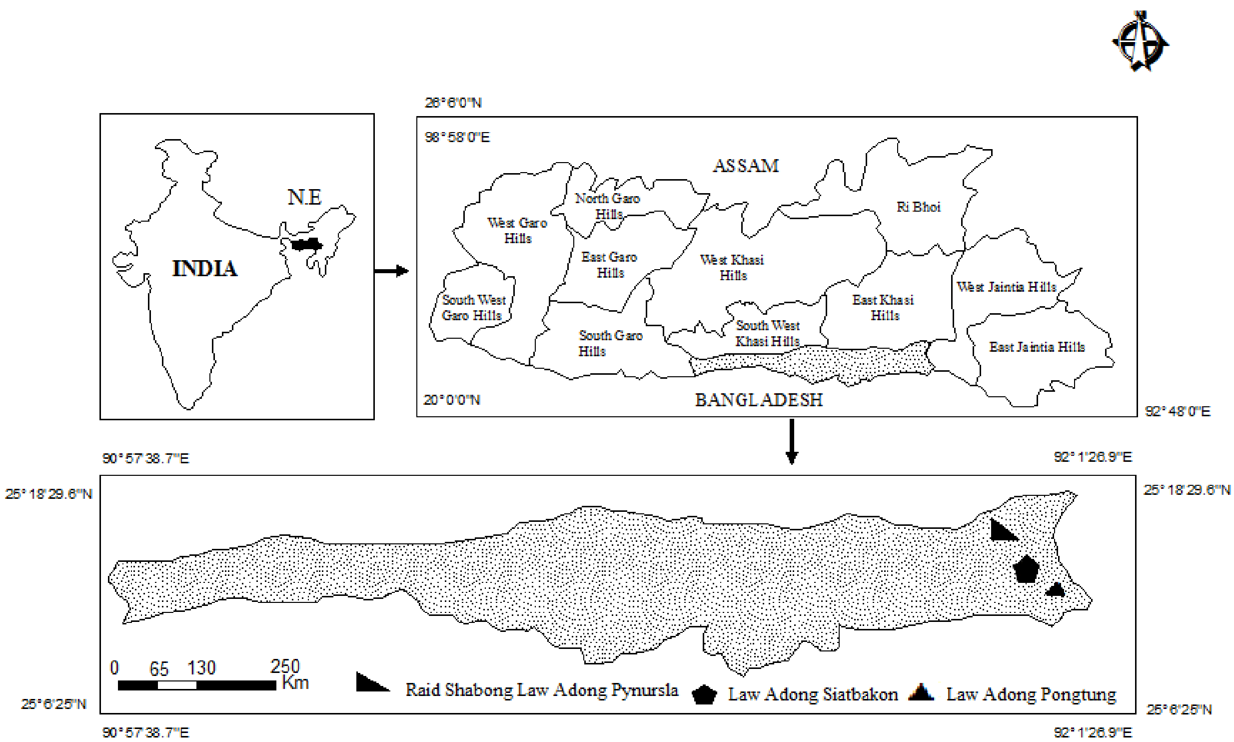

Figure 1. Location of the study area in Meghalaya, India

The plant diversity survey was conducted in the three natural forests (Village Community Forests) with mature stands viz., Raid Shabong Law Adong Pynursla (RSLP), Law Adong Siatbakon (LAS), and Law Adong Pongtung (LAP) of southern slopes of Meghalaya, North East India (Figure 1). The RSLP is located in Pynursla Village (latitude 25018' N, longitude 91054' E, altitude 1200 m asl), LAS in Siatbakon village (latitude $25^0$16' N, longitude $91^0$56' E, altitude 1003 m asl) and LAP in Pongtung Village (latitude 25014' N, longitude 91057' E, altitude 776.1m asl). All three forests are affected by human interference, such as encroachment for house construction and the widening of existing roads.

The mean annual maximum and minimum temperatures of south Meghalaya are 23ºC and 13ºC, respectively, and the mean annual rainfall is 11565 mm (Tynsong and Tiwari 2010). Southern Meghalaya is rugged and undulating hilly terrain, and the slope angle varies between 10º and 40º (Tynsong et al. 2018). The region has many rivers and rivulets, which drain into the plains of Bangladesh (Tynsong and Tiwari 2010). At times, narrow and deep river valleys separate one hill range from the other. As a result, the population density is sparse. Horticulture, cash crops (broom grass, betel leaf, and areca nut), and limited fisheries are the principal occupations of the people. Agriculture is restricted to some small valleys where mainly tuber crops are grown. The important products of the region include orange, betel leaf, betel nut, jackfruit, bay leaf, edible seed, honey, and broom grass (Tynsong et al., 2012). The War Khasi people inhabit the region, a tribal community with a long forest conservation tradition. People collect, process, and market a huge quantity of non-timber forest products (NTFPs) and medicinal and aromatic plants (MAPs) like *Piper peepuloides*, *Cinnamomum tamala*, *Phrynium capitatum*, bamboo, mushrooms, nuts, tubers, wild honey, worms, insects and wild fruits and leafy vegetables from the forests (Tynsong et al. 2012).

Data collection

Extensive field surveys were carried out for plant diversity studies, and data were collected once every season from January 2006 to October 2008. Species composition and vegetation structure of RSLP, LAS, and LAP were determined by randomly placing 100 quadrats per site of 10 m × 10 m for the tree (dbh ≥15 cm). The total sample area for each study site was 1 ha, as Sykes and Horrills (1977) suggested for the rugged and undulating hilly terrain. Tree species with >15 cm diameter at breast height (dbh) were individually counted, measured, and numbered in each plot (100 m^2 plot). The density and frequency of tree species per site per plot were also estimated. The height of stems of each tree species was recorded by rough estimation in all plots, and they were grouped into four height classes [Under-canopy (< 8 m height), Sub-canopy (8-15 m height), canopy (15-30 m height) and emergent (>30 m height)]. The representative species were collected and identified with the help of regional floras (Balakhrishnan 1981-1983; Kanjilal et al. 1934-1940). The herbaria specimens housed in the Botanical Survey of India, Eastern Circle, were consulted to confirm the identification. The nomenclature of the species follows the regional flora (Balakrishnan 1981-1983; Haridasan and Rao 1985-1987; Kanjilal et al. 1934-1940). The voucher specimens were processed following Jain and Rao (1976).

Data analysis

The frequency, density, basal cover, dominance, abundance, and importance value index (IVI) of the species were determined according to Misra (1968) and Mueller-Dombois and Ellenberg (1974). The individuals were allocated into six dbh classes: (i) 15-25 cm, (ii) 25-35 cm, (iii) 35-45 cm, (iv) 45-55 cm, (v) 55-65 cm and (vi) > 65 cm to understand the population structure of species in the area. The IVI of tree species was determined as the sum of relative frequency, relative density, and relative dominance (Curtis and McIntosh 1950). The data were also used to compute the community indices.

Diversity index (H')

The species diversity index was calculated following Shannon and Wiener (1963) by using equation (1):

H' = **-** $\sum$ (pi)(lnpi) (Eq.1)

Where pi = ni/N, N is the total individuals of all species; ni is the number of species.

Dominance index (Cd)

The species dominance was calculated following the index by Simpson (1949) using equation (2):

Cd = $\sum (ni/N)^2$ (Eq. 2)

Where, ni = number of individuals of ith species and N = total number of individuals of all the species.

