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Inventory of trees in tropical dry deciduous forests of Tiruvannamalai district, Tamil Nadu, India

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ABSTRACT

Sanjay-Gandhi D, Sundarapandian S. 2014. Inventory of trees in tropical dry deciduous forests of Tiruvannamalai district, Tamil Nadu, India. Biodiversitas 15: 169-179. Diversity and distribution patterns of tree species were inventoried in 20 one hectare plots in Sathanur Reserve Forest of Tiruvannamalai district, Tamil Nadu, India. These plots were grouped into three sites based on their location in the reserve forest and the level of disturbance. Site I (8 plots) near to the road and agricultural lands, Site II (8 plots) away from the road and human settlements and site III (4 plots) along the canal-side where the terrain contain rocks here and there. A total of 60 species belonging to 48 genera and 29 families were enumerated including 13,412 stems (≥3.2cm DBH size class). The species richness in the stand (plot) varied from 7 ha^{-1} to 28 ha^{-1} and the stand density varied from 336 ha^{-1} to 1075 ha^{-1}. *Albizia amara* (7999) was the dominant species in terms of density, basal area and IVI in all the study plots except plot no.16, where *Chloroxylon swietenia* was dominant indicates a mono-species dominated forest ecosystem. The mean values of Shannon and dominance indices were 1.406 and 0.411 respectively. Diameter class-wise distribution showed L-shaped curve, a sign of good regeneration status. Cattle grazing and illegal fuel wood collection have been observed to pose huge pressure to the integrity of this tropical dry forest, still it have substantial tree species diversity similar to many other dry forests in India and elsewhere.

Key words: Species composition, structure of forest, tree species diversity, tropical dry deciduous forest.

INTRODUCTION

Tropical and subtropical forests harbor maximum diversity of plant species on the earth (Anonymous 1992). Tropical forest ecosystem is one of the most species diverse terrestrial ecosystems which shelters variety of natural resources and help to sustain the livelihood of local communities (Dash et al. 2009). Dry forests account for nearly half of the world's tropical and subtropical forests spreading large areas of Africa, Latin America and the Asia Pacific (Murphy and Lugo 1986). Waeber et al. (2012) stated that up to 60% of Indian forests are comprised of dry forests and 38.2% are tropical dry deciduous forests (Anonymous 2009; Blackie et al. 2014).

Tropical dry forests are not in species-rich, when compared to tropical wet forests (Gentry 1995), but they also contain good species richness and diverse life-forms (Medina 1995). These forests occur under varied climatic conditions with alternating wet and dry periods. The structure, composition and functioning of these dry forests undergo changes with the length of wet period, amount of rainfall, latitude, longitude and altitude (Uma Shankar 2001). The microclimatic variations alter the species richness, structure and composition, density, growth and survival rate of the tree species in their habitat. Thus, special and temporal variations determine the habitat differentiation and habitat specialization of tree species (Kobe 1999; Pearson et al. 2003). The tropical dry forests conservation is significant because they are the most used and threatened ecosystems (Janzen 1998) especially in India (Uma Shankar 2001). Tropical dry forests (TDF) are ecologically, socially and economically highly valued all over the world (Mooney et al. 1995) and provide many goods and ecosystem services (Li et al. 2003; Wang 2003; Armentaras et al. 2009), although they are exposed to a range of threats, mainly from human disturbances (Yosi et al. 2011; Baithalu et al. 2013).

In most of the developing countries including India, even protected forests experience extensive anthropogenic disturbance due to grazing, extraction of fuel wood, collection of non-wood forest products, conversation of forest lands into croplands and agroforestry systems, and various developmental activities (Singh et al. 1997; Hegde and Enters 2000; Pattanayak et al. 2003; Sundarapandian and Pascal 2013), which alter the tree species diversity and population structure considerably from place to place (Pitman et al. 2002). A study on tree species diversity, distribution pattern and population structure of tropical forests is ecologically significant besides its usefulness in forest management (Sahu et al. 2012). Vegetation structure and species composition of Kalrayan hills (Kadavul and Parthasarathy 1999a,b) Kolli hills (Chittibabu and Parthasarathy 2000; Jayakumar et al. 2002), Chitteri hills (Natarajan et al. 2004) and six major hill complex of southern Eastan Ghats (Arulpragasan and Parthasarathy 2010) were studied. However, published information is not available on Sathanur Reserve Forests of Eastern Ghats. Hence, the present study was aimed to assess large scale quantitative inventory on the structure and floristic composition of trees in tropical dry forests of Sathanur dam Reserve Forests in Tiruvannamalai district, Tamil Nadu, India. This study provides the baseline data of tree species richness, population structure and distribution patterns to develop the conservation measures to protect the vanishing resources.

