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Original Research Article

Density, Species Richness and Aboveground Biomass of Trees in 10 Hectare Permanent Study Plot, Pachaimalai, Tamil Nadu

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Abstract: A quantitative ecological study was conducted in Pachaimalai(PM) of Southern Eastern Ghats (SEG), Tamil Nadu to estimate density, species richness and aboveground biomass of trees. A 10 ha long term forest dynamics plot was established in study area. All trees ≥10cm diameter at breast height (DBH) were recorded and tagged with consecutively numbered permanent aluminium tags for continuous monitoring and further survey. 10 ha plot was sub-divided into two hundred and fifty 20m × 20m workable sub-plots for tree inventories. An allometric formula has been developed through destructive sampling method to estimate aboveground biomass stockpile of trees in semi evergreen forests. In total, 29 species recorded from Pachaimalai hills. As a whole, 2127 trees recorded from study plot. Density of trees varied considerably among species, *Memecylon umbellatum* represented by 1470 individuals followed by *Buchanania lanceolata* (246 trees) and *Clausena dentata* (72 trees).
Keywords: peninsular India; tree biomass; tropical forest; tropical trees.

INTRODUCTION

Trees are playing vital roles in forest dynamics [1-3]. They constitute considerable proportion of tropical forest biodiversity in India and around the world [2]. Eastern Ghats are less studied compared to Western Ghats in India [4]. Baseline data such as density, species richness and biomass stockpile of trees are essential to formulate conservation measures. Conservation of trees in *in situ* is a pre-requisite to protect gene pool of trees.

Woody plants accumulate carbon in their wood and other organs, thereby acting as relatively a long-term carbon stockpile. More than 50% of all terrestrial carbon stored in forests, contributing about three-fourths of total carbon exchange between terrestrial ecosystem and the atmosphere, and sequestering up to three billion Mg (Mega gram = one tonne) of carbon annually [5]. Among world's forests tropical forests (212 Gt C) hold highest carbon stock followed by Boreal (88 Gt C) and temperate forests (59 Gt C) [6].

To date, few studies have been concentrated on arboreal ecology [7-10] of Eastern Ghats in Tamil Nadu. In addition, information on biomass stockpile of trees in study area is very limited [11].This study aimed to record density, species richness and aboveground biomass (AGB) stockpile of trees in a 10 ha permanent study plot at Pachaimalai, a part of Eastern Ghats of Tamil Nadu.

MATERIALS AND METHODS

Study area

Pachamalai situated in Eastern Ghats of Tamil Nadu. The Eastern Ghats are a series of discontinuous low ranges running generally northeast-southwest parallel to the coast of the Bay of Bengal. They cover an area of about 75,000 sq km in the Indian peninsular, with an average width of 220 km in the north and 100 km in the south. They extend over a length of 1750 km between the rivers of Mahanadi and Vaigai along the East Coast of India across the states of Orissa, Andhra Pradesh and Tamil Nadu.

Vegetation

Vegetation of Eastern Ghats 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 forests occupy (locally known as 'sholas') the elevation between 1200 to 1600 m.

Field survey

A 10 hectare plot was established in Pachaimalai, Southern Eastern Ghats, and Tamil Nadu. The 10 ha plot was sub-divided into two hundred and fifty 20m × 20m workable sub-plots for tree inventories. In the experimental plots all trees with diameter at breast height (dbh) ≥10 cm were measured and recorded. All documented trees were marked and

tagged with consecutively numbered aluminium tags to facilitate further survey and monitoring. For multi-stemmed trees, stem diameter were measured individually, basal area (BA) calculated and summed.

Aboveground biomass

Aboveground dry biomass of trees was calculated by allometric formula developed by destructive harvesting of trees with the permission of Forest Department of Tamil Nadu, India. Biomass estimate of developed formula was compared with a widely used and accepted tree allometric formula which constructed with destructive trees from a wide range of tropical dry forests. Allometric formula developed through this study: AGB_{dry} = exp(2.2014*LN(DBH)-1.0615); where, AGB_{dry} = Aboveground dry biomass of tree (kg); DBH = diameter at breast height (cm); 2.2014 and -1.0615 are constants

Allometric formula which constructed with destructive trees from a wide range of tropical dry forests: AGB = *p* x exp(-0.667 + 1.784 ln(D) + $0.207(\ln(D))^2$ - $0.0281(\ln(D))^3$)[12]; where -0.667, 1.784, 0.207 and -0.028 are constants; D = trunk diameter at breast height (cm); LN = Natural logarithm; *p* = oven-dry wood specific gravity/wood density (g cm^{-3}). As per the regression model the total AGB (kg) of a tree with diameter D is proportional to the product of wood specific gravity (g cm^{-3}) (*p*, represent an oven-dry mass (105 °C, 48 h) divided by green volume. Wood density of species retrieved from Sekar [13].

RESULTS

Density and species richness

A total of 2197 trees (≥10 cm dbh) recorded from Pachaimalai hills. Density varied considerably among species, *Memecylon umbellatum* represented by 1470 individuals followed by *Buchanania lanceolata* (246 trees) and *Clausena dentata* (72 trees). In all, 29 species spread in 23 genera and 17 families recorded from study plot. The family Euphorbiaceaere presented by large number of species (5 species) followed by Ebenaceae (4), Rutaceae (3) and Combretaceae, Melastomataceae and Rubiaceae each represented by two species,whereas, 11 families had one species' each in study plot (Table 1).

Tree basal area and aboveground biomass

1) Tree basal area

In total, trees had 124.72 basal area m^2/10 ha in study area. Basal area of trees (m^2/10ha) varied considerably among species. In Pachaimalai, *Memecylon umbellatum* recorded the highest tree basal area (77.22m^2/10ha) followed by *Buchanania lanceolata*(22.07m^2/10ha) and *Plumeria alba* (5.41 m^2/10ha) (Table 2).

2) Aboveground biomass

On an average, each ha of study plot had 117.77 tonne aboveground biomass in study area (total 1177.66 tonne/10 ha). AGB stockpile varied considerably among species in all study plots. *Memecylon umbellatum* constituted the highest amount of aboveground dry biomass (751.34tonne/10 ha) followed by *Buchanania lanceolata* (222.85 tonne/10 ha) and *Vitex altissima* (43.96tonne/10 ha) in study plot (Table 3).

3) Difference between biomass stockpile estimates in study plots

The formula developed by Chave et al. [12] estimated the biomass stockpile of trees in study area with 99% accuracy. The error percentage of formula developed by Chave et al. [12] was 1.00% in Pachaimalai. Allometric equation developed through this study estimated 1148.73 AGB (Mg/10 ha), while formula of Chave et al. [12] estimated 1177.66 AGB (Mg/10 ha).

DISCUSSION

Tree density

The average tree density 220 trees ha^{-1} recorded in this study is higher than in thorn scrub forests of Mudumalai (156 trees ha^{-1}; [14]) tropical forest of Mudumalai[14]; scrub forest of Western Ghats [15]; Littoral forest site of Andaman [16]; tropical dry forests of Vindhyan hills (35 trees ha^{-1}; [17]); tropical dry forests of Chattishgarh (216 trees ha^{-1}; [18]); tropical forests of Panama (168-173 trees ha^{-1}; [19]) while the mean density found in this study is lower than in many tropical forests (276 to 2685 trees ha^{-1}; [20, 21]).

Species richness

Species richness recorded in this study (29 species in 10 ha; range 22-25 species ha^{-1}) is higher than in tropical dry evergreen forest(TDEF) of Villupuram (21 species; [22]) deciduous forests of Mandla (12-14; [23]); tropical dry forests of Chattishgarh (5-9; [18]); tropical dry deciduous of Madhya Pradesh (2-14; [24]). However, this study recorded tree species which are ≥10 cm DBH. Tree species richness recorded in present is lower than in tropical dry evergreen forests of Thiruvarur and Nagapattinam (range 26-34; [2]; giant evergreen forests of Andaman (68, 75; [16]; tropical evergreen of Western Ghats (64-82; [25] and many forests [2].

Basal area

The mean basal area found in present study (12.47 m^2 ha^{-1}) is higher than in what has been recorded

for TDEF of Villupuram (4.31 m^2 ha^{-1}; [22]; tropical dry forests of Chattishgarh (4.99-7.34 m^2 ha^{-1}; [18]); thorn scrub forest of Mudumalai (6 m^2 ha^{-1}; [14]) while basal area of this study is lower than in TDEFs of Nagapattinam and Thiruvarur (mean 18.99 m^2 ha^{-1}; [2]);Cuddalore (21.54 m^2 ha^{-1}; King, 1997), Pudukottai (22.1 m^2 ha^{-1}; [26]) and tropical dry forests of Mudumalai (24.7 m^2 ha^{-1}; [27]).

Aboveground biomass

The average dry AGB quantified in this study (117.77 tonne ha^{-1}) is higher than in TDEFs of Cuddalore, Villupuram and Pudukottai (102.14 tonne ha^{-1}; [28]);dry deciduous forest (70.55- 77.9 tonne ha^{-1}; [29]);tropical forest ofPachaimalai (50.6 tonne ha^{-1}; [11]);Asian natural forests (70 tonne ha^{-1}; [5]). Whereas, the average AGB of study area is lesser than what has been recorded for rain forests of India (420-649 tonne ha^{-1}; [30]); Asia's undisturbed closed forests (214.66 tonne ha^{-1}; [31]); moist evergreen (400.2- 465.4 tonne ha^{-1}; [32]); wet (759.9 tonne ha^{-1}) and giant evergreen forests of Andaman (332.40-353 tonne ha^{-1}; [33]). Density, species richness, wood density of trees, and type, elevation, species composition and other environmental factors plays major role in AGB stockpile of trees in forests [2].