Evenness index (E)

The equitability or evenness refers to the degree of the relative dominance of each species in that area. It was calculated according to Pielou (1975) by using equation (3):

E: $^{-}\sum (ni/N) \log_e (ni/N)/ \log_e S$ (Eq. 3)

Where, ni = IVI of each species, N = total IVI, and S = number of species

Basal area (BA)

BA of each overstory tree was calculated using equation (4):

BA = πD_2 (Eq. 4).

Where: BA: basal area (m^2ha^{-1}); D: diameter at breast height (cm); and π: pi (3.142)

Species richness index (R)

The species richness index was calculated following Margalef (1968) using equation (5):

$R = S_1 / \log N$ (Eq. 5)

Where: S is the number of species and N is the number of individuals.

Whitford's index (W)

Whitford's index was calculated following Whitford (1948) to study the horizontal distribution pattern of species in the community using equation (6):

W= Abundance (A)/Frequency (F) (Eq. 6)

Where, A/F ratio = <0.025 signifies regular distribution, 0.025-0.05 random distribution and >0.05 clumped distribution

RESULTS AND DISCUSSION

Species richness and diversity

We counted a total number of 6,016 individual trees belonging to 146 species from a 3 ha area of 1 ha area in each plot (138 identified up to species level and 8 up to genus), 95 genera, and 56 families from three 1 ha plots within the tropical evergreen forests of southern Meghalaya. The species richness of the tree species within the three forest stands is given in Table 1. A total of 30 species (20.54%) were common species in all the forest stands, 31 species (21.23%) were found only in RSLP, 15 species (10.27%) only in LAS, and 24 species (16.44%) only in LAP. The similarity index between RSLP and LAS was 56.96%, RSLP and LAP 46.42%, and LAS and LAP was 50.98%. All the tree species encountered were native (Table S1). The diversity of the tree species within the three forest stands calculated using Shannon-Wiener Index (H') showed that the highest was in forest stand LAP (3.95) while there's a slight decrease in Shannon-Wiener Index (H') for LAS (3.87) and RSLP (3.74). The dominance of Simpson's index started from 0.02 (LAS and LAP) to 0.04 (RSLP). The evenness index was highest at stand LAS (0.83) and lowest at stand LAP (0.68), while the Margalef index was highest in stand RSLP (27.39) and lowest in stand LAS (23.07) (Table 1A).

Stratification

The three forest stands of southern Meghalaya showed three distinct layers viz., canopy layer composed of the huge tree (15-30 m height), sub-canopy composed of the middle-sized tree (8-15 m height), and under-canopy composed of small trees (<8 m height). The most common tree species within the canopy layer were *Betula alnoides, Engelhardtia spicata, Lithocarpus fenestratus*, *Syzygium tetragonum,* etc., sub-canopy composed of *Aglaia perviridis, Callicarpa vestita, Glochidion khasicum,* and *Styrax serrulatum* while under canopy composed of *Ardisia floribunda, Erythroxylum kunthianum,* and *Eurya acuminata*. Further, 35 (38.46%) in stand RSLP, 33 (43.42%) in LAS, and 28 (35.44%) in LAP species were canopy trees (≥15 m height). On the other hand, at sub-canopy layer 42 (46.15%) in stand RSLP, 31 (40.78%) in LAS, and 31 (39.24%) in LAP species (8-15 m height), and the rest were under-canopy trees (<8 m height) (Table 1B).

Frequency

Analysis of Raunkier's frequency classes revealed that 63-75% of the tree species in all the stands belonged to Raunkier's frequency class A, while the remainder were distributed in B, C, D, and E classes (Figure 2). The *S. tetragonum, Ficus* sp., *Garcinia spicata,* and *Castanopsis hystrix* in RSLP, *S. tetragonum, Sarcosperma griffithii, Lithocarpus elegans,* and *L. fenestratus* in LAS and *L. elegans, Quercus lanceofolia* and *Litsea elongata* in LAP were the foremost frequently found tree species within the three forest stands. All the tree species showed a contagious distribution pattern in all the forest stands.

Table 1. Composition, diversity, and community characteristics of tree species (dbh ≥15 cm) in 1 ha area of three different sites of southern Meghalaya, India

Variable	RSLP	LAS	LAP	Mean (±SD)
Community characteristic				
No. of species	93	77	79	83 (±5.03)
No. of genera	70	61	62	64 (±2.33)
No. of family	39	38	41	39 (±2.18)
Density (ha^{-1})	2100	1972	1944	2005 (±48.01)
Basal area (m^2/ha)	68.05	52.26	64.84	61.72 (±4.82)
Shannon	3.74	3.87	3.95	3.85 (±0.06)
Simpson	0.04	0.02	0.02	0.03 (±0.01)
Evenness	0.78	0.83	0.68	0.76 (±0.04)
Margalef	27.39	23.07	24.02	24.83 (±1.31)
Sampling size (ha)	1	1	1	1 (±0)
Stratification				
Emerging (> 30 m height)	0	0	0	0
Canopy (15 - 30 m height)	35	33	28	32 (±2.08)
Sub-canopy (8 - 15 m height)	42	31	31	35 (±3.66)
Under-canopy (< 8 m height)	16	13	20	16 (±2.40)

Note: RSLP: Raid Shabong Law Adong Pynursla, LAS: Law Adong Siatbakon, LAP: Law Adong Pongtung

Density and stand basal area

The mean stand density of three forest stands was 2005 (±48.01) individuals/ha. The highest stand density was observed in RSLP with 2,100 individuals/ha, whereas the lowest stand density was observed in LAP with 1944 individuals/ha (Table 1). In RSLP, *Ficus* sp. (196 stem/ha), *S. tetragonum* (194 stem/ha), and *C. hystrix* (136 stem/ha) had the highest density and accounted for 25.05% of tree density in this forest stand. In LAS, *L. fenestratus* (169 stem/ha), *L. elegans* (133 stem/ha), and *S. griffithii* (104 stem/ha) accounted for 20.58% of tree density. In LAP, *L. elegans* (131 stem/ha), *Machilus bombycina* (118 stem/ha), and *Wenderhardia tinctoria* (83 stem/ha) had the highest density and accounted for about 17.07%) (Table 2). The basal area recorded was highest in RSLP stand with 68.05 (m^2/ha), followed by LAP at 64.84 (m^2/ha) and lowest in LAS at 52.26 (m^2/ha) (Table 1A).

Size class distribution

The distribution of density in different dbh classes was 83.38% to 92.95% in the 15-25 cm dbh class, 4.86% to 14.40% in 25-35 cm dbh class, 0.33% to 0.96% in 35 to 45 cm dbh class, 0.61% to 1.13% in 45-55 cm dbh class, 0% to 0.56% in 55-65 cm dbh class and 0.61% to 1.86% in >66 cm dbh class. Tree species richness, as well as diversity, decreased with increasing girth classes (Figure 3). That shows that the regeneration rate was good and fresh recruits survived in good numbers. The number of species per unit area (density) within the community was examined by measuring some tree species in 100 m2 plots to check the distribution of species richness. The species density per 100 m2 ranged from 12-44 in the three forest stands. The species distribution in all three forest stands followed a normal distribution (Figure 4).

Species area curves

The species-area curves for LAS and LAP were very similar. After a gradual increase in the species number with an increase in area, they reached an asymptote at 0.6-0.7 ha for LAS and LAP, while RSLP reached an asymptote at 0.7-0.8 ha. About 60-70% of the species were found in a 0.5 ha area for LAS as well as LAP and in a 0.6 ha for RSLP, while 89-90% of the species were encountered in 0.7 to 0.8 ha for LAS and LAP, while RSLP at 0.8 ha (Figure 5). Plots of a cumulative number of tree species against sampling size (ha) showed that RSLP is slightly more diverse than LAS and LAP for a given sampling size.

Dominance and distribution pattern

The pattern of dominance distribution in all three forest stands was similar, with a standard log distribution pattern, signifying high equality and low dominance of species (Figure 6). In RSLP, *Oroxylum indicum* (IVI= 28.75) and *S. tetragonum* (IVI= 23.63), in LAS, *L. fenestratus* (IVI=40.66) and *L. elegans* (IVI= 30.80) and in LAP, *L. elegans* (IVI= 21.05) and *M. bombycina* (IVI= 17.98) were dominant and co-dominant species respectively (Table 2). In RSLP and LAP, all plant species (100%) and LAS (93.51%) in the forest had a contagious/clumped distribution pattern, with only a few species in LAS having random distribution. Higher contagious distribution revealed that the species were found in patches which were further supported by the frequency distribution pattern, with most species having a low frequency.

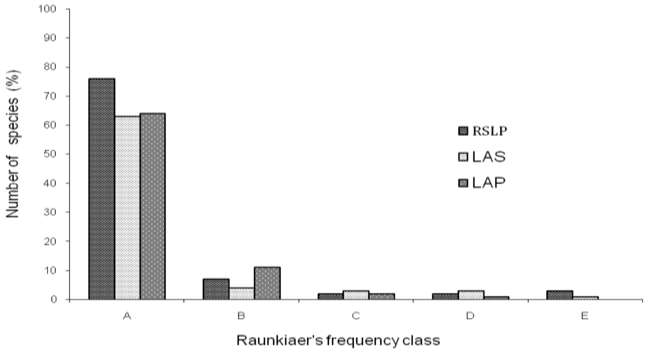

Figure 2. Distribution of tree species in the three forest stands of south Meghalaya, India (RSLP: Raid Shabong Law Adong Pynursla, LASI: LAW Adong Siatbakon, LAP: LAW Adong Pongtung)

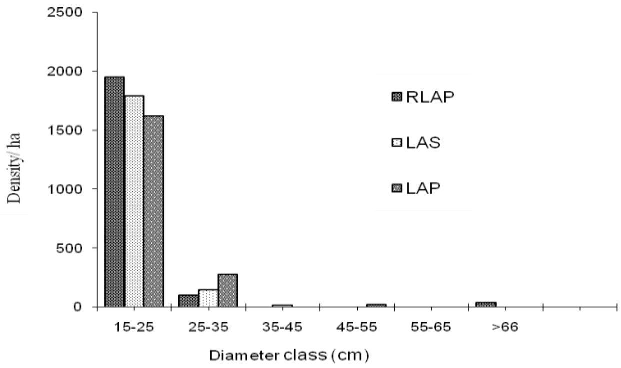

Figure 3. Density-diameter distribution of tree species in the three forest stands of south Meghalaya, India (RSLP: Raid Shabong Law Adong Pynursla, LASI: LAW Adong Siatbakon, LAP: LAW Adong Pongtung)

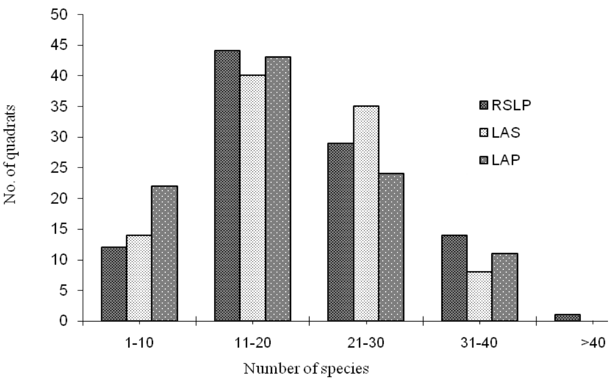

Figure 4. Number of tree species per quadrat (100 m^2) in the three forest stands of Meghalaya, India (RSLP: Raid Shabong Law Adong Pynursla, LASI: LAW Adong Siatbakon, LAP: LAW Adong Pongtung)

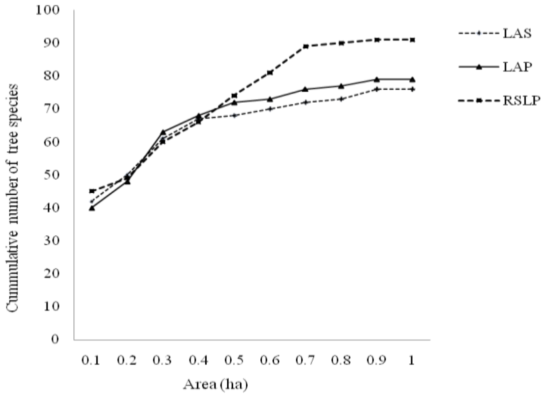

Figure 5. Species area curve of tree species in the three forest stands of Meghalaya, India (RSLP: Raid Shabong Law Adong Pynursla, LASI: LAW Adong Siatbakon, LAP: LAW Adong Pongtung)

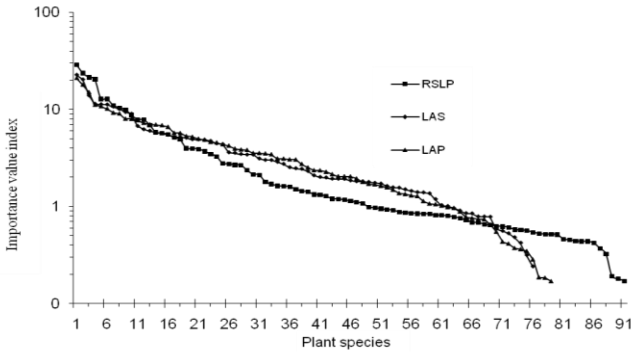

Figure 6. Species area curve of tree species in the three forest stands of Meghalaya, India (RSLP: Raid Shabong Law Adong Pynursla, LASI: LAW Adong Siatbakon, LAP: LAW Adong Pongtung)

Population density

The population density of the enumerated 6,016 tree species varied across the three stands. In RSLP *Oroxyrum indicum* (IVI = 28.75, Density= 37 ha^{-1} and Basal area= 16.55 m^2/ha), *S. tetragonum* (IVI= 23.63, Density= 194 ha^{-1} and Basal area = 4.40 m^2/ha) and *Ficus* sp. (IVI= 21.34, Density= 196 ha^{-1} and Basal area= 3.47 m^2/ha); in LAS *L. fenestratus* (IVI= 40.66, Density= 169 ha^{-1} and Basal area= 4.96 m^2/ha), *L. elegans* (IVI= 30.8, Density= 133 ha^{-1} and Basal area= 4.29 m^2/ha) and *S. griffithii* (IVI= 16.18, Density= 104 ha^{-1}and Basal area= 1.55 m^2/ha) and LAP *L. elegans* (IVI= 21.05, Density= 118 ha^{-1}and Basal area= 3.88 m^2/ha), *M. bombycina* (IVI= 17.98, Density= 131 ha^{-1}and Basal area= 7.94 m^2/ha), *Phoebe cooperiana* (IVI = 15, Density= 74 ha^{-1}and Basal area = 0.12 m^2/ha) are the most important species in term of IVI, Density and Basal area. The name, Importance value index (IVI), Density (D), and Basal area (BA) of the 10 most important species in three forest stands encountered during the study period are given in Table 2. The identified tree species within the three forest stands belonged to 56 plant families. Dominant families based on Importance value index, number of species, genera and individuals includes Fagaceae (IVI= 205.29, species= 11, genera= 4 and Individual= 1,184), Lauraceae (IVI = 139.42, species= 22, genera= 9 and Individual= 882) and Euphorbiaceae (IVI= 68.39, species= 17, genera= 8 and Individual= 478). Arecaceae, represented by *Arenga pinnata* recorded in LAP and *Caryota* sp., and Pandanaceae, represented by *Pandanus odoratissimus* recorded in LAS, were the only monocot families, and Pinaceae, the sole gymnospermic family, represented by *Pinus kesiya* recorded in LAS. Detail of tree families recorded in three 1 ha plots within the tropical evergreen forests of south Meghalaya, including importance value index, the number of species, genera, and individuals, is given in Table 3.

Discussion

Tropical evergreen forests of the southern slopes of Meghalaya are multi-layer forest communities made up of big, medium, and small trees divided into three distinct layers. The canopy, sub-canopy, and under-canopy layers were composed of large (15-30 m tall), medium (8-15 m tall), and small (<8 m tall) trees, respectively. The high species abundance of sub-canopy and sub-canopy layers (61.54%) is attributed to the presence of individuals of canopy species who are either young or whose development has been stopped due to the heavy shade of the overhead canopy (Jamir et al. 2006).

Table 2. Importance value index (IVI), Density (D ha^{-1}), and basal area (BA m^2/ha) of the 10 most important species in three 1 ha plots of southern slopes of Meghalaya, India

Species	RSLP			Species	LAS			Species	LAP		
	IVI	D	BA		IVI	D	BA		IVI	D	BA
Oroxyrum indicum	28.75	37	16.55	*Lithocarpus fenestratu*	40.66	169	4.96	*Lithocarpus elegans*	21.05	118	3.88
Syzygium tetragonum	23.63	194	4.40	*Lithocarpus elegans*	30.8	133	4.29	*Machilus bombycina*	17.98	131	7.94
Ficus sp.	21.34	196	3.47	*Sarcosperma griffithii*	16.18	104	1.55	*Phoebe cooperiana*	15	74	0.12
Castanopsis hystrix	20.4	136	6.06	*Syzygium tetragonum*	12.5	89	1.25	*Knema andamanica*	11.65	74	0.54
Garcinia spicata	12.82	93	1.31	*Machilus bombycina*	12.35	79	1.61	*Wenderhardia tinctoria*	10.76	83	1.80
Lithocarpus elegans	12.82	101	2.11	*Schima wallichii*	11.56	62	2.94	*Antidesma khasianum*	10.26	77	0.50
Macropanax undulatus	10.99	50	4.19	*Quercus lanceifolia*	10.51	66	1.84	*Arenga pinnata*	9.44	81	1.89
Machilus bombycina	10.39	61	2.74	*Castanopsis hystrix*	10.48	56	2.12	*Schima wallichii*	9.05	78	0.91
Sarcosperma griffithii	9.88	81	1.29	*Helicia erratica*	8.76	52	1.02	*Erythroxylum kunthianum*	8	22	0.06
Erythroxylum kunthianum	8.77	134	0.41	*Castenea sativa*	8.5	48	2.52	*Itea macrophylla*	7.98	61	0.17

Note: RSLP: Raid Shabong Law Adong Pynursla, LAS: Law Adong Siatbakon and LAP: Law Adong Pongtung

Table 3. Dominant families based on importance value index (IVI), number of species, genera, and individuals in three 1 ha plots of southern slopes of Meghalaya, India

Family	IVI	Species	Genera	Individual
Fabaceae	229.32	16	9	522
Lauraceae	139.42	22	9	815
Phyllanthaceae	48.12	10	5	149
Myrtaceae	38.87	1	1	223
Moraceae	35.32	7	1	45
Theaceae	34.45	5	3	285
Bignoniaceae	31.59	2	2	134
Erythroxylaceae	29.55	1	1	22
Rubiaceae	28.46	5	5	309
Sapotaceae	27.37	3	2	117
Euphorbiaceae	22.32	8	5	371
Iteaceae	21.94	1	1	122
Clusiaceae	21.2	5	1	68
Myristicaceae	15.84	5	1	37
Magnoliaceae	13.87	2	1	17
Primulaceae	13.45	1	1	1
Elaeocarpaceae	12.94	1	1	16
Proteaceae	12.34	1	1	3
Sterculiaceae	10.91	3	2	170
Myricaceae	9.45	2	1	39
Arecaceae	9.44	2	1	57
Styraceae	9.13	1	1	144
Juglandaceae	8.76	1	1	19
Meliaceae	7.12	4	4	336
Rutaceae	6.55	1	1	7
Symplocaceae	6.15	2	1	256
Ebenaceae	5.88	1	1	17
Sapindaceae	5.76	3	2	84
Ehretiaceae	5.42	1	1	20
Daphniphyllaceae	5.25	1	1	32
Vitaceae	5.22	1	1	4
Actinidiaceae	3.44	1	1	103
Oleaceae	3.25	1	1	4
Lythraceae	2.45	1	1	7
Aquifoliaceae	2.33	1	1	26
Lamiaceae	2.04	1	1	3
Ericaceae	1.99	1	1	37
Araliaceae	1.58	4	4	514
Anacardiaceae	1.55	2	2	79
Pandanaceae	1.45	1	1	38
Burseraceae	1.3	1	1	21
Betulaceae	1.15	2	2	18
Cyatheaceae	0.93	1	1	98
Vaccinaceae	0.92	1	1	181
Simaroubaceae	0.9	1	1	16
Hamamelidaceae	0.84	1	1	1
Apocynaceae	0.7	2	2	326
Urticaceae	0.65	1	1	1
Achariaceae	0.43	1	1	3
Dilleniaceae	0.36	1	1	2
Celastraceae	0.19	1	1	81
Pinaceae	0.16	1	1	16
Total	900	146	95	6016

Upadhaya et al. (2003) reported similar observations from the two sub-tropical humid forests in Jaintia Hills, Meghalaya, and Quigley and Platt (2003) from nine seasonally deciduous forests in America. A total of 146 tree species were recorded in the study area (in 3 ha, for trees ≥15 cm gbh). However, the number of tree species identified in this study was found to be lower than that documented by several workers in other tropical forests. For instance, Condit et al. (1996) reported 683 species (in 50 ha) in the Pasoh Forest Reserve of Malaysia. Lieberman et al. (1996) reported 561 species (in 23.4 ha) along an elevation gradient of Costa Rica. Condit et al. (1996) reported 229 species (in 50 ha) in Barro Colorado Island, Panama. Ayyappan and Parthasarathy (1999) recorded 148 species (in 30 ha) in Varagalaiar tropical evergreen forest in Western Ghats, India, and Kumar et al. (2006) recorded 165 species (35 ha) in the tropical forest of Garo Hills, Meghalaya. However, tree species recorded in southern Meghalaya are much greater than the 63 species (50 ha) recorded in the deciduous forest of Mudumalai, south India (Condit et al. 1996), 103 species (in 28 ha) encountered in the Western Ghats, India (Pascal and Pelissier 1996) and 40 species (in 0.16 ha) in tropical wet evergreen forest in Bangladesh (Feroz et al. 2016).

The species richness in each forest stand of south Meghalaya ranged from 77 to 93 species ha^{-1}, with a mean of 83(±5.03) species ha^{-1}. That may be considered moderate as compared to species richness in neo-tropical forests, which ranges from 20 species ha^{-1} in the Varzea forest of Rio Xingu, Brazil (Campbell et al. 1992) to 307 species ha^{-1} in the Amazonian Equator (Valencia et al. 1994) and other tropical forests where it ranged from 26 species ha^{-1} in Kolli hills of India (Chittibabu and Parthasarathy 2000) to 231 species ha^{-1} in Brunei Darussalam of Southeast Asia (Poulsen et al. 1996) and 76 species ha^{-1} recorded in evergreen tropical forests, Meghalaya (Tripathi and Tripathi 2010). However, it may be considered as considerably higher when compared to other sites in southern and central Western Ghats, viz., 30 species ha^{-1} in Nelliampathy (Chandrashekara and Ramakrishnan 1994), 57 species ha^{-1} in Mylodai forest of Courtallum (Parthasarathy and Karthikeyan 1997), 60 species ha^{-1} recorded in the wet temperate forest of Fakim Wildlife Sanctuary, Nagaland, India (Ao et al. 2020), and 75 species ha^{-1} recorded in the tropical dry deciduous forest of the Eastern Ghats, India (Gandhi and Sundarapandian 2020).

Species diversity indices are computed to understand the diversity and abundance of tree species in different ecosystems for comparison, and the higher the value, the greater the species richness (Naidu and Kumar 2016). The higher values of the diversity indices imply that the forest exhibits high diversity and abundance of tree species (Adekunle et al., 2013). Shannon-Weiner values for tree species diversity in the present study ranged from 3.74-3.95 (mean 3.85±0.06), which is comparable to that of Varagalaiar tropical evergreen forest of Western Ghats, India 3.93 (Ayyappan and Parthasarathy 1999), tropical forests in Eastern Ghats of Andhra Pradesh, India 3.76-3.96 (Naidu and Kumar 2016), tropical forest of Garo Hills, Meghalaya 3.78-4.27 (Kumar et al. 2006), evergreen and sub-tropical forests, Meghalaya 4.2-4.21(Tripathi and Tripathi 2010), betel leaf agroforest, Meghalaya 4.1 (Tynsong and Tiwari 2010) and wet temperate forest of Fakim Wildlife Sanctuary, Nagaland, India 3.9 (Ao et al.

2020). However, Shannon-Weiner values in this study are much higher than that of the areca nut agroforest of Meghalaya 3.3 (Tynsong and Tiwari 2010), sacred groves of the Jaintia hills, Meghalaya 3.42-3.55 (Upadhaya et al. 2003) and Khasi hill sal forest, 3.39 (Tripathi and Shanker 2014). The Margalef index ranged from 23.07-27.39 (mean 24.83±1.31), which falls within the range of 4.54-23.41 for tropical forests reported by earlier workers (Mishra et al. 2005; Sathish et al. 2013). Based on the number of species recorded per hectare and species diversity indices, sub-tropical evergreen forests of southern Meghalaya may be considered a high diversity and abundance of tree species. Ayyappan and Parthasarathy (1999) stated that one of the most important features of the tropical forest is the richness of species. Estimating species richness is a valuable tool in plant and forest ecology to compare the species composition of different forest ecosystems (Naidu and Kumar 2016). Huang et al. (2003) opined that the forest structure and composition significantly influence species diversity. Changes in forest species diversity are often caused by anthropogenic activity, which can harm the forest ecosystem (Sukumar et al. 1992).

The density distribution of woody species in the forests of the southern slopes of Meghalaya ranged from 1,944 to 2,100 trees ha^{-1}; (mean 2,005±48.01) which is similar to a Himalayan temperate forest with 1,570-1,785 stem ha^{-1} in the montane forests of Garhwal Himalaya (Bhandari and Tiwari 1997), 2,090-2,100 stem ha^{-1} recorded in Dolpa District of Mid-West Nepal (Kunwar and Sharma 2004), tropical wet evergreen forests in the Western Ghats, India 1,875 stem ha^{-1} (Giriraj et al. 2008) and Ades forest, Oromia Regional State, West Hararghe Zone, Ethiopia 1,453 stem ha^{-1} (Atomsa and Dibbisa 2019). However, the density of tree species recorded in the present study was found to be much higher than that of evergreen forests of the Andaman Islands of 1,137 trees ha^{-1}, semi-evergreen forests of the Andaman Islands 1,027 trees ha^{-1} (Padalia et al. 2004), tropical forests rainforest remnants of Australian rainforests 94 stem ha^{-1} (Fox et al. 1997), Central Himalaya tropical forests 92 stem ha^{-1} (Khera et al. 2001), Northern forest-Sananna ecotone of Ghana 88 stem ha^{-1} (Attua and Pabi 2013) and evergreen tropical forests, Meghalaya 1,023 stem ha^{-1} and semi-tropical forests of Meghalaya 838 stem ha^{-1} (Tripathi and Tripathi 2010). Other tropical forests such as those of Bolivia (649 trees ha^{-1}) (Boom 1986), Costa Rica (448-617 stem ha^{-1}) (Heaney and Proctor 1990), and Lowland tropical forests in Kurupukari, Guayana (716 to1,440 stem ha^{-1}) (Johnston and Gilman 1995) are also lower in tree density compare to the current study. The total density in several other tropical forests ranged from 5.5 to 18 trees ha^{-1} (Visalakshi 1995), and temperate forests ranged from 3.2 to 21 trees ha^{-1} (Debel and Day 1977; Ralhan et al. 1982; Saxena and Singh 1982).

The total Basal area of trees recorded on the southern slopes of Meghalaya ranged from 52.26 to 68.05 m^2/ha (mean 61.72±4.82). The *O. indicum* contributed the highest basal area with 16.55 m^2/ha, followed by *M. bombycina* (7.94 m^2/ha), *C. hystrix* (6.06 m^2/ha), and *L. fenestratus* (4.96 m^2/ha). A similar study conducted by various workers showed that in the tropical forest of Western Ghats, India, the Basal area ranges from 24.2-75.3 m^2/ha (Subashree et al. 2020), tropical moist deciduous forest of Saptasajya Hill range, Eastern Ghats, India 22.21-46.73 m^2/ha (Sahu et al. 2019), tropical forest of Baratang Island, India, 94.18 m^2/ha (Mane et al. 2019). The basal area of trees in this study is much higher than tropical dry evergreen forests of southern India, where it ranges from 10.79-20.44 m^2/ha (Parthasarathy and Sethi 1997), Miombo woodlands, Tanzania range: 3.9-16.7 m^2/ha (Backeus et al. 2006), New Caledonia range: 47-49.5 m^2/ha (Jaffre and Veillon 1990) and evergreen tropical forests, Meghalaya 33.3 m^2/ha and semi-tropical forests, Meghalaya 49.5 m^2/ha (Tripathi and Tripathi 2010). The emergent layer comprising very tall trees is absent in the studied forests, which may be due to the nutrient-poor soil of studied forests (Visalakshi 1995; Upadhaya et al. 2003).

