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## Structure and Floristic Composition of Tree Diversity in Tropical Dry Deciduous Forest of Eastern Ghats, Southern Andhra Pradesh, India\*

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**Abstract:** This study inventoried three tropical dry deciduous forest tree communities in Eastern Ghats of Southern Andhra Pradesh, India. Three 1 ha plots area were established one each in Nallamalais, Seshachalam and Nigidi hills. A total of 137 tree species, 2205 stems ( $735 \text{ ha}^{-1}$ ) of  $\geq 10$  cm girth were enumerated. Tree communities at the three sites differed in dominance, composition, diversity and structure. Tree stand density varied from 674 to  $796 \text{ ha}^{-1}$  with average basal area of  $11.46 \text{ m}^2 \text{ ha}^{-1}$ . Shannon-Wiener index (H) ranges from 4.11 to 4.89. Site 1 is dominated by *Pterocarpus marsupium* (28.1) and *Anogeissus latifolia* (26.2), site 2 by *Pterocarpus santalinus* (44.5) and *Terminalia pallida* (42.4) and site 3 by *Chloroxylon swietenia* (46.2) and *Albizia amara* (25.9). Site 1 (Nallamalais) forests are more diverse at spatial scale and all taxonomic levels than their counterparts, due to high rainfall and favourable edaphic conditions. The present study can serve as baseline information for monitoring and sustaining the phytodiversity of tropical dry deciduous forests in the State of Andhra Pradesh.

**Key words:** Structure, composition, tree diversity, dry deciduous forest, Eastern Ghats, India

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## INTRODUCTION

Species diversity in the tropics varies dramatically from place to place. Compared to other tropical forest types, dry deciduous forests are among the most exploited and endangered ecosystems of the biosphere (Murphy and Lugo, 1986; Janzen, 1988; Gentry, 1992).

The Indian subcontinent, with its rich biodiversity, is one of the 12 mega-diversity centers of the world. The Eastern Ghats, the Western Ghats and the north eastern hills are the main biodiversity hotspots of India. Primary forests of Asia, particularly those of the Western Ghats and the Eastern Ghats of peninsular India are disappearing at an alarming rate due to anthropogenic activities and are replaced by forests comprising inferior species or their land use pattern changed (Bahuguna, 1999). Studies from Forest Survey of India showed an average of 54.7% of forest is affected by fire and 72.1% of the forest area is subjected to grazing. Annually 3.73 million hectares of the forest area are burnt resulting in economic losses of approximately 440 crores (Anonymous, 1990).

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Information on floral composition, diversity and biomass are absolutely essential in understanding the forest ecosystem dynamics and conservation. It may become a tool to estimate the level of adaptation to the environment and their ecological significance (Pascal and Pelissier, 1996). Tropical dry deciduous forests are enriched with economically important species. Vegetation composition, diversity of species and their habitats are well understood for other tropical forest types compared to dry deciduous forests.

In Eastern Ghats of India, few quantitative phytodiversity inventories are available from the forests of Eastern Ghats of Tamil Nadu (Kaduvul and Parthasarathy, 1999a, b; Jayakumar *et al.*, 2002; Natarajan *et al.*, 2004). These kinds of studies are poorly explored for these aspects in the State of Andhra Pradesh, which covers a major part of Eastern Ghats.

Hence, the present study was undertaken to determine the structure and floristic composition of tree diversity within a three 1 ha plots in tropical dry deciduous forests of Eastern Ghats of southern Andhra Pradesh, India.

### Study Area

The Eastern Ghats are located along the Peninsular India extending over 1750 km with average width of about 100 km and covering the area under 11°03' to 22°03' N Latitudes and 77°02' to 87°02' E Longitudes. The Eastern Ghats are delimited in the north by Similipal hills of Orissa State. The middle section extends from River Krishna (Andhra Pradesh) to near about Chennai city (Tamil Nadu) and includes the Nallamalais, Nigidi, Seshachalam and Veligonda hills. The last section runs in S-SW direction meeting the Western Ghats in the Nilgiris (Meher-Homji, 2001).

The area studied is located in the Nallamalais-Seshachalam-Nigidi hill ranges of Eastern Ghats in southern part of Andhra Pradesh state, India (Fig. 1). Three 1 ha plots area were established at three different sites: Site 1 is located about 3 km from Peddacheruvu, a chenchu tribal hamlet in Nallamalais of Kurnool district which receives mean annual rainfall about 900-1000 mm. Site 2 is located about 4 km from Talakona, a Yanadi tribal hamlet in Seshachalam hill of Chittoor district which receives mean annual rainfall 800-900 mm. Site 3 is located about 2 km from K. Kuntlapalli village, Anantapur district receives mean annual rainfall about 600-700 mm. The rocks are of Kurnool-Cuddapah formations (quartzite and slate formations predominate) and altitude ranges of three 1 ha plots are in between 400 to 600 m. Thus, these study sites showed variability in rainfall pattern even though their phytogeographic range is contiguous.

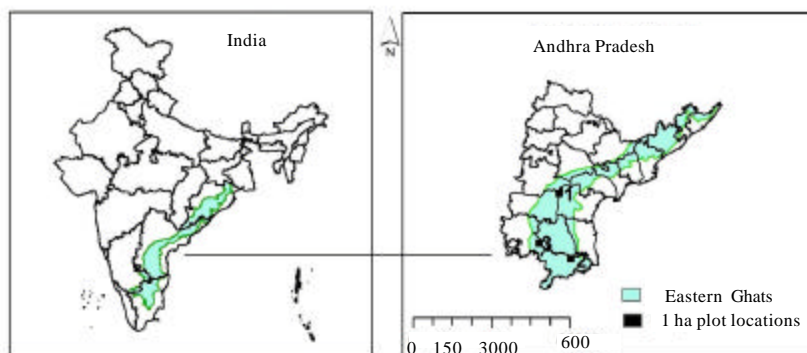


Fig. 1: Location map of study area

## MATERIALS AND METHODS

### Field Sampling

Phytosociological data were collected in three 100×100 m quadrants which are divided into 20×20 m subplots and were systematically surveyed for all trees ≥ 10 cm girth at breast height (gbh-above 130 cm from the ground) during September 2005 to January 2006 in Nallamalais-Seshachalam-Nigidi hill ranges of Eastern Ghats, India. Thus data were obtained from a total of 75 subplots (total area = 3 h). All plots sampled were representative of the most common vegetation type in the Eastern Ghats, i.e., tropical dry deciduous forest. The species were identified with the help of Flora of Presidency of Madras (Gamble and Fischer, 1915-1935) and Flora of Tamil Nadu Carnatic (Matthew, 1984).

### Data Analysis

The vegetation data were quantitatively analysed for basal area, relative density, relative frequency and relative dominance (Phillips, 1959). The Importance Value Index (IVI) for the tree species was determined as the sum of the relative frequency, relative density and relative dominance (Cottam and Curtis, 1956).

$$\text{Basal area (m}^2\text{)} = \text{Area occupied at breast height (1.3 m)} = [\text{p}-(\text{dbh}/2)^2].$$

Relative density	=	No. of trees of species/total number of trees of all species × 100
Relative frequency	=	No. of time species occurs/total number of species × 100
Relative dominance	=	Total basal area of a species/total basal area for all species × 100
Importance Value Index (IVI)	=	Sum of relative density+relative frequency+ relative dominance

Species diversity of each forest type was determined using Shannon-Weiner Index ( $H'$ ) =  $-\sum ((ni/N) \ln (ni/N))$  (Shannon and Wiener, 1949; Odum, 1971).

Where:

ni	=	IVI of individual species
N	=	IVI of all species

Concentration of dominance was also measured using the formula (Simpson, 1949):  $C = -S(ni/N)$  where, ni and N are the same as those for the Shannon-Weiner information function.

Similarity between three communities was determined using Sorenson's index of similarity (Sorenson, 1948).

Local diversity was defined as the number of species found in a hectare. Regional diversity of each hill was derived independently of our plot data, via flora checklists that summarize historical plant collections in the study regions (Reddy *et al.*, 2007).

## RESULTS

### Forest Floristics

A total of 137 tree species were recorded within the 3 ha plots area, representing 98 genera in 44 families. Mean stem density was 735 trees ha<sup>-1</sup> (range 674-796) and mean basal area was 11.46 m<sup>2</sup> ha<sup>-1</sup>. Plot-wise tree species richness was 69 for site 1, 64 for site 2 and 60 for site 3 with major differences between the plots (Table 1). Site 1 (Nallamalais) forests are more diverse at spatial scale and all taxonomic levels than their counterparts (Table 1). There are 202 species/ha at the local scale in site 1 (Nallamalais), along with 1541 species at the regional scale (Reddy and Rao, 2007). Within the 3 h area the most abundant families were Euphorbiaceae and Rubiaceae, both representing 20 species.

Table 1: Consolidated details of species inventory in the 3 ha plots

Description	Site 1	Site 2	Site 3	Total for 3 ha
No. of tree species	69.00	64.00	60.00	137.00
No. of genera	51.00	45.00	41.00	98.00
No of families	26.00	24.00	23.00	44.00
Density (stems ha <sup>-1</sup> )	674.00	735.00	796.00	2205.00
Species diversity index (H')	4.89	4.75	4.11	4.97
Simpson index	0.95	0.93	0.92	0.95
Basal area (m <sup>2</sup> ha <sup>-1</sup> )	26.89	21.99	8.55	34.39
No. of shrub species	28.00	24.00	22.00	47.00
No. of herb species	76.00	57.00	68.00	123.00
No. of climber species	29.00	21.00	26.00	49.00
<b>Similarity index</b>				
Site 1	---	44.00	39.00	
Site 2		---	51.00	
Site 3			---	

Table 2: IVI of the 10 most important species in the three sites, Eastern Ghats of southern Andhra Pradesh

Species	Relative dominance	Relative density	Relative frequency	IVI
<b>Site 1</b>				
<i>Pterocarpus marsupium</i>	16.7	5.3	6.1	28.1
<i>Anogeissus latifolia</i>	6.8	10.5	8.9	26.2
<i>Dalbergia paniculata</i>	11.1	6.2	6.7	24.0
<i>Lannea coromandelica</i>	6.8	8.1	8.4	23.3
<i>Mitragyna parvifolia</i>	6.0	5.3	4.5	15.7
<i>Lagerstroemia parviflora</i>	4.4	5.7	5.0	15.2
<i>Grewia tiliifolia</i>	1.9	4.8	5.0	11.7
<i>Terminalia alata</i>	1.4	5.3	5.0	11.7
<i>Madhuca indica</i>	4.7	2.4	2.8	9.9
<i>Chloroxylon swietenia</i>	4.8	2.4	2.2	9.5
<b>Site 2</b>				
<i>Pterocarpus santalinus</i>	19.4	16.3	8.9	44.5
<i>Terminalia pallida</i>	21.2	14.5	6.8	42.4
<i>Anogeissus latifolia</i>	7.4	9.3	6.8	23.4
<i>Terminalia chebula</i>	7.3	5.8	4.2	17.3
<i>Dolichandrone atrovirens</i>	5.2	4.8	5.1	15.0
<i>Boswellia ovalifoliolata</i>	3.3	4.0	4.7	11.9
<i>Syzygium alternifolium</i>	3.5	4.5	3.8	11.8
<i>Buchanania lanzan</i>	1.7	2.0	3.4	7.1
<i>Terminalia alata</i>	1.4	2.3	3.4	7.0
<i>Shorea roxburghii</i>	1.5	2.5	3.0	7.0
<b>Site 3</b>				
<i>Chloroxylon swietenia</i>	14.6	14.4	17.2	46.2
<i>Albizia amara</i>	8.1	8.1	9.7	25.9
<i>Premna tomentosa</i>	8.3	8.5	3.8	20.6
<i>Anogeissus latifolia</i>	6.7	6.7	6.9	20.3
<i>Ixora arborea</i>	7.2	7.2	4.2	18.6
<i>Diospyros chloroxylon</i>	5.1	5.1	4.9	15.0
<i>Santalum album</i>	5.4	4.7	2.7	12.9
<i>Hildegardia populifolia</i>	2.5	2.5	7.3	12.2
<i>Acacia chundra</i>	2.6	2.5	3.1	8.3
<i>Erythroxylum monogynum</i>	2.8	2.9	2.3	8.0

An obvious variation in representation of tree species and the proportion of dominant species in the three sites can directly be attributed to rainfall distribution and favourable edaphic conditions. The most frequently occurring species in three sites was *Anogeissus latifolia*. In site 1 some moisture indicating species are prevalent, i.e., *Pterocarpus marsupium*, *Anogeissus latifolia*, *Dalbergia paniculata*, *Lannea coromandelica* and *Mitragyna parvifolia*. Where as in site 2 and site 3 species composition possess more dry elements, indicating dry habitats. In site 2, *Pterocarpus santalinus*, *Terminalia pallida*, *Anogeissus latifolia*, *Terminalia chebula* and *Dolichandrone atrovirens* and in site 3, *Chloroxylon swietenia*, *Albizia amara*, *Premna tomentosa*, *Anogeissus latifolia*, *Ixora arborea* and *Diospyros chloroxylon* are predominant (Table 2). While in site 1 top most 10 species represented 56%