Table 1: Binomial, local name, family and density of trees recorded from Pachaimalai in Tamil Nadu

S.No	Botanical Name	Common Name	Family	Density
1	*Albizia amara*	Thurinjai	Mimosaceae	9
2	*Atalantia manophylla*	Kattu Elumichai	Rutaceae	3
3	*Buchanania lanceolata*	-	Anacardiaceae	246
4	*Chloroxylon swietenia*	Purasu	Rutaceae	9
5	*Clausena dentata*	Anamaram	Rutaceae	72
6	*Commiphora caudata*	Pachai kiluvai	Burseraceae	18
7	*Diospyros buxifolia*	Irumpuli	Ebenaceae	6
8	*Diospyros ebenum*	Irumpuli	Ebenaceae	33
9	*Diospyros montana*	Irumpuli	Ebenaceae	9
10	*Euphorbia antiquorum*	Sadura kalli	Euphorbiaceae	9
11	*Euphorbia nivulia*	Yellai kalli	Euphorbiaceae	15
12	*Ficus benghalensis*	Alamaram	Moraceae	6
13	*Manilkara hexandra*	Magizhammaram	Sapotaceae	3
14	*Memecylon edule*	Vellaikasaan	Melastomataceae	24
15	*Memecylon umbellatum*	Kasan	Melastomataceae	1470
16	*Ochna serrata*	Serunthi	Ochnaceae	3
17	*Phyllanthus emblica*	Nelli	Euphorbiaceae	9
18	*Phyllanthus polyphyllus*	Karunelli	Euphorbiaceae	12
19	*Plumeria alba*	Perunkalli	Apocynaceae	30
20	*Premna tomentosa*	Pudangunari	Ebenaceae	3
21	*Psydrox dicoccus*	Alumba	Rubiaceae	63
22	*Sapium insigne*	Panaivedi	Euphorbiaceae	3
23	*Strychnos nux-vomica*	Yetti	Loganiaceae	18
24	*Syzigium cumini*	Naval	Myrtaceae	3
25	*Tarenna asiatica*	Therani	Rubiaceae	18
26	*Terminalia paniculata*	Puluvaimaram	Combretaceae	3
27	*Terminalia tomentella*	Semmara	Combretaceae	3
28	*Vitex altissima*	Mailadi	Verbenaceae	18
29	*Zizyphus xylopyrus*	Kottamaram	Rhamnaceae	9
			Total	2127

Table 2: Binomial, basal area and dry biomass of trees recorded from 10 ha permanent study plot of Pachaimalai

No.	Binomial	Basal area (m^2/10 ha)	Aboveground dry biomass (tonne/10 ha)
1.	*Albizia amara*	0.60	5.19
2.	*Atalantia manophylla*	0.02	0.15
3.	*Buchanania lanceolata*	22.07	222.85
4.	*Chloroxylon swietenia*	0.44	3.18
5.	*Clausena dentata*	0.88	5.36
6.	*Commiphora caudata*	1.94	11.96
7.	*Diospyros buxifolia*	0.22	2.10
8.	*Diospyros ebenum*	1.24	10.38
9.	*Diospyros montana*	0.72	6.05
10.	*Euphorbia antiquorum*	0.22	1.02
11.	*Euphorbia nivulia*	0.49	2.50
12.	*Ficus benghalensis*	0.47	3.37
13.	*Manilkara hexandra*	0.17	1.35
14.	*Memecylon edule*	0.97	9.06
15.	*Memecylon umbellatum*	77.22	751.30
16.	*Ochna serrulata*	0.03	0.19
17.	*Phyllanthus emblica*	0.26	2.34
18.	*Phyllanthus polyphyllus*	0.30	2.51
19.	*Plumeria alba*	5.41	36.73
20.	*Premna tomentosa*	0.18	1.37
21.	*Psydrax diccocus*	1.88	14.69
22.	*Sapium insigne*	0.29	2.34
23.	*Strychnos nux-vomica*	0.89	8.75
24.	*Syzygium cumini*	0.89	8.09
25.	*Tarenna asiatica*	0.18	1.19
26.	*Terminalia paniculata*	0.16	1.46
27.	*Terminalia tomentella*	0.23	2.15
28.	*Vitex altissima*	4.86	43.96
29.	*Ziziphus xylopyrus*	1.58	16.04
	Total	**124.72**	**1177.66**

CONCLUSION

Density, species richness, basal area and aboveground biomass of trees recorded in this study is relatively higher, equal and lower than in tropical forests around the world. This study concentrated only on a contiguous 10 ha area in Pachaimalai in Southern Eastern Ghats. Pachaimalai is a home for kinds of forests and trees. This study recorded significantly higher AGB than an earlier study conducted by Arul Pragasan [11] in Pachaimalai. Future studies should concentrate on most of the species and forest types of Pachaimalai. This kind of study is essential to record baseline data on trees. On the other hand, baseline studies are vital to frame conservation measures by conservationists and the Government.

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