The presence of a higher number of smaller trees than large ones is perceived as an indicator of a regenerating forest (Bhat et al., 2011). The present study showed a decline in the species richness and density with the increasing diameter class, suggesting a 'reverse J-shaped' curve feature, which in turn indicates strong regeneration status of the forest (Ganesh et al. 1996; Varghese and Balasubramanyan 1999; Bhat et al. 2011; Joglekar et al. 2015; Mohandass et al. 2016). Regeneration in the forest ecosystem is a critical mechanism for the species' survival (Khumbongmayum et al., 2005). Swamy et al. (2010) stated that tropical forests have a great intrinsic self-maintenance capacity, although many have lost this ability in recent years due to anthropogenic disturbances. Chauhan et al. (2010) considered that the distribution of species in a forest depends on the regeneration in space and time of the species that make up the ecosystem. Species diversity, heterogeneity, and dynamic community organization are one of the most perceptible characteristics of tropical and subtropical forests (Tripathi and Tripathi 2010). Two forest stands, RSLP and LAP (100%) and LAS (93.51%), had a contagious/clumped pattern of distribution which could be attributed to insufficient seed dispersal (Richards 1996), topography, and soil factors (Currie 1991). Since most of the species were contagiously distributed and frequency class A was dominant, the forest can be termed highly heterogeneous and patchy in terms of species distribution. Poore (1968), Ashton (1969), and Herwitz (1981) identified tropical rain forests as highly patchy communities primarily because of the species' gap formation and dispersal mechanism of the species. Hubbell (1979) found that the dry tropical forest was either clumped or scattered at random, with uncommon species clumping more than common species. Whitmore (1990) has also recorded patchy ground flora distribution in most tropical rainforests. The dominance of families like Fagaceae, Lauraceae, Euphorbiaceae, Myrtaceae, and Rubiaceae in the study area is similar to the tropical rain forests of Pasoh reserve forests in Malaysia, tropical wet evergreen forests, Western Ghats (Giriraj et al. 2008), the wet temperate forest of Nagaland (Ao et al. 2020) and sub-tropical forests/sacred forests in Meghalaya (Manokaran et al. 1990; Mishra et al. 2004; Tripathi and Khongjee 2010; Tripathi et al. 2010).

Table 4. Vegetation characteristics of various tropical forests located in the tropics

Forest type	Location	Sample area (ha)	DBH (cm)	Species richness (no.)	Diversity index (H')	Density (Tree/ha)	Basal area (m^2/ha)	References
Tropical evergreen	**Southern Meghalaya**	**1**	**≥ 15**	**83**	**3.85**	**2005**	**61.72**	**This study**
Tropical Forests	Eastern Ghats, India	4	≥ 15	129	3.86	601	23.31	Naidu and Kumar (2016)
Sub-tropical Evergreen	Meghalaya	1	≥ 15	76	4.2	1023	33.3	Tripathi and Tripathi (2010)
Subtropical Semi-Evergreen	Meghalaya	1	≥ 15	77	4.21	838	49.5	Tripathi and Tripathi (2010)
Sal Forest	Ri-Bhoi, Meghalaya	5.2	≥10	111	3.39	747	15.54	Tripathi and Shankar (2014)
Tropical Semi- evergreen	Bangladesh	2	≥10	66	-	384	48.05	Biswas and Misbahuzzaman (2008)
Tropical Evergreen	Andaman Island, India	4	≥17	264	2.05	1137	44.8	Padalia et al. (2004)
Tropical Semi-Evergreen	Andaman Island, India	4	≥17	231	1.99	1027	33.76	Padalia et al. (2004)

Note: (-) indicates data absent

One of the unique features of the sub-tropical evergreen forests of southern Meghalaya is the presence of Fagaceae as one of the dominant families with 11 species. Though it was difficult to explain the causes of high species richness in the forests of southern Meghalaya, it seemed that high rainfall, unique topographic condition, and protection over a long period may have played a major role in making the community highly complex and rich in diversity of plants. As a result, tree density and basal area are higher in our studied area, but species richness and plant diversity are significantly lower compared to some tropical forests (Table 4).

In conclusion, the present study shows that the sub-tropical evergreen forests of the southern slopes of Meghalaya show near similarity in terms of species richness with the tropical dry deciduous forests of Eastern Ghats, India, and evergreen tropical forests of Meghalaya in terms of species diversity indices; with the tropical forest of Garo Hills, tropical evergreen forest the Western Ghats and tropical forests in the Eastern Ghats, in term of tree density; with tropical wet evergreen forests of the Western Ghats, montane forests of Garhwal Himalaya and community forests of Dolpa district, mid-west Nepal and in term of the basal area with the tropical forest of the Western Ghats, tropical moist deciduous forest of Saptasajya Hill range, Eastern Ghats and tropical forest of Baratang Island, India. An increase in the disturbance in the form of human encroachment into the forest area would jeopardize the robustness of the forest structure and further threaten the forests of the southern slopes of Meghalaya. This study offers valuable knowledge about tree species' density, distribution, and population structure, which is a prerequisite for efficient management and protection of the forests conserved by the local village communities primarily for ecosystem services.

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Table S1. Plant species, their families, frequency, density (individual ha^{-1}) and IVI recorded in sub-tropical forests of southern slopes of Meghalaya, India

Plant species	Family	Frequency			Density			IVI		
		RSLP	LAS	LAP	RSLP	LAS	LAP	RSLP	LAS	LAP
Acer negundo L.	Sapindaceae	4	3	-	6	4	-	0.97	0.48	-
Acer oblongum Wall. ex DC.	Sapindaceae	3	-	-	3	-	-	0.52	-	-
Actinodaphne angustifolia Nees.	Lauraceae	3	3	3	4	6	5	0.78	0.61	0.74
Actinodaphne obovata (Nees.) Bl.	Lauraceae	4	4	3	6	7	4	0.95	0.77	0.76
Adenanthera pavonina L.	Fabaceae	1	-	18	3	-	54	0.45	-	6.6
Aesculus assamica Griff.	Sapindaceae	-	7	8	-	12	14	-	1.55	2.24
Albizia stipulata (DC.) Boivin	Fabaceae	2	-	3	2	-	12	0.46	-	2.37
Alstonia scholaris (L.) R.Br.	Apocynaceae	2	-	-	2	-	-	0.46	-	-
Amoora rohituka (Roxb.) Wight & Arn.	Meliaceae	-	6	8	-	11	8	-	1.76	1.4
Antidesma diandrum (Roxb.) B.Heyne ex Roth	Phyllanthaceae	2	-	-	3	-	-	0.44	-	-
Antidesma khasianum Hk.f.	Phyllanthaceae	1		7	1	-	77	0.18	-	10.26
Aporosa octandra (Buch.-Ham. ex D.Don) Vickery.	Phyllanthaceae	3	11	-	6	18	-	0.81	2.35	-
Aralia sp.	Araliaceae	3	-	-	4	-	-	0.57	-	1
Ardisia floribunda Roem. & Schult.	Primulaceae	18	16	30	33	42	37	3.98	4.55	4.87
Arenga pinnata (Wurmb) Merr.	Arecaceae	-	-	18	-	-	81	-	-	9.44
Baccaurea sapida (Roxb.) Muell.	Phyllanthaceae	-	24	25	-	46	19	-	5.52	2.52
Beilschmiedia sp.	Lauraceae	2	-	-	2	-	-	0.66	-	-
Betula alnoides Buch.-Ham. ex D.Don.	Betulaceae	2	-	-	3	-	-	0.61	-	-
Bridelia montana (Roxb.) Willd.	Phyllanthaceae	3	-	-	6	-	-	0.76	-	-
Bridelia retusa (L.) A.Juss.	Phyllanthaceae	-	-	10	-	-	48	-	-	6.85
Callicarpa vestita Wall. ex C.B.Clarke.	Lamiaceae	-	-	22	-	-	7		-	1.02
Camellia caduca C.B.Clarke ex Brandis	Theaceae	9	-	-	69	-	-	5.12	-	-
Camellia caudata Wall.	Theaceae	3	-	-	8	-	-	0.85	-	-
Canthium glabrum Blume.	Rubiaceae	3	6	4	3	9	9	0.54	1.17	4.55
Carpinus viminea Wall. ex Lindl.	Betulaceae	2	-	-	4	-	-	0.53	-	-
Caryota mitis Lour.	Arecaceae	4	-	-	17	-	-	1.32	-	-
Caryota urens L.	Arecaceae	-	2	6	-	8	12	-	0.66	1.7
Castanea sativa Mill.	Fagaceae	-	19	-	-	48	-	-	8.5	-
Castanopsis hystrix Hook.f. & Thomson ex A.DC.	Fagaceae	45	34	8	136	56	6	20.4	10.48	1.07
Castanopsis indica (Roxb. ex Lindl.) A.DC.	Fagaceae	5	-	-	9	-	-	1.62	-	-
Castanopsis tribuloides (Sm.) A.DC.	Fagaceae	-	-	5	-	-	45	-	-	6.99
Cedrela toona Roxb. ex Rottler & Willd.	Meliaceae	2	-	-	2	-	-	0.52	-	-
Chrysophyllum roxburghii G.Don.	Sapotaceae	-	5	-	-	11	-	-	0.96	-
Cinnamomum bejolghota (Buch.-Ham.) Sweet.	Lauraceae	5	-	7	12	-	27	2.11	-	3.54
Cinnamomum camphora (L.) J.Presl.	Lauraceae	25	9	15	53	14	28	7.83	1.71	4.22
Cinnamomum caudatum Nees.	Lauraceae	3	-	-	7	-	-	0.8	-	-
Cinnamomum cecidodaphne Meisn.	Lauraceae	4	-	-	8	-	-	1.2	-	-
Cinnamomum tamala (Buch.-Ham.) T.Nees & Eberm.	Lauraceae	19	21	27	31	34	13	5.52	4.86	2.15
Cinnamomum wightii Meisn.	Lauraceae	12	-	-	25	-	-	3.91	-	-
Citrus latipes (Swingle.)Tanaka.	Rutaceae	17	6	14	22	7	7	3.27	1.05	0.75
Coffea khasiana Hook.f.	Rubiaceae	4	-	3	14	-	24	1.27	-	2.36
Croton caudatus Geiseler.	Euphorbiaceae	-	2	6	-	5	19	-	0.37	3.54
Cryptocarya amygdalina Nees	Lauraceae	9	12	-	14	20	-	2.15	2.76	-
Cyathea gigantea (Wall. ex Hook.) Holttum.	Cyatheaceae	3	-	-	10	-	-	0.93	-	-
Daphniphyllum himalayense Müll.Arg.	Daphniphyllaceae	6	5	-	10	19	-	1.8	1.72	-
Debregeasia longifolia (Burm.f.) Wedd.	Urticaceae	3	-	-	4	-	-	0.58	-	-
Derris robusta Benth.	Fabaceae	-	12	11	-	58	41	-	5.82	5.72
Dillenia pentagyna Roxb.	Dilleniaceae	-	-	23	-	-	1	-	-	0.17
Diospyros kaki L.f.	Ebenaceae	-	8	1	-	12	6	-	1.54	1.37
Drimycarpus racemosus Hook.f.	Anacardiaceae	3	-	6	4	-	6	0.73	-	0.74
Duabanga grandiflora (Roxb. Ex DC.) Walp.	Lythraceae	-	6	-	-	15	-	-	2.45	-
Ehretia acuminata (DC.) R.Br.	Ehretiaceae	9	7	-	26	11	-	2.78	1.32	-
Elaeocarpus lanceifolius Roxb.	Elaeocarpaceae	15	11	4	27	13	17	3.7	2.58	2.04
Engelhardtia spicata Bl.	Juglandaceae	25	5	-	46	9	-	7.82	0.94	-
Erythroxylum kunthianum A.St.-Hil.	Erythroxylaceae	16	7	5	134	25	22	8.77	2.39	8
Eurya acuminata Wall.	Theaceae	4	8	11	18	14	5	1.51	1.64	1.05
Exbucklandia populnea (R.Br. ex Griff.) R.W.Br.	Hamamelidaceae	3	-	-	6	-	-	0.84	-	-
Ficus cunia Buch.-Ham. ex Roxb.	Moraceae	-	-	11	-	-	13	-	-	1.94
Ficus foveolata Pittier ex Tamayo.	Moraceae	-	4	-	-	14	-	-	1.21	-
Ficus gibbosa Blume.	Moraceae	2	-	-	16	-	-	1.17	-	-
Ficus hirta Vahl.	Moraceae	-	5	-	-	7	-	-	0.82	-
Ficus roxburghii Wall.	Moraceae	-	-	9	-	-	8	-	-	1.34

Ficus sp.	Moraceae	62	13	-	196	27	-	21.34	3.15	-
Garcinia morella (Gaertn.) Desr.	Clusiaceae	-	-	7	-	-	3	-	-	0.51
Garcinia lanceifolia Roxb.	Clusiaceae	-	7	5	-	13	11	-	1.73	1.48
Garcinia paniculata Roxb.	Clusiaceae	-	13	-	-	17	-	-	2.42	-
Garcinia pedunculata Roxb.	Clusiaceae	4	-	-	7		-	0.86	-	-
Garcinia spicata (Wight & Arn.) Hook.f.	Clusiaceae	58	5	-	93	15	-	12.82	1.38	-
Garuga pinnata Roxb.	Burseraceae	-	4	-	-	6	-	-	0.65	-
Glochidion khasicum (Müll.Arg.) Hook.f.	Phyllanthaceae	22	6	2	44	13	30	5.81	1.37	3.94
Glochidion lanceolarium (Roxb.) Voigt.	Phyllanthaceae	5	-	-	6	-	-	1.11	-	-
Glochidion sp.	Phyllanthaceae	-	-	16	-	-	4	-	-	0.55
Glochidion thomsoni (Muell-Arg.) Hk.f.	Phyllanthaceae	-	-	2	-	-	37	-	-	5.69
Gynocardia odorata R.Br.	Achariaceae	-	-	20	-	-	2	-		0.43
Helicia erratica Hk.f.	Proteaceae	4	40	2	9	52	7	1.08	8.76	1.27
Hyptianthera stricta (Roxb. ex Schult.) Wight & Arn.	Rubiaceae	1	-	-	2	-	-	2.67	-	-
icus elastica Roxb. ex Hornem.	Moraceae	-	-	3	-	-	25	-	-	4.35
Ilex sulcata Wall.	Aquifoliaceae	2	-	6	3	-	8	0.64	-	1.69
Itea macrophylla Wall. ex Roxb.	Iteaceae	5	7	4	8	21	61	1.14	2.42	7.98
Knema andamanica (Warb.) W.J.de Wilde.	Myristicaceae	1	-	27	22	-	74	1.42	-	11.65
Knema angustifolia (Roxb.) Warb.	Myristicaceae	-	-	29	-	-	1	-	-	0.19
Knema latifolia (Roxb.) Warb.	Myristicaceae	4	-	-	5	-	-	0.85	-	-
Knema linifolia (Roxb.) Warb.	Myristicaceae	-	8	-	-	10	-	-	1.4	-
Knema sp.	Myristicaceae	-	2	-	-	3	-	-	0.33	-
Leea umbraculifera C.D.Clarke.	Vitaceae	-	-	1	-	-	40	-	-	5.22
Ligustrum robustum (Roxb.) Blume.	Oleaceae	5	8	18	7	8	6	1.44	1.3	0.96
Lindera caudata (Nees) Hook.f.	Lauraceae	3	-	4	9	-	131	0.88	-	17.98
Lindera latifolia Hook.f.	Lauraceae	-	-	48	-	-	50	-	-	7.25
Lindera pulcherrima Benth.	Lauraceae	-	-	30	-	-	12	-	-	2.03
Lithocarpus elegans (Bl.) Hatus ex Soep.	Fagaceae	44	48	7	101	133	118	12.82	30.8	21.05
Lithocarpus fenestratus Rehder.	Fagaceae	-	41	-	-	169	-	-	40.66	-
Litsea citrata Blume.	Lauraceae	3	8	-	3	11	-	0.51	1.53	-
Litsea elongata (Nees ex Wall.) Benth. & Hook.f.	Lauraceae	-	-	25	-	-	38	-	-	6.95
Litsea leiantha Hook.f.	Lauraceae	-	3	17	-	6	4		0.6	2.45
Litsea semecarpifolia (Wall. ex Nees) Hook.f.	Lauraceae	2	4	-	3	7	-	0.57	0.7	-
Macaranga denticulata Muell. Arg.	Euphorbiaceae	4	-	-	4	-	-	0.68	-	-
Macaranga indica Wight.	Euphorbiaceae	-	9	-	-	14	-	-	1.74	-
Macaranga peltata Muell. Arg.	Euphorbiaceae	4	-	-	16	-	-	1.63	-	-
Machilus bombycina King ex Hook.f.	Lauraceae	31	38	3	61	79	4	10.39	12.35	0.78
Machilus khasyana Meissn.	Lauraceae	6	-	-	11	-	-	1.6	-	-
Macropanax undulatus (Wall.ex D.Don) Seem.	Araliaceae	22	-	3	50	-	4	10.99	-	0.36
Magnolia pterocarpa Roxb.	Magnoliaceae	4	2	2	5	4	55	0.99	0.39	5.3
Magnolia sp.	Magnoliaceae	10	14	-	14	41	-	2.68	4.51	-
Mallotus ferrugineus (Roxb.) Müll.Arg.	Euphorbiaceae	3	-	14	3	-	1	0.63	-	0.28
Melia azedarach L.	Meliaceae	-	-	1	-	-	5	-	-	0.98
Microtropis discolor (Wall.) Wall.	Celastraceae	1	-	-	1	-	-	0.19	-	-
Myrica esculenta Buch-Ham.ex D.Don.	Myricaceae	20	9	-	50	11	-	6.91	1.61	-
Myrica nagi Thunb.	Myricaceae	-	4	-	-	7	-	-	0.81	-
Neolitsea sp.	Lauraceae	1	-	-	3	-	-	0.37	-	-
Oroxylum indicum Vent.	Bignoniaceae	24	14	5	37	25	5	28.75	3.82	1.72
Ostodes paniculata Blume.	Euphorbiaceae	-	2	-	-	3	-	-	0.33	-
Pandanus odoratissimus Blume.	Pandanaceae	-	5	-	-	13	-	-	1.39	-
Parkia roxburghii G.Don.	Fabaceae	-	-	1	-	-	1	-	-	0.19
Pentapanax umbellatus Seem.	Araliaceae	2	-		3	-	-	0.44	-	-
Phoebe cooperiana P. C. Kanjilal & Das.	Lauraceae	-	17	5	-	24	74	-	3.61	15
Phoebe lanceolata (Nees) Nees.	Lauraceae	-	9	18	-	17	15	-	2.02	3.82
Picrasma javanica Blume.	Simaroubaceae	3	-	-	8	-	-	0.81	-	-
Pinus kesiya Royle ex Gordon.	Pinaceae	-	1	-	-	1	-	-	0.16	-
Quercus dealbata Hook.f. & Thomson.	Fagaceae	8	8	35	25	24	47	3.94	3.06	7.7
Quercus dilatata Royle.	Fagaceae	6	12	-	13	46	-	1.7	5.5	-
Quercus lanceifolia Roxb.	Fagaceae	10	29	-	37	66	-	3.47	10.51	-
Quercus sp.	Fagaceae	-	-	10	-	-	24	-	-	3.51
Quercus sp.	Fagaceae	5	16	25	9	52	20	1.2	6.77	3.54
Randia dumetorum (Retz.) Poir.	Rubiaceae	-	-	13	-	-	2	-	-	0.37
Rhododendron arboreum Sm.	Ericaceae	2	1	-	3	3	-	0.42	0.65	-
Rhus acuminata DC.	Anacardiaceae	1	-	-	2	-	-	0.62	-	-
Sapium baccatum Roxb.	Euphorbiaceae	2	6	-	3	13	-	0.44	2.07	-
Sapium insigne (Royle) Trimen.	Euphorbiaceae	22	7	14	31	9	24	5.7	1.31	4.6
Saraca indica L.	Fabaceae	-	9	2	-	16	1	-	2.24	0.18

Sarcosperma griffithii Hook.f. ex C.B.Clarke.	Sapotaceae	37	51	18	81	104	2	9.88	16.18	0.35
Saurauia punduana Wall.	Actinidiaceae	-	-	1	-	-	22	-	-	3.44
Schima khasiana Dyer.	Theaceae	3	-	-	4	-	-	0.69	-	-
Schima wallichii Choisy.	Theaceae	13	22	2	15	62	78	2.66	11.66	9.05
Sterculia colorata Roxb.	Sterculiaceae	-	-	17	-	-	7	-	-	1.57
Sterculia roxburghii Wall.	Sterculiaceae	1	3	-	1	6	-	0.17	0.54	-
Sterculia villosa Roxb.	Sterculiaceae	6	16	26	7	34	19	1.33	4.2	3.1
Stereospermum chelonoides (L.f.) DC.	Bignoniaceae	2	4	7	3	9	14	0.84	0.65	1.79
Styrax serrulatum Roxb.	Styraceae	21	14	15	43	30	6	4.88	3.12	1.13
Symplocos ramosissima Wall.	Symplocaceae	-	7	7	-	12	8	-	1.54	0.88
Symplocos sp.	Symplocaceae	-	-	5	-	-	16	-	-	3.11
Toona ciliata Roem.	Meliaceae	-	12	-	-	19	-	-	2.46	-
Trevesia palmata (Roxb.) Vis.	Araliaceae	11	27	3	15	37	25	2.36	6.02	3.05
Vaccinium donianum Wight.	Vaccinaceae	4	-	-	8	-	-	0.92	-	-
Wendlandia tinctoria (Roxb.) DC.	Rubiaceae	1	18	7	3	36	83	0.33	4.44	10.76
Wrightia tomentosa Roem. & Schult.	Apocynaceae	-	-	9	-	-	22	-	-	2.74
Syzygium tetragonum (Wight) Wall. ex Walp.	Myrtaceae	71	42	34	194	89	23	23.63	12.5	3.84
Total		-	-	-	2100	1972	1944	300	300	300

Note: - : indicates absence