Table 3: Population density of tree species ( $\geq 10$  cm gbh) in three sites across Girth Class intervals, Eastern Ghats of Southern Andhra Pradesh

Girth class (cm)	Site 1		Site 2		Site 3		Total		Percent of total individuals
	Species	Individuals	Species	Individuals	Species	Individuals	Species	Individuals	
<30	48	202	51	335	49	282	101	819	37.1
30-50	37	185	53	206	52	297	118	688	31.2
50-70	24	118	20	68	29	134	64	320	14.5
70-90	18	74	29	90	15	55	46	219	9.9
90-110	12	43	14	16	9	19	43	78	3.5
110-130	7	22	9	12	5	9	31	43	2.0
131-150	7	16	4	5	0	0	9	21	1.0
>150	6	14	3	3	0	0	7	17	0.8
	78	674	64	735	60	796	137	2205	100.0

Table 4: Girth class wise basal area in three different sites, Eastern Ghats of southern Andhra Pradesh

Girth class (cm)	Site 1	Site 2	Site 3	Total basal area	Percent total basal area
<30	2.8	8.3	13.1	24.2	8.1
30-50	10.4	20.1	35.3	65.8	21.9
50-70	17.0	21.7	24.7	63.5	21.2
70-90	12.6	28.6	12.9	54.1	18.0
90-110	13.0	10.8	10.0	33.7	11.2
110-130	10.2	2.8	4.0	16.9	5.6
131-150	14.5	1.5	0.0	16.0	5.3
>150	19.6	6.2	0.0	25.8	8.6
	100.0	100.0	100.0	300.0	100.0

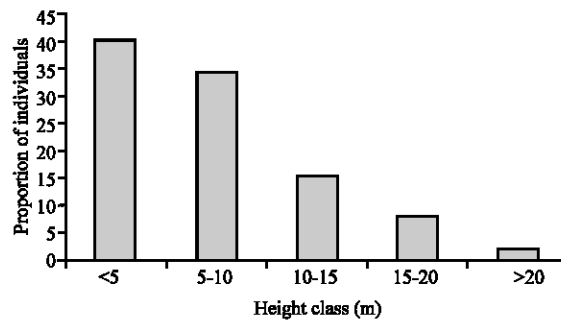


Fig. 2: Height class wise proportion of individuals in three different sites, Eastern Ghats of Southern Andhra Pradesh

of individuals, where as in case of site 2 and site 3 the proportions are 65 and 62%, respectively. A large group of species (34%) are represented by  $\leq 2$  individuals.

Site 2 represents all the seven endemic tree species of Seshachalam hill (*Pterocarpus santalinus*, *Terminalia pallida*, *Boswellia ovalifoliolata*, *Syzygium alternifolium*, *Cycas beddomei*, *Shorea tumbagaia*, *Phyllanthus indofischeri*). Site 1 and site 3 represents one endemic tree species each (*Eriolaena lushingtonii* and *Hildegardia populifolia*, respectively). In addition to it site 3 shows unique representation of *Santalum album* (one of the costliest scented wood of the world and known as pride tree of Eastern Ghats).

### Forest Structure

The total basal area for all stems within the 3 ha area is 34.39 m<sup>2</sup> (Table 1). The distribution of the basal area across the 1 ha plots, using gbh interval classes, reveals the dominance of small stemmed individuals in the plot (Table 3). The mean diameter of top 10 dominant tree species covers 62% of ground cover. It means minority of species dominate the majority of the available resources (Table 4).

Tree distribution by height intervals is shown in Fig. 2. The mean tree height is 12 m, with a height range from 1 to 25 m. The tallest individual trees were *Pterocarpus marsupium* (25 m) and

*Terminalia bellirica* (23 m) in site 1. In site 2, *Pterocarpus santalinus* (22 m) and *Terminalia pallida* (21 m) are tallest. Tree species in site 3 (Nigidi hill) show trends towards shorter stature (49.5% of individuals are with less than 5 m height) than trees in site 1 (32.4%) and site 2 (44.4%).

The basal area and vertical structure of a forest is difficult to summarise as these relies heavily upon the climate and edaphic conditions. Tree heights are heavily influenced by the abundance of saplings, richness of nutrients and anthropogenic pressure (since forest fires are recurrent).

## DISCUSSION

The predominant forest type of the Eastern Ghats of southern Andhra Pradesh is tropical dry deciduous forest (Champion and Seth, 1968). It occupies 93% of forest area (Anonymous, 2006).

Through the use of the subset of tree individuals = 10 cm gbh, our 3 ha plot area contains 2205 individual stems representing 44 families with 137 species. The Shannon-Weiner index ( $H'$ ) for the 3 ha was 4.97 but varied largely with the plot (4.89, 4.75 and 4.11), with Simpson's value ranging from 0.92 to 0.95. These values infer that Eastern Ghats are also high species diverse systems.

The mean stand density of 735 stems  $ha^{-1}$  and range of 674 to 796 stems  $ha^{-1}$  in the forests of southern Andhra Pradesh is well within the range of 276-905 stems  $ha^{-1}$  reported for trees = 10 cm gbh in the tropics (Murali *et al.*, 1996; Sundarapandian and Swamy, 1997; Ghate *et al.*, 1998). This range of stand density in the present study is higher when compared to the other Eastern Ghats sites (Kaduvul and Parthasarathy, 1999a, b; Chittiababu and Parthasarathy, 2000; Jayakumar *et al.*, 2002; Natarajan *et al.*, 2004).

In terms of the overall ecological dominance within our plot, the high importance value species (IVI) are differs from site to site, except for *Anogeissus latifolia*. It is commonly found (wide niched) in all dry deciduous forests.

Species rarity (those represented by = 2 individuals) of 34% obtained in the present study area is higher as compared to Kuzhanthaikuppam and Thirumanikkuzhi (26 and 31%, respectively) dry evergreen forest sites on the Coromandel coast (Parthasarathy and Karthikeyan, 1997) and lower than that of (43%) the Kalrayan hills, Eastern Ghats (Kaduvul and Parthasarathy, 1999).

Species similarity between different sites was studied using presence/absence data. 39% of the species recorded are found similar between site 1 and site 3. Site 2 and site 3 are closer having 51% common species (Table 1). The top ten predominant species with their relative dominance, relative density, relative frequency and IVI are given in Table 2.

In the tropical rainforest, the range of tree species count per hectare is about 20 to a maximum of 223 (Parthasarathy and Sethi, 1997). In the present analysis a maximum of 69 tree species per hectare has been recorded for dry deciduous forest. The present study also supports the fact that Euphorbiaceae and Rubiaceae are the dominant families in almost all types of forests except the mangrove (Padalia *et al.*, 2004).

In the present study maximum tree species diversity is obtained for the site 1, followed by site 2. It is observed that species diversity in three sites is positively correlated with the taxonomical studies. These studies reported the presence of 1541 species in Nallamalais, 1450 in Seshachalam hill and 418 in Nigidi hill (Reddy and Rao, 2007). Most of the tree species shows random distribution.

Stem density and species richness have consistently decreased with increasing girth class of tree species from 10 to more than 150 cm girth. The highest number of species are encountered in the low gbh classes (10-50 cm). Species number gradually decreases with the fall in the count of stems in higher girth class category (Table 1 and Fig. 2). Girth class having <30 cm gbh contributed to about 37% of species richness.

Girth class frequency showed J-shaped population structure of trees exhibited in all the three study sites are in conformity with other forest stands in Eastern Ghats such as Shervarayan hills (Kaduvul and Parthasarathy, 1999a) and Kalrayan hills (Kaduvul and Parthasarathy, 1999b).

## CONCLUSIONS

Calculations of IVI have helped in understanding the ecological significance of the species in the tropical dry deciduous forest type. Species diversity and stem density were observed to decrease with increasing girth class. The variability in rainfall and distinct hilly terrains of three sites has resulted in unique species in terms of species diversity and endemism.

Hence it may be concluded that Eastern Ghats are still rich in tree species diversity, even after disturbance in terms of fire, grazing, extraction of economic/medicinal species and invasion of exotic species. Therefore, priority should be given to conserve Eastern Ghats, which are facing pressure from increasing population and developmental activities.

The immediate attention on people's participation is most essential for effective conservation. The present study will serve as a primary input towards monitoring and sustaining the phytodiversity of tropical dry deciduous forests in the State of Andhra Pradesh.

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