MATERIALS AND METHODS

Study area

Phytosociological investigation was carried out in Sathanur reserve forest which occupies an area of 870 ha and located in Chennakesava Hills of Tiruvannamalai district, Tamil Nadu, India. It is a part of the Eastern Ghats, lies between longitude 78° 51' 10" and latitude 12° 4' 48" (Figure 1). The forest receives both south-west (June to September) and north-east (October to December) monsoons, but the latter brings more copious rainfall. The mean annual rainfall for 32 years (1980 to 2012) was 965.49 mm (Figure 2). This forest area here falls under the tropical dry deciduous forest type under the Champion and Seth (1986) forest type classification in India. The climate is generally hot. The annual rainfall during the study period was ranged from 464 mm to 1613 mm (PWD data). The predominant soil types are red loam and red sand loam spread over in the forest area.

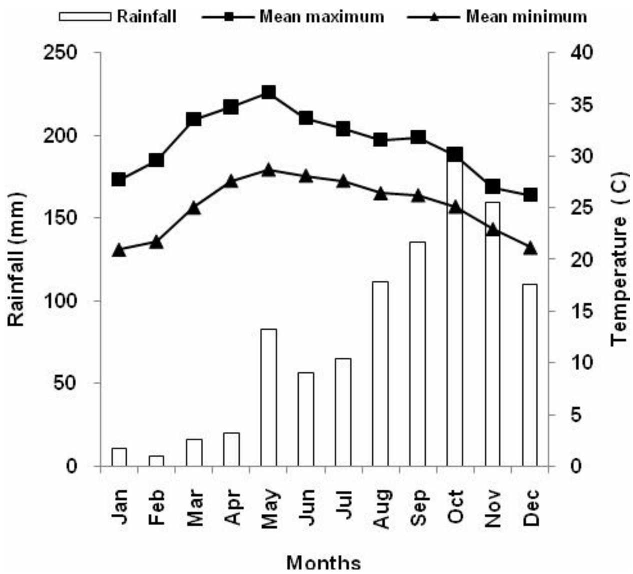

Figure 2. Patterns in monthly distribution of rainfall and temperatures for Sathanur dam, the nearest station to the study sites, based on 22 years of data.

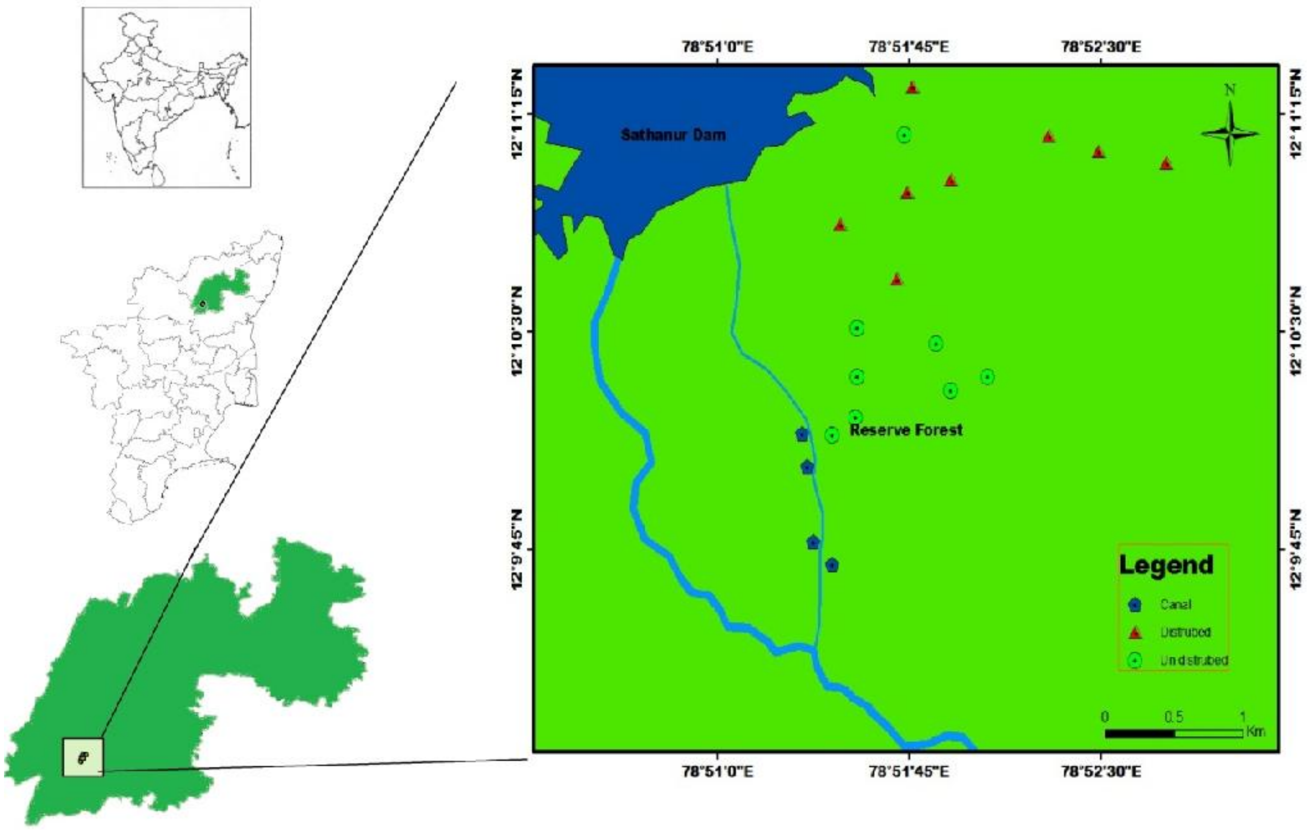

Figure 1. Map showing the location of the study area in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

Methods

In total, 20 plots (of 1 ha each) were laid randomly (approximately at 500 m intervals) in the Sathanur Reserve forest from March 2012 to December 2013 (Figure 1). The forest is classified into three categories based on the location and level of disturbance such as disturbed forest site (Site I, 8 plots, are adjacent to road and agriculture field, grazing and illegal collection of fuel wood is common in these plots), undisturbed forest site (Site II, 8 plots, far away for the human settlement, grazing is uncommon and very rare only during peak summer, since it is away from the settlements and illegal cutting is almost nil) and canal-side forest site (Site III, 4 plots, plots were located along canal-side, human disturbance is common in these area; the area is predominantly build up with granite and gneisses rocks of archean period here and there). Each 1 ha plot was further sub gridded into 10 m x10 m quadrates as workable units. All living trees (≥10 cm girth at breast height (GBH)) were enumerated and their diameter was measured at 1.37 m from the ground level. For multi-stemmed trees, bole girths were measured separately, and their basal area was calculated and summed up. The plant samples were collected for confirming species identity and were deposited in the herbarium, Department of Ecology & Environmental Sciences, Pondicherry University, Puducherry, India.

The vegetation data collected in each plot were analyzed for frequency, density, abundance and importance value index (IVI). The diversity indices were calculated by using PAST software.

RESULTS AND DISCUSSION

Results

A total of 60 tree species (≥3.2 cm DBH) belong to 47 genera and 29 families and 12,548 stems were enumerated in 20 ha plots (stand mean 627.4 stems/ha) of three different sites (Table 1). The number of tree species in a stand (1 ha plot) varied from 7 ha^{-1} to 28 ha^{-1} and the stand density varied from 336 ha^{-1} to 1075 ha^{-1}. In total, *Albizia amara* (7522 number of stems in 20 ha) was the dominant tree species according to density and basal area (251.16 m^2 20 ha^{-1}), except one stand in undisturbed forest site, where *Chloroxylon swietenia* was the dominant species. It indicates that Sathanur reserve forest is a mono-species dominated forest ecosystem.

Species richness was significantly greater in undisturbed forest site II (54) compared to other two study sites (Table 1). The least was recorded in disturbed forest site I (32). Total number of stems threshold ≥ 10 cm GBH were significantly greater in site I (727) compared to all the other study sites and the least was observed in site III (451). The mean basal area of the three different study sites ranged from 18.85 m^2 ha^{-1} to 27.21 m^2 ha^{-1}. Greater mean basal area was observed in study site III than in other study sites (site I and II). Shannon's index ranged from 1.639 to 2.194. Greater value of Shannon's index was observed in site II than in other study sites. In contrast, dominance index was greater in site I (0.375) compared to other study sites. The greatest Fisher alpha value was observed in site II (8.48) compared to other study sites. Bray-Curtis cluster analysis based on density and species composition form two groups, site I and II form one group and site III left as a separate group (Figure 3). The site I and II have more similarity in species composition, which may be the reason to form a group.

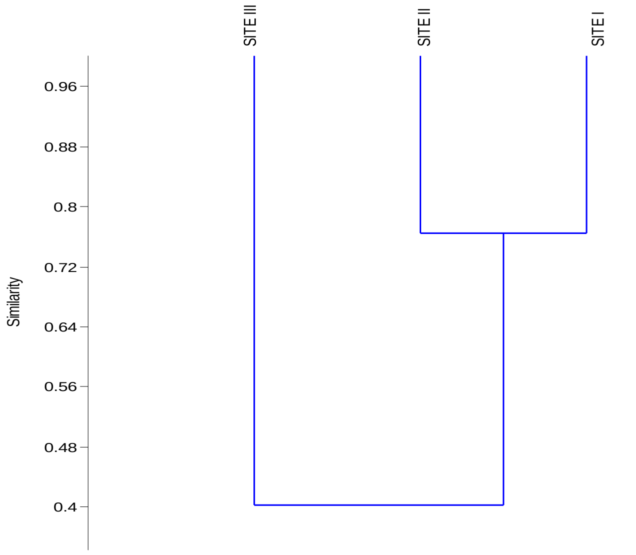

Figure 3. Bray-Curtis cluster analysis based on abundance of tree species in three different study sites in tropical dry forests at Sathanur reserve forests, Tamil Nadu, India

Albizia amara was the dominant species in terms of density in all the three study sites followed by *Chloroxylon swietenia* (Table 2). Ten tree species were rare in distribution because their presence is less than two individuals in all the 20 stands. Twenty one tree species were commonly present in all the three study sites i.e. *Acacia catechu*, *Albizia amara*, *Albizia lebbeck*, *Atalantia monophylla*, *Azadirachta indica*, *Canthium dicoccum*, *Cassia siamea*, *Chloroxylon swietenia*, *Dalbergia paniculata*, *Dichrostachys cinerea*, *Diospyros ebenum*, *Diospyros ferrea*, *Drypetes sepiaria*, *Ficus benghalensis*, *Grewia tiliaefolia*, *Gyrocarpus jacquinii*, *Mallotus philippinensis*, *Pongamia pinnata*, *Prosopis juliflora*, *Sapindus emarginatus* and *Wrightia tinctoria*, while 18 species occurred only in one of the three study sites and not in other two. However, 8 species are common in between site I and site II whereas 9 species were common in between site II and site III. In terms of mean basal area of study sites, *Albizia amara* was the dominant species in all the study sites. Similarly, IVI value revealed that *Albizia amara* was the dominant species in all the study sites.

Out of 29 families of tree species, Mimosaceae, Caesalpiniaceae, Fabaceae and Rubiaceae were the dominant families in terms of number of species in all the three study sites while Rubiaceae (5 genera) was the dominant family in terms of number of genera in study site II (Table 3). However, Mimosaceae (4206 in site I, 2671 in site II and 1047 in site III) was the dominant family in terms of number of individuals followed by Flindersiaceae (1017 in site I, 1191 in site II and 87 in site III). Twelve families in site I, 16 families in site II and 15 families in site III were represented by only one species. Species genera ratio also showed the greater value in Mimosaceae, Caesalpiniaceae, and Fabaceae in all the study sites. However, all other families showed the same value (1). Species-family ratio sowed high value in site II (2.8) followed by site I (2.7) and site III (2.2).

Tree density decreased with increasing tree diameter class (DBH) in all the study sites (Table 4). Similarly, species richness also decreased with increasing diameter size class. The juvenile population of trees (3.2-10 cm) contributed to 32.5%-42.5% of total tree density and 71%-78% to species richness. In adult tree species, 47%-53% of stems belong to smaller size classes i.e. DBH of 10-30 cm. Dominant tree species, *Albizia amara*, *Chloroxylon swietenia* and *Azadirachta indica* showed similar trend in diameter class wise distribution (Figure 4a-4c).

Table 1. Summary of tree diversity inventory in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

Variable	**Site I (8ha)**	**Site II (8ha)**	**Site III (4ha)**	**Total (20ha)**
Species richness	32	54	38	60
Genera	26	45	33	47
Families	18	28	23	29
Stand species richness range (no. ha^{-1})	7-21	14-25	18-28	7-28
Diversity indices				
Shannon	1.639	2.194	2.014	2.102
Simpson	0.374	0.248	0.288	0.292
Fisher's alpha	4.46	8.48	6.81	8.178
Individuals	5817	4929	1802	12548
Density (stems ha^{-1})	727+ 101	616 + 50	450.5 +22.4	627.4 +49.3
Total basal area (m^2)	150.79	162.54	108.82	422.15
Basal area (m^2 ha^{-1})	18.85+1.80	20.32+3.02	27.2+3.16	21.1+1.6
Stand tree density range (stems ha^{-1})	336-1075	400-809	406-512	336-1075
Stand basal area range (m^2 ha^{-1})	9.8-25.1	8.4-30.0	19.9-34.2	8.4-34.2

Table 3. Contribution of families to tree genera (G), species (S) richness, species-genera ratio and tree density (D) in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

Family	**Site I**				**Site II**				**Site III**			
	G	**S**	**D**	**S/G ratio**	**G**	**S**	**D**	**S/G ratio**	**G**	**S**	**D**	**S/G ratio**
Alangiaceae			0		1	1	4	1	1	1	40	1
Anacardiaceae	1	1	1	1	2	2	25	1			0	
Annonaceae			0		1	1	2	1			0	
Apocynaceae	1	1	59	1	1	1	28	1	1	1	27	1
Arecaceae			0				0		1	1	1	1
Bignoniaceae			0		1	1	1	1			0	
Caesalpiniaceae	2	3	10	1.5	4	5	138	1.25	2	3	7	1.5
Combretaceae			0		1	2	6	2	1	1	2	1
Ebenaceae	1	3	95	3	1	3	97	3	1	2	63	2
Erythroxylaceae			0		1	1	26	1	1	1	1	1
Euphorbiaceae	2	2	35	1	3	3	40	1	2	2	28	1
Fabaceae	3	4	29	1.33	2	4	90	2	3	4	226	1.33
Flindersiaceae	1	1	1017	1	1	1	1191	1	1	1	87	1
Hernandiaceae	1	1	20	1	1	1	100	1	1	1	16	1
Meliaceae	1	1	201	1	2	2	197	1	2	2	63	1
Mimosaceae	4	6	4206	1.5	4	6	2671	1.5	4	6	1047	1.5
Moraceae	1	1	3	1	1	2	9	2	1	1	5	1
Moringaceae	1	1	6	1	1	1	37	1	1	1	3	1
Nyctaginaceae			0		1	1	2	1			0	
Rhamnaceae			0		1	1	18	1	1	1	78	1
Rubiaceae	2	2	50	1	5	5	61	1	2	2	34	1
Rutaceae	1	1	60	1	2	2	114	1	1	1	22	1
Sapindaceae	1	1	9	1	1	1	10	1	1	1	1	1
Sapotaceae			0		1	1	2	1			0	
Simaroubaceae	1	1	1	1	1	1	20	1			0	
Strychnaceae	1	1	14	1	1	1	2	1	1	1	9	1
Symphoremataceae			0		1	1	5	1	1	1	33	1
Tiliaceae	1	1	1	1	1	1	8	1	1	1	3	1
Verbenaceae			0		2	2	25	1	2	2	6	1
	26	32	5817		45	54	4929		33	38	1802	

Table 4. Diameter class vise distribution of species richness and density of trees in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

Diameter class (DBH, cm)	Number of tree individuals			Number of tree species		
	Site I (8ha)	Site II (8ha)	Site III (4ha)	Site I (8ha)	Site II (8ha)	Site III (4ha)
3.2-10	3064	2510	789	25	42	27
10.-20	2877	1944	849	27	44	31
20-30	946	755	440	21	32	30
30-40	230	339	151	15	24	19
40-50	93	145	86	12	21	6
50-60	26	45	40	6	14	6
60-70	9	20	27	5	11	5
70-80	6	7	24	5	3	6
80-90	2	9	14	1	8	3
90-100	0	5	3	0	4	2
100-110	0	2	0	0	2	0
110-120	0	2	2	0	2	2

Discussion

Structurally and floristically the tropical dry forests are less complex than the wet forests, comprising about half or less number of tree species than those of wet forests (Murphy and Lugo 1986). The total species richness recorded in the three study sites was 60 species in 20 ha (for individuals ≥10 cm) and this value is lower than the values reported by others in other parts of forests in Eastern Ghats, India such as in Shervarayan hills (70/4ha; Kadavul and Parthasarathy 1999b), Kolli hills (78/8ha; Chittibabu and Parthasarathy 2000), Kalrayan hills (89/4ha; Kadavul and Parthasarathy 1999a), tropical forests at six major hill complex of southern Eastern Ghats (272/60ha, Arulpragasan and Parthasarathy 2010), Similipal Biosphere Reserve, Orissa (76/8.48 ha, Reddy et al. 2007), Nallamalais, Seshachalam and Nigidi hill ranges (137/3ha, Reddy et al. 2008), Sileru-Maredumilli range (153/3ha, Reddy et al. 2011) and Vishakapatnam (274/2 ha, Reddy and Prachi 2008). Similarly the value obtained here are lower than the values reported from large scale permanent plots inventories in wet tropical forests (Condit et al. 1996; Condit 2000; Kochumen et al. 1990; Ayyappan and Parthasarathy 2001). The low species richness obtained in the present study could be attributed to low and erratic rainfall pattern, anthropogenic perturbations and over grazing. However, the value obtained in the present study is closer to the values reported in tropical deciduous forests of Mudumalai (71/50 ha, Sukumar et al. 1992) and Vindhyan dry tropical forests (65/15 ha, Sagar and Singh 2005).

Quantitative inventories of tree species (≥10 cm dbh) across the tropics reveals a wide variation, ranging from 20 species ha^{-1} in flooded Varzea forest of Rio Xingu, Brazil (Campbell et al. 1992) to 300 species ha^{-1} in terra firma, Yanamono, Peru (Gentry 1988). The number of tree species (7-28 ha^{-1}) per stand recorded in the present study is at the lower end of the above said global range. Similarly, the values obtained here were low compared to various studies in Western Ghats (Chandrashekara and Ramakrishnan 1994; Ganesh et al. 1996; Parthasarathy and Karthikeyan 1997; Swamy et al. 2000). However, the range obtained in the present study is similar to several other studies (19-35 ha^{-1}; Mani and Parthasarathy 2005; 1-15 ha^{-1}, Sagar et al. 2008; 1-27 ha^{-1}, Sahu et al. 2008; 6-17 ha^{-1}; Krishnamurthy et al. 2010; 18-27 ha^{-1}, Anbarashan and Parthasarathy 2013). There is a wide variation in species richness in tropical dry forests in India and elsewhere. The variation in species composition, families and stand structure here may be due to location of the study sites, surface area of the forest, availability of water, intensity of grazing, intensity of human activates. Understorey vegetation here is dominated by alien invasive species *Lantana camara* and *Ageratum conyzoides* which indicator that these study sites are still under anthropogenic pressure. Alien plant invasions itself alter/affect the local plant diversity. This could also be one of the reasons for low diversity as well as changes in species composition and structure. Mani and Parthasarathy (2005) also reported that the geography, location, rainfall pattern, edaphic factors alter species composition, families and strand structures in tropical dry forest.

The species diversity depends on the adaptation of species and increases with the stability of community (Knight 1975) and reported that Shannon's index (H') is generally higher for tropical forests. But for Indian forests, the values ranged from 0.83 to 4.0 (Singh et al. 1984). The Shannon's diversity indices for trees in the present study ranged from 1.64 to 2.19 which is lower than those indices recorded by others in Eastern Ghats (Shervarayan hills, 2.37-3.072, Kadavul and Parthasarathy 1999b; Kalrayan hills, 2.305-2.869, Kadavul and Parthasarathy 1999a; Northern Andhra Pradesh, 4.56-5.18, Reddy et al. 2011; Malyagiri hill ranges, 3.38, Sahu et al. 2012) and other tropical dry forests (tropical dry deciduous forests in Sagar, 3.66, Thakur and Khare 2006; tropical dry deciduous forests in Bhadra Wildlife sanctuary, 3.39, Prakasha et al. 2008; Niyamgiri hills, 3.84-4.86, Dash et al. 2009; Dry deciduous forest of north Gujarat, 2.65, Kumar and Kalavathy 2012) of India while it lies closure to the values (1.85-2.05) reported by Panda et al. (2013) who study the whole range of Eastern Ghats. Comparison of indices is very difficult because of the difference in the area samples and lack of uniform plot dimensions and method of calculation. However, the dominance index is higher than those in other studies (mean-0.015; range 0.013-0.018, Panda et al. 2013; 0.099-0.192, Kadavul and Parthasarathy 1999a; 0.070-0.143, Kadavul and Parthasarathy 1999b). The higher dominance index could be attributed to mono-species dominance in this forest ecosystem.

Table 2. List of tree species with its density, basal are and IVI in 20 one hectare plots in tropical dry forests at Sathanur reserve forests, Tamil Nadu, India

Name of the Species	Family	Mean density (No. ha^{-1})			Mean basal area (m^2 ha^{-1})			IVI		
		site I (8ha)	Site II (8ha)	Site III (4 ha)	site I (8ha)	Site II (8ha)	Site III (4 ha)	site I (8ha)	Site II (8ha)	Site III (4 ha)
Acacia catechu (L.f.) Willd.	Mimosaceae	11.75	17.25	6.25	0.436	0.561	0.155	7.79	10.39	4.19
Acacia leucophloea Roxb.	Mimosaceae	0.13	1.75		0.001	0.028		0.06	1.30	
Acacia nilotica (L.) Willd. ex Delile	Mimosaceae			0.75			0.024			0.39
Aglaia elaeagnoidea (A. Juss.) Benth.	Meliaceae		0.25	0.25		0.001	0.011		0.14	0.19
Ailanthus excelsa Roxb.	Simaroubaceae	0.13	2.5		0.004	0.008		0.13	1.31	
Alangium salvifolium (L.f.) Wang.	Alangiaceae		0.5	10		0.015	0.202		0.41	4.56
Albizia amara (Roxb.) Bavi	Mimosaceae	504.75	310.75	249.5	14.178	10.740	15.092	176.73	136.90	153.21
Albizia lebbeck (L.) Benth.	Mimosaceae	0.88	1.63	0.5	0.084	0.437	0.026	0.72	3.65	0.39
Annona squamosa Linn.	Annonaceae		0.25			0.001			0.16	
Atalantia monophylla (L.) Correa	Rutaceae	7.5	14.13	5.5	0.121	0.189	0.148	10.64	5.69	4.07
Azadirachta indica A.Juss	Meliaceae	25.13	24.38	15.5	0.843	0.686	0.293	23.33	13.79	9.27
Bauhinia racemosa Lam.	Caesalpiniaceae	0.88	1.63		0.026	0.106		0.56	1.19	
Borassus flabellifer L. var.	Arecaceae			0.25			0.022			0.22
Butea monosperma (Lam.) Kuntze,	Fabaceae	1.13		0.5	0.009		0.033	0.75		0.53
Canthium dicoccum (Gaertn.) Teys. & Binn.	Rubiaceae	5.5	5.25	4.75	0.181	0.066	0.200	6.84	3.87	3.71
Cassia fistula Linn.	Caesalpiniaceae		0.13			0.003		0.00	0.07	
Cassia didymobotrya Fresen.	Caesalpiniaceae	0.13			0.001			2.34		
Cassia roxburghii DC.	Caesalpiniaceae			1			0.051	0.00		1.02
Cassia siamea Lam.	Caesalpiniaceae	0.25	11.88	0.25	0.001	0.530	0.005	0.07	9.85	0.19
Chloroxylon swietenia DC.	Flindersiaceae	127.13	148.88	21.75	1.534	2.165	0.283	40.53	54.24	12.72
Cleistanthus collinus (Roxb.) Benth.	Eubhorbiaceae		2.25			0.073		0.00	1.33	
Dalbergia lanceolaria L.	Fabaceae	0.13	0.13		0.009	0.001		0.10	0.08	
Dalbergia paniculata Roxb.	Fabaceae	2.25	0.88	2.75	0.171	0.101	0.085	1.84	0.53	1.25
Dalbergia sