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Original Research Article

Diversity of Trees Recorded in a 10 Hectare Long-term Forest Dynamic Study Plot in Kolli Hills, Southern Eastern Ghats, Tamil Nadu

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Abstract: A quantitative ecological study was conducted in evergreen forests of Kolli hills, Tamil Nadu. A 10 ha forest dynamics plot was laid in intact evergreen forests. The 10 ha study plot divided in to 250 25m×25m workable elementary plots. All trees ≥10cm diameter at breast height were measured at 137 cm from above the ground, tagged with consecutively numbered aluminium tags. All recorded individuals were identified up to species level with regional floras. Density, species richness, basal area and diversity indices were calculated. Density of species varied significantly among species. A sum of 5000 trees recorded from study plot. A total of 61 species belonged to 52 genera and 26 families were recorded from study plot. Basal area of trees also varied significantly among species. The present study recorded moderate density and diversity of trees. Continuous monitoring and further surveys are essential to decipher impact of climatic factors on tree dynamics in evergreen forests of Kolli hills, South India.
Keywords: forest dynamics plot; Indian forests; Tamil Nadu; tropical forest.

INTRODUCTION

Compared to Western Ghats Eastern Ghats are least studied in terms of ecological studies. In Tamil Nadu Javadhu hills is relatively undisturbed compared to other hills. As a reserved forest (where illegal poaching and non-timber forest products collection are banned), Kolli hills serves as a suitable forest ecosystem (a) for establishment of forest dynamics plot; (b) to understand the long-term effect of environmental factors on indigenous trees; and, (c) to assess biomass and carbon stockpile of trees. Compared to other countries, India is having very limited forest area under long-term forest dynamic monitoring plots. The present study concentrated on density, species richness and diversity of trees in a 10 ha forest dynamics plot situated in Kuzhivalavu Shola, Kolli hills (Figure 1).

Fig-1: Overview of Kuzhivalavu Shola, Kolli hills

Importance of long-term monitoring

Long-term monitoring is both science and research. All organisms including humans, depend upon the functioning of ecosystems for their well being and survival. Long-term ecological studies provide critical insights into changes of organisms' ecosystems services. Without long-term studies, we would have no knowledge about the changing status of the life-support system of the planet. Hence, data from long-term monitoring studies are fundamentally vital for many purposes including:

1. Long-term monitoring is fundamental in quantifying problems associated with increasing carbon emission
2. Identifying measures to mitigate against, or better adapt to, the effects of rapid climate change
3. Documenting and providing baselines against which change or extremes can be evaluated
4. Evaluating ecological responses to natural or experimental disturbance
5. Detecting and evaluating changes in ecosystem structure and functions
6. Providing empirical data for testing ecological theory

Importance of woody plants

Woody plants including trees are important component of forest bionetwork, they provide many ecosystem services to consumers including human. Woody plants provide habitat, food and shelter to animals. Plant inventories have been mostly concentrated on woody plants [1], which is a major part of forest biodiversity [2]. In addition, woody plants accumulate carbon in their wood and other organs, thereby acting as a long-term carbon sink. Woody plants store approximately 90% of all biomass carbon on earth (*c*. 500 Giga ton C), this amount is not so different in size from sum of C in the atmosphere. Thus, atmospheric C content is highly sensitive to forest disturbances as well as forest biomass enrichments [3].

MATERIALS AND METHODS

Vegetation

Vegetation of Kolli hills varies considerably with elevation. Scrub vegetation occupies the foot hills. The mixed deciduous forest is present in the elevation between 400 to 1200 m, while semi-evergreen and evergreen forests occupy (locally known as 'sholas') the elevation between 1200 to 1600 m.

Fig-2: Measuring DBH of trees in forest dynamics plot

Fig-3: Tagging of tree with permanent tag

Forest Dynamics Plot (FDP)

A 10-hectare area in evergreen forests of Kolli hills was designated as Forest Dynamics Plot (FDP) for long-term monitoring to record population changes and impact of climate change on vegetation. All woody stems larger than 10 cm in diameter at breast height (DBH) were measured, tagged and identified.

Estimation of density, species richness and diversity

All free standing woody stems >10 cm DBH were measured, recorded, tagged, and identified with the help of regional floras. For multi-stemmed trees, stem diameter were measured individually, basal area (BA) calculated and summed.

Shannon diversity (*H*) and Equitability index (E_H)

A diversity index reveals the structure of biological community in terms of numerical value. It gives more information on community composition than species richness. Further, it offers insights in to rarity and commonness of species in a community, thereby diversity index functions as an important tool for biologists in the understanding of community structure.

Species diversity and equitability were calculated for all the study plots (10 ha) by the Shannon's diversity index (*H*) and Shannon's evenness (E_H) respectively [4].

$$H = -\sum_{i=1}^{S} Pi \ln Pi$$

Where: H = the Shannon diversity index; P_i = fraction of the entire population made up of species i; S = number of species encountered; $\sum$ = sum from species 1 to species S. The Shannon diversity index (H) is commonly used to characterise species diversity in a community. This index considers both abundance and evenness of the species present. Shannon's equitability (E_H) calculated by dividing H by H_{max} (where H_{max} = ln$S$). Shannon's evenness (E_H) = H / H_{max} = H / ln S.

Simpson's index (*D*)

Simpson's dominance index (D) was calculated as in Magurran [4].

$D = \sum n_i(n_i-1)/N(N-1)$

Where D is measure of dominance; n_i = the number of individuals in the i^{th} species; N = the total number of individuals of all the species in the sample.

RESULTS

Species richness

A total of 61 species belonged to 52 genera and 26 families were recorded from study plot. The most speciose families of study area are Lauraceae (8 species) followed by Moraceae (6), Euphorbiaceae and Meliaceae (each 5). While, 11 families including Annonaceae, Burseraceae, Erythroxylaceae and Myrtaceae represented by just single species' each in study plots (Table 1).

Density of trees

Density of species varied significantly among species. *Memecylon umbellatum* recorded the highest number of density 2587 followed by *Phoebe wightii* (505 trees), *Memecylon edule* (391 trees) and *Psydrax dococcos* (325) in study area. While, three species namely, *Callicarpa tomentosa*, *Ficus mollis* and *Morinda coreia* each represented by single individual in study plot. The mean density of study plot is 500 trees ha^{-1} (Table 1).

Table-1: Binomial, local name, family and density of trees recorded from Kolli hills

S. No.	Binomial name	Family	Density
1	*Aglaia jainii*	Meliaceae	3
2	*Agrostistachye indica*	Euphorbiaceae	2
3	*Albizia odoratissima*	Mimosoideae	2
4	*Alseodaphne semecarpifolia*	Lauraceae	22
5	*Antidesma menasu*	Euphorbiaceae	2
6	*Artocarpus heterophyllus*	Moraceae	14
7	*Beilschmiedia gemmiflora*	Lauraceae	7
8	*Bischofia javanica*	Bischofiaceae	2
9	*Buchanania axillaris*	Anacardiceae	12
10	*Callicarpa tomentosa*	Verbenaceae	1
11	*Canaarium strictum*	Burseraceae	13
12	*Casine glauca*	Celastraceae	2
13	*Celtis tetrandra*	Ulmaceae	3
14	*Celtis timorensis*	Ulmaceae	2
15	*Chrysophyllum lanceolatum*	Sapotaceae	7
16	*Chukrasia tabularis*	Meliaceae	16
17	*Cinnamomum malabatrum*	Lauraceae	8
18	*Cipadessa baccifera*	Meliaceae	5
19	*Clausena dentate*	Rutaceae	35
20	*Diospyros angustifolia*	Ebenaceae	25
21	*Diospyros buxifolia*	Ebenaceae	18
22	*Diospyros ebenum*	Ebenaceae	17
23	*Eleaeocarpus serratus*	Elaeocarpaceae	2
24	*Erythrina sticta*	Papilionaceae	8
25	*Erythroxylum manogynum*	Erythroxylaceae	4
26	*Euonymus indicus*	Celastraceae	4
27	*Ficus beddomei*	Moraceae	3
28	*Ficus microcarpa*	Moraceae	4
29	*Ficus mollis*	Moraceae	1
30	*Ficus nervosa*	Moraceae	5
31	*Ficus talbotii*	Moraceae	6
32	*Flacourtia indica*	Flacourtiaceae	2
33	*Gmelina arborea*	Verbenaceae	6
34	*Ligustrum robustum*	Oleaceae	3
35	*Litsea insignis*	Lauraceae	3
36	*Litsea oleoides*	Lauraceae	7
37	*Mallotus philippensis*	Euphorbiaceae	12
38	*Manilkara hexandra*	Sapotaceae	6
39	*Maytenus rothiana*	Celastraceae	33
40	*Meliosma pinnata*	Sabiaceae	161
41	*Meliosma simplicifolia*	Sabiaceae	17
42	*Memecylon edule*	Melastomataceae	391
43	*Memecylon gracile*	Melastomataceae	97
44	*Memecylon umbellatum*	Melastomataceae	2587
45	*Miliusa tomentosa*	Annonaceae	25
46	*Mimusops elengi*	Sapotaceae	8
47	*Morinda coreia*	Rubiaceae	1
48	*Myristica dactyloides*	Myristicaceae	23
49	*Neolitsea scrobiculata*	Lauraceae	71
50	*Nothopegia heyneana*	Anacardiaceae	7

51	*Pavetta indica*	Rubiaceae	3
52	*Persea macrantha*	Lauraceae	8
53	*Phoebe wightii*	Lauraceae	505
54	*Phyllanthus emblica*	Euphorbiaceae	2
55	*Pongamia pinnata*	Papilionaceae	12
56	*Premna tomentosa*	Verbenaceae	10
57	*Prunus ceylanica*	Rosaceae	12
58	*Psydrax dicoccos*	Rubiaceae	325
59	*Scolopia crenata*	Flacourtiaceae	87
60	*Syzygium cumini*	Myrtaceae	316
61	*Toona ciliate*	Meliaceae	5
		Total	**5000**

Basal area

Basal area of trees varied considerably among species. *Memecylon umbellatum* had the largest share in tree basal area (130.36 m^2/10ha) followed by *Syzygium cumini* (30.83 m^2/10ha), *Phoebe wightii* (29.82m^2/10ha), *Memecylon edule* (13.44 m^2/10ha) and *Psydrax dicoccos* (11.26 m^2/10ha). On an average, each hectare had 27.09 m^2/ha in study plot (Table 2).

Table-2: Binomial and basal area of trees recorded from 10 ha permanent study plot at Kolli hills

No.	**Binomial**	**Basal area (m^2/10 ha)**
1.	*Aglaia jainii*	0.30
2.	*Agrostistachys indica*	0.08
3.	*Albizia odoratissima*	0.14
4.	*Alseodaphne semecarpifolia*	2.08
5.	*Antidesma menasu*	0.03
6.	*Artocarpus heterophyllus*	0.61
7.	*Beilschmiedia gemmiflora*	0.10
8.	*Bischofia javanica*	0.40
9.	*Buchanania axillaris*	1.37
10.	*Callicarpa tomentosa*	0.03
11.	*Canarium strictum*	0.67
12.	*Cassine glauca*	0.18
13.	*Celtis tetrandra*	0.04
14.	*Celtis timorensis*	0.04
15.	*Chrysophyllum lanceolatum*	0.46
16.	*Chukrasia tabularis*	2.69
17.	*Cinnamomum malabatrum*	0.17
18.	*Cipadessa baccifera*	0.23
19.	*Clausena dentate*	1.20
20.	*Diospyros angustifolia*	0.20
21.	*Diospyros buxifolia*	0.45
22.	*Diospyros ebenum*	0.82
23.	*Eleaeocarpus serratus*	0.02
24.	*Erythrina sticta*	0.24
25.	*Erythroxylum monogynum*	0.12
26.	*Euonymus indicus*	0.15
27.	*Ficus beddomei*	0.16
28.	*Ficus microcarpa*	1.84
29.	*Ficus mollis*	0.02
30.	*Ficus nervosa*	1.23
31.	*Ficus talbotii*	0.51
32.	*Flacourtia indica*	0.04
33.	*Gmelina arborea*	0.13
34.	*Ligustrum robustum*	0.12
35.	*Litsea insignis*	0.11
36.	*Litsea oleoides*	0.56
37.	*Mallotus philippensis*	0.48
38.	*Manilkara hexandra*	0.11

39.	*Maytenus rothiana*	3.79
40.	*Meliosma pinnata*	8.72
41.	*Meliosma simplicifolia*	0.56
42.	*Memecylon edule*	13.44
43.	*Memecylon gracile*	2.69
44.	*Memecylon umbellatum*	130.36
45.	*Miliusa tomentosa*	1.50
46.	*Mimusops elengi*	0.53
47.	*Morinda coreia*	0.03
48.	*Myristica dactyloides*	3.64
49.	*Neolitsea scrobiculata*	2.98
50.	*Nothopegia heyneana*	0.37
51.	*Pavetta indica*	0.13
52.	*Persea macrantha*	0.78
53.	*Phoebe wightii*	29.82
54.	*Phyllanthus emblica*	0.32
55.	*Pongamia pinnata*	0.49
56.	*Premna tomentosa*	0.63
57.	*Prunus ceylanica*	0.38
58.	*Psydrax dicoccos*	11.26
59.	*Scolopia crenata*	8.85
60.	*Syzygium cumini*	30.83
61.	*Toona ciliata*	0.18
	Total	**270.94**

Diversity indices

The Shannon diversity index of study area is 1.99, Shannon equitability index is 0.48, while Simpson dominance index was 0.29 in study area.

DISCUSSION

Tree density

The average stand density recorded in this study (500 trees ha^{-1}) is higher than what has been reported for many tropical forest sites. Campbell et al. [5] recorded 473 trees ha^{-1} (mean) in terra firme forest of Brazilian Amazon; Lieberman et al. [6] recorded 446 trees ha^{-1} (mean) for Costa Rican forest sites; in lowland rain forest of Sulawesi, Malaysia; Whitmore and Sidiyasa [7] found 408 trees ha^{-1}; Black et al. [8] enumerated 423 trees ha^{-1} in a terra firme forest of Belem, Brazil; Thompson et al. [9] recorded 419 trees ha^{-1} in lowland forest of Mara Brazil; and Sundarapandian and Swamy [10] found 276 trees ha^{-1} in an Indian moist deciduous forest. However, the standard tree stand density recorded in this study is lesser than what has been reported for Sal dominated central Himalayan forest of India (1150-1920 trees ha^{-1}) [11]; deciduous scrub forest of BR hills in India (2685 trees ha^{-1}) [12]; and, tropical semi evergreen forest of Pachaimalai (213 trees ha^{-1}) [13]. A variety of factors influence the density of plants at different levels. Important phenomena such as births, immigration, emigration and death of plants are affected by population density in several ways. Studies observed some general trends with density irrespective of organism and type of ecosystem. It has been reported that smaller-sized organisms tend to occur in larger numbers than greater-sized individuals.

Tree diversity

The mean Shannon's diversity index obtained in this study (1.99) is lower than those recorded in a tropical evergreen forest of Kerala (3.102) [14], in a tropical rain forest of Barro Colorado Island, Panama (4.8) [15], in species rich Silent valley, India (4.89) (Singh et al. 1981), in a evergreen forest of Nelliampathy, India (4.0; [16]), in three tropical evergreen forest sites of Western Ghats, India (3.69, 3.32, 3.52) [17], and, in two giant evergreen forests of Andaman, India (3.14, 3.05) [18]. However, the index value (1.99) obtained in this study is higher than those reported earlier for a tropical dry evergreen forest site of Coromandel Coast (1.82) [19], and inland TDEF site of Pudukottai, Tamil Nadu (1.29) [20]. The present study shows higher Shannon index value when compared to some TDEF sites. The little-higher Shannon index values (*H*) recorded in this study indicate that species are contributed more equally to abundance and evenness than species contributed in two TDEF sites of Venkateswaran and Parthasarathy [19] and Mani and Parthsarathy [20]. The variation in the relative abundance of recorded species in each study plots attributed to the differences in diversity indices.

The Shannon equitability index (0.48) calculated for study plot indicates that in this site half of the represented species contributed equally to the abundance. The mean Simpson's dominance index (D = 0.29) found in this study is slightly lower than what has been reported earlier by others. Parthasarathy and Karthikeyan [21] reported 0.17 (D) for a TDEF site, Venkateswaran and Parthasarathy [19] calculated 0.22

and 0.16 for two TDEF sites, Mani and Parthasarathy [20] estimated 0.21, 0.24, 0.5 and 0.26 for four TDEF sites. However, the index value (*D*) obtained in this study is higher than the value recorded for Silent Valley, Kerala (0.06; [14]); for Nelliampathy (0.06±0.14; [16]), and for giant evergreen forest of Andaman (0.07, 0.12; [18]). The lower the index value, the higher the community is diverse. It is well known that a community is less diverse where one or few species are dominant, whereas a community is highly diverse when several species have similar abundance. It has been broadly reported that the forests of high species diversity are healthier than forests of poor species diversity [22, 23]. Present study plot recorded moderate diversity indices.

CONCLUSION

The present study recorded a moderate density and diversity of trees. If we monitor the study plot for long-term then impact of natural and anthropogenic pressures on tree diversity could be deciphered. India is a large developing country, known for its diverse forest ecosystems and biodiversity. It ranks 10th amongst the most forested nations of the world with 23.84% (78.37 million ha) of its geographical area under forest tree cover. However, long-term monitoring plots are very limited. More number of long-term forest dynamics plot of Indian forests are essential to know about the impact of climate on tropical forest trees.

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