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Diversity and distribution of tree species in tropical forests of Northcentral Eastern Ghats, India

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Abstract. *Premavani D, Naidu MT, Kumar OA, Venkaiah M. 2017. Diversity and distribution of tree species in tropical forests of Northcentral Eastern Ghats, India. Asian J For 1: xxxx.* The diversity and distribution of tree species were studied in three 1 ha sites of tropical forests in the northcentral Eastern Ghats of India. The phytosociological data from forest sites were analyzed quantitatively to determine the basal area, species diversity, richness and stand density. A total of 1,507 individuals of 104 plant taxa, pertaining to 82 genera under 41 families were enumerated at ≥15 cm gbh using belt transects (5 m × 1000 m). Tree stand density varied from 371-660 individuals per ha while average basal area ranged from 14.54 – 46.51 m^2 ha^{-1}. Shannon-Weiner Index (H') ranged from 0.97-0.98, Equitability or evenness index ranged from 0.70-0.79 and Margalef richness index ranged from 10.54 – 10.82. The most dominant families were Rubiaceae, Euphorbiaceae, Fabaceae, Moraceae, and Verbenaceae. Our results suggest further development of forest management and biodiversity conservation in Eastern Ghats region.

Keywords: Diversity, species richness, stand structure, conservation, tropical forests, Eastern Ghats

INTRODUCTION

Tropical forests of the world are commonly decked with luxuriant vegetation rich in species and often referred as one of the most species-diverse terrestrial ecosystems on the planet (Sathish et al. 2013). They provide many ecosystem services such as prevention of soil erosion, species conservation and preservation of habitat for plants and animals (Anbarashan and Parthasarathy 2013). Tropical forests cover only 7% of the earth's land surface, but harbor more than half of the world's species (Wilson 1988). Variation in tropical tree composition and structure over small geographic scales often has been correlated with changes in topography and soil characteristics (Svenning 1999; Webb and Peart 2000). Trees form the major structural and functional basis of tropical forest ecosystems and can serve as robust indicators of changes and stresses at the landscape scale (Sahu et al. 2012a). In recent years, tropical forests are under great anthropogenic pressure and require management intervention to maintain the overall biodiversity, productivity and sustainability (Dash et al. 2009; Naidu and Kumar 2015).

Quantitative inventories in tropical forests have been concentrated on tree species than the other life forms, since tree species diversity is an important part of an ecosystem (Mani and Parthasarathy 2006; Reddy et al. 2011). Conservation management also requires data on plant species diversity and the forest community structure. Quantitative plant diversity inventories of Indian tropical forests are available from various forests of Eastern Ghats (Kadavul and Parthasarathy 1999a, b; Jayakumar et al. 2002; Natarajan et al. 2004; Reddy et al. 2008; Reddy et al. 2011; Sahu et al. 2012a, b; Premavani et al. 2014). These kinds of studies are scarce in Andhra Pradesh, which covers a major part of the Eastern Ghats. In view of these conditions, we evaluated diversity and distribution of tree species in a section of north central Eastern Ghats, as part of East Godavari district in Andhra Pradesh, aiming to provide fundamental data for appropriate management strategies which will help to improve the ecosystem conservation status.

MATERIALS AND METHODS

Study area

The present study was carried out in three forest stands located in East Godavari district, Andhra Pradesh and the stands were located 245 km away from south-west direction of Visakhapatnam. They include Maredumilli (MM: 17° 35′18.66″N 81°43′18.66″E), Rajavommangi (RV: 17°33′35.61″N 82°13′50.44″E) and Rayapalli (RP: 17°34′15.53″N 82°01′08.42″E) (Figure 1). These forests are classified as Southern moist deciduous and dry deciduous forests (Champion and Seth 1968). The hill range consists chiefly of charnokites and kondalites and varied crystalline metamorphic rocks (Subrahmanyam 1982). Soil of the study sites is black, loamy and lateritic. Lateritic soils are abundant in the deciduous forests of the area (Naidu et al. 2014). The temperature rises from 28^0 to 46^0C in summer while in winter ranges from 13^0 to 27^0C and annual precipitation was 1300 mm (Public Works Department/PWD data). The intervention of different anthropogenic activities like an intentional forest fire, cut stem, lopping, grazing, fuelwood collection, medicinal plant collection and intrusion of exotic species are also observed.

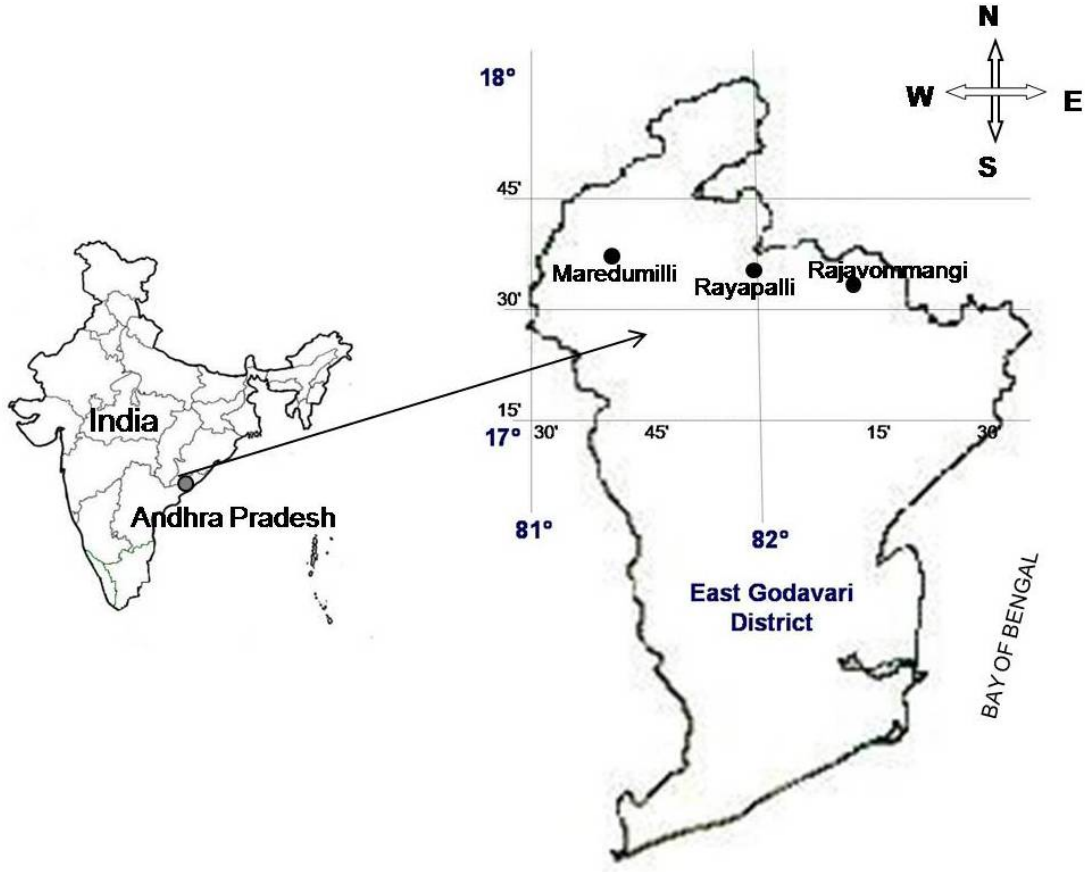

Figure 1. Map showing the land marks of the study sites in East Godavari district of Andhra Pradesh, India. Note: MM = Maredumilli, RP = Rayapalli, RV = Rajavommangi

Sampling methods

The study was carried out during 2009-2011 as part of a national level project. Two belt transects of size 5 × 1,000 m were laid. Depending on the shape of the forest stand, these transects were sub-divided into five 5 × 200 m and care was taken to cover landscape heterogeneity and was given with by their locality name which was used for further analytical use. All individual trees covered in the quadrats were measured at girth at breast height (GBH) ≥ 15 cm. Voucher specimens were collected, processed and identified by following Gamble and Fischer (1915-1935) and Rao et al. (1999) and housed in the Botany Department Herbarium (BDH), Department of Botany, Andhra University, Visakhapatnam, for reference.

Data analysis

Vegetation data were quantitatively analyzed for basal area, relative density (RD), frequency (RF) and dominance (RDom). The Importance Value Index (IVI) of tree species was determined (Curtis and McIntosh 1950). The collected data also used to compute community indices like Species diversity (H') was calculated by using the Shannon-Weiner Index (Shannon and Weiner 1963), following formula:

$$H' = -\Sigma (Pi)/ \ln (Pi),$$

Where, Pi =ni/N, ni= number of all individuals of one species, N=he total number of individuals of all species, and In=Logarithm.

Species dominance (Cd) was calculated following Gini-Simpson (Simpson 1949): Such that

$$Cd = \Sigma (ni/N)^2,$$

Where, ni and N are the same as those of Shannon-Weiner index. Equitability refers to the degree of relative dominance of each species in that area. It was calculated according to Pielou (1966) as:

$$\text{Evenness (e)} = H'/\log S$$

Where, H'= Shannon index, S = number of species. Species richness was determined by Margalef index (Margalef 1968) as:

$$d = S_1/\log N$$

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

RESULTS AND DISCUSSION

Species richness and diversity

A total of 1,507 individual trees of 104 species with ≥ 15cm gbh representing 82 genera of 41 families were documented. Of these, 71 species of 61 genera and 33 families occurred in MM, 66 plant taxa under 60 genera and 33 families occurred in RV and 65 species of 56 genera and 30 families occurred in RP sites. Stem density varied in the three study sites, 660 in MM, 476 in RV and 371 individuals in RP (Table 1). Rubiaceae is the predominant family with eight species, followed by Euphorbiaceae (6 spp.) and 5 species of each by Anacardiaceae, Apocynaceae, Caesalpiniaceae, Combretaceae, Flacourticaceae, Mimosaceae, Moraceae, Papilionaceae, Rutaceae, Sterculiaceae and Verbenaceae while three families Annonaceae, Ebenaceae and Sapotaceae were represented by three species each, eight families had two species each and 16 families were represented by only single species. Diversity values 3.9, 3.86, and 3.94 for the sites MM, RV, and RP, respectively. The Simpson index was 0.97, 0.97, and 0.98, respectively, Evenness index of tree communities at MM, RV, and RP, represented 0.70, 0.72 and 0.79, respectively. The Margalef richness index was performed 10.78, 10.54 and 10.82 (Table 1) for the sites MM, RV and RP, respectively.

Table 1. Number of taxa, diversity indices and structural characteristics of 3 1-ha sites in the northcentral Eastern Ghats, India

Variable	MM	RV	RP
No. of species	71	66	65
No. of genera	61	60	56
No. of families	33	33	30
Density	660	476	371
Basal area	46.51 m^2 ha^{-1}	27.47 m^2 ha^{-1}	14.54 m^2 ha^{-1}
Shannon_H	3.9	3.86	3.94
Simpson_1-D	0.97	0.97	0.98
Evenness_e	0.70	0.72	0.79
Margalef	10.78	10.54	10.82
Elevation (m)	654	310	307
Latitude	17º 35' 37.01"	17º 33' 35.61"	17º 34' 15.53"
Longitude	81º 43' 18.66"	82º 13' 50.44"	81º 01' 08.42"

Density and basal cover

The average tree density was 502 individuals ha^{-1} with a range of 371 (Site RP) to 660 individuals ha^{-1} (MM). Site wise tree species densities were shown as *Xylia xylocarpa* (36 individuals) followed by *Terminalia alata* (29 individuals) and *Lannea coromandelica* (27 individuals) in MM; *Cleistanthus collinus* (36 individuals), *Anogeissus latifolia* (32 individuals) and *Xylia xylocarpa* (27 individuals) in RV; *Chloroxylon swietenia* (20 individuals), *Lannea coromandelica* (19 individuals) and *Dalbergia paniculata* (18 individuls) in RP. A sum of total tree basal area of three sites was 88.52 m^2 ha^{-1} with a range from 14.54 m^2 ha^{-1} (RP) to 46.51 m^2 ha^{-1} (MM). A comparison was made to perceive the relative distribution of the total number of individuals and their basal area in each diameter class. The girth (GBH) class-wise tree density followed to girth class intervals were found more for 31-60 cm and 61-90 cm. In most of the individuals with 52.7% fall in 31 to 90 gbh. The basal area of these classes showed 2.44 and 8.81 m^2 ha^{-1}. The highest basal area contributed in >120 cm girth class about 31.08 m^2 ha^{-1} (Figure 2.A). In Site RV, girth classes decreased from the smallest to largest trees in context to their stem density except for <30 girth class. The girth class 61-90 cm contributed 26% of stem density. The distribution of basal area in different girth intervals i.e more than 120 cm and 91-120 cm contributed about 15.01 m^2ha^{-1} and 7.05 m^2 ha^{-1}, respectively (Figure 2.B). In site RV, stem density decreased consistently with increase in girth class of tree species beyond 31-60 girth class. The distribution of basal area across different girth intervals i.e >120 cm and 91-120 cm contributed 6.21 m^2 ha^{-1} and 3.74 m^2 ha^{-1} respectively (Figure 2.C).

The average tree height was 18.2 m with the ranging from 2-21 m. Tree height distribution intervals showed that most of trees in the study area are between 5 and 15m height (Figure 3). This pattern is common for all the three sites. The forests in the study sites can be considered for having two defined strata. The first comprises the majority of individuals, which are between 5 and 10 m. The second stratum consists of individuals with 11-15 m high canopy. Very few species reach heights greater than 15 m.

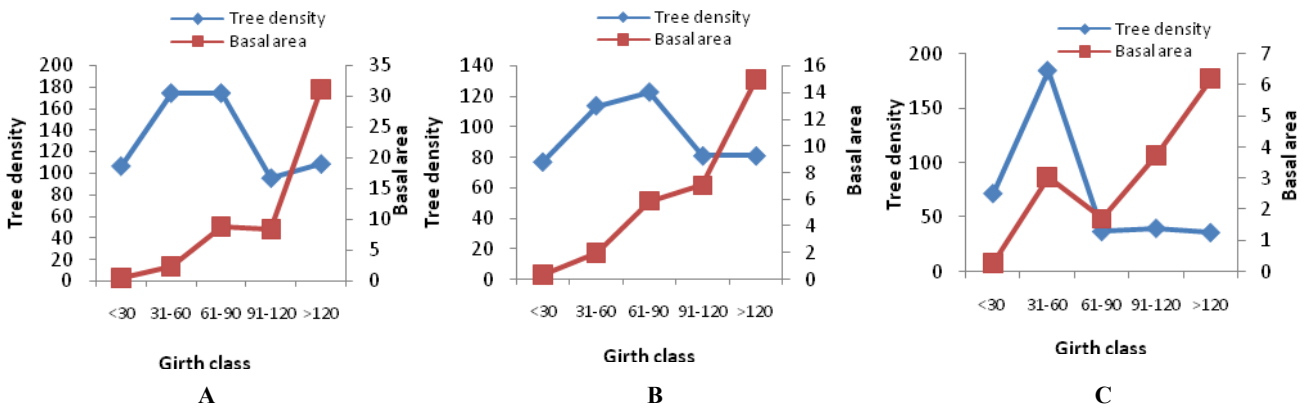

Figure 2.A-C. Contribution of tree species stands density and basal area based on girth class distribution in northcentral Eastern Ghats, India

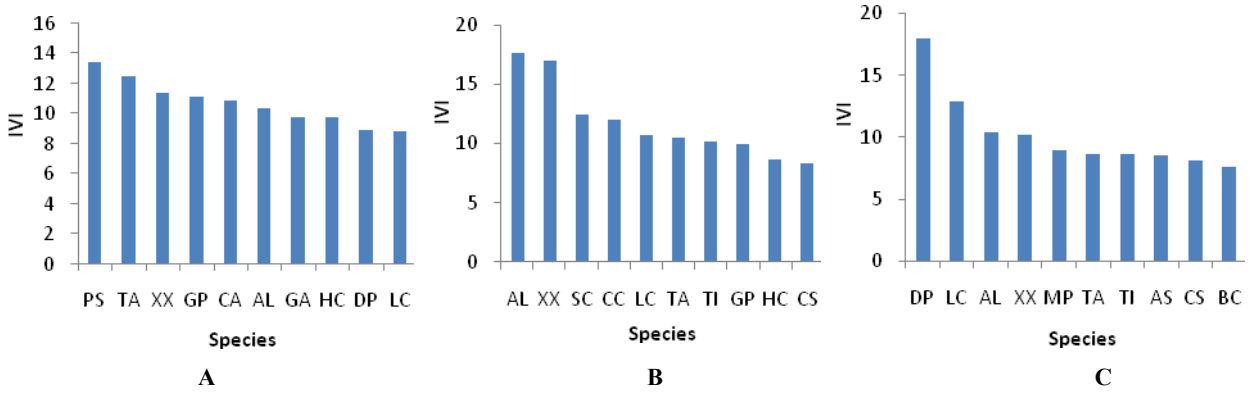

Figure 4.A-C. Top ten IVI of tree species in northcentral Eastern Ghats. Abbreviations used (a-c). PS = *Protium serratum*; TA = *Terminalia alata*; XX = *Xylia xylocarpa*; GP = *Garuga pinnata*; CA = *Careya arborea*; AS = *Alangium salvifolium*; GA = *Gmelina asiatica*; HC = *Haldinia cordifolia*; DP = *Dalbergia paniculata*; LC = *Lannea coromandelica*; SC = *Syzygium cumini*; CC = *Cleistanthus collinus*; TI = *Tamarindus indica*; CS = *Chlooxylon swietenia*; *Mitragyna parvifolia*; AL = *Anogeissus latifolia*.

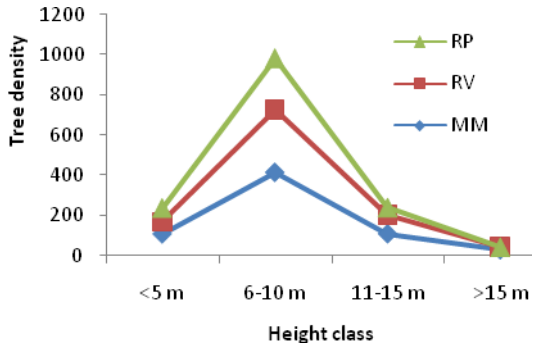

Figure 3. Distribution of individuals per height classes in northcentral Eastern Ghats, India

Important Value Index

The top ten species accounting for 36% in MM, *Protium serratum* is the dominant species with 13.5 IVI. The co-dominant species were *Terminalia alata*, *Xylia xylocarpa*, *Garuga pinnata*, *Careya arborea* and *Anogeissus latifolia* (Figure 4.A). In RV, top ten species accounting for 39% and *Anogeissus latifolia* was dominant species with 17.67 IVI. The co-dominant species include *X. xylocarpa*, *Syzygium cumini*, *Cleistanthus collinus*, *Lannea coromandelica*, *Terminalia alata* and *Tamarindus indica* (Figure 4.B). In RP, top ten species accounted for 34%, *Dalbergia paniculata* was dominant species with 17.89 IVI. The co-dominant species were *L. coromandelica*, *A. latifolia*, *X. xylocarpa* and *Mitragyna parviflora* (Figure 4.C).

Discussion

The present study can be compared with a large number of similar forest sites studied in India and elsewhere in the Tropics. Tree species richness varied in different stands, a total 1506 individuals belonging to 104 species among 41 families from 3 ha^{-1} sites, species richness ranging from 65-71 ha^{-1} with mean value of 67 ha^{-1} recorded. The mean value of 67 species ha^{-1} recorded in the present study is higher than that of 31 species ha^{-1} in dry deciduous forests western India (Kumar et al. 2010), 9 to 41 species ha^{-1} in Bannerghatta National Park (Gopalakrishna et al. 2015), 32 to 48 species ha^{-1} in natural forests of Barak valley (Nandy and Das 2013) and 64 species ha^{-1} in tropical dry deciduous forests of Eastern Ghats, Southern Andhra Pradesh (Reddy et al. 2008). Species number per ha found in the present study is smaller when compared to results of low land moist deciduous forests in northeast India, which have 105 species ha^{-1} (Majumdar et al. 2012), 150 species in Indonesia (Whitemore 1990), 223 and 214 species ha^{-1} in Malaysia (Proctor et al. 1983), 223 species ha^{-1} (Parthasarathy and Sethi 1997). The species richness ranges 65-71 at the 1 ha scale, which is well within the range reported for tropical forests i.e. from low value of 22-29 species ha^{-1} in Niyamgiri hill range of Eastern Ghats (Sahu et al. 2012b) to a high value of 52-110 species ha^{-1} in Eastern Ghats of northern Andhra Pradesh.

Rubiaceae, Euphorbiaceae, and Papilionaceae were predominant families in the present study area. There are similar predominant families to be recorded from Eastern Ghats of northern Andhra Pradesh (Reddy et al. 2011). Shervarayan hills (Kadavul and Parthasarathy 1999a), Warangal region along Godavari valley (Raju et al. 2014), Leguminosae is a predominant family in many Indian deciduous forests, whereas Lauraceae, Meliaceae, Combretaceae, Rubiaceae, Euphorbiaceae and Moraceae etc. elsewhere in other areas of India (Sukumar et al. 1992; Shankar 2001). But in tropics, Fabaceae is a most speciose family in Neotropical deciduous forests (Gentry 1995; Martin et al. 1997; Steege et al. 2000). For instance, *Protium serratum* and *Terminalia alata* were dominant in MM; *Anogeissus latifolia* and *X. xylocarpa* in RV and *Dalbergia paniculata* and *Lannea coromandelica* in RP. Reddy et al. (2011) reported *Xylia xylocarpa* and *Pterocarpus marsupium* were dominant species in Eastern Ghats of northern Andhra Pradesh; *Albizia amara* and *Euphorbia antiquorum* were dominant species in tropical

forests of southern Eastern Ghats (Pragasan and Parthasarathy 2010); *Microtropis discolor* and *Camella caudata* were the dominant trees in Jaintia hills of north east India (Upadhaya et al. 2003).

The average stand density of 504 individuals ha^{-1} in the present study sites exists well within the range of 276-905 individuals ha^{-1} reported for trees ≥15 cm gbh in other tropical forests (Sahu et al. 2012a; Bhadra et al. 2010; Kumar et al. 2010; Sahu et al. 2007) and are close to the value reported by Jha and Singh (1990) for dry tropical forest of Vindhyan region of India. The basal area is an important aspect of studying forest vegetation and structure (Williams-Linera 1990). The mean basal area was 29 m^2 ha^{-1} for the study sites, ranging from 14.54 to 46.51 m^2 ha^{-1}. It is close to that of other tropical forests, such as dry evergreen (32.8 m^2 ha^{-1}) forests of Puthupet, south India (Parthasarathy and Sethi 1997), tropical forests of Eastern Ghats of northern Andhra Pradesh (Reddy et al. 2011), fan-palm dominated forests of east coast (25.3-48.6 m^2 ha^{-1}) in Malaysia (Nizam et al. 2013) but when compared to tropical rain forest in Amazonia (Campbell et al. 1992) lower in value (78 m^2 ha^{-1}).

With respect to girth class wise distribution, tree density decreased with increasing tree size classes, except in lower size class. This agrees with the studies from Malayagiri and Niyamgiri hill ranges of Eastern Ghats (Sahu et al. 2012a, 2012b). The mean tree height was 18.2 m, ranging from 2 to 21 m. The distribution of tree height class showed that individuals were between 5 and 15 m, this is in conformity with the findings for the Malayagiri hill ranges of Eastern Ghats (Sahu et al. 2012a) and dry tropical forests of Peru (Palomino and Alvarez 2005).

Species diversity depends upon adaptation of species and increases with stability of community. The Shannon – Weiner (H') index for all three sites varies from 3.86 to 3.94, which falls within the range of 0.67-4.86 reported by earlier workers for tropical forests (Sundarapandian et al. 2000; Dash et al. 2009; Kumar et al. 2010; Sahu et al. 2012a). These values indicate that the present tropical deciduous forest in a species diverse system. The concentration of dominance (Simpson's index) in the present study is within the reported range 0.21-1.0 for tropical forests by several workers (Kumar et al. 2010; Visalakshi 1995; Sahu et al. 2012c). The evenness index values fall within the range between 0.64-1.34 in other forests (Lalfakwma et al. 2009; Sahu et al. 2012a). The Margalef richness index also within the range of 4.54-23.41 for other tropical forests (Mishra et al. 2005; Kumar et al. 2010).

In conclusion, forests are a rich repository of India's biodiversity but wide spread habitat destruction is threatening its status. Plant diversity in tropical forests was mostly associated with forest structure and species composition. Quantitative inventory of tree species diversity revealed a considerable variation in the composition of dominant species and stood density between forest areas and calculations of IVI which have helped in understanding the ecological significance of species, from different communities. However, the present study clearly shows the fact that the tree diversity in tropical forests of Eastern Ghats varies in species richness and structure among study sites, mainly due to variation in physical heterogeneity and habitat disturbance. Our results highlight the necessity of preparing a comprehensive management plan to conserve the ecosystem of the north-central Eastern Ghats for its rich biodiversity. The present study further helps to policy makers to formulate policies to conserve the natural forest ecosystems and as well for the proper utilization of natural resources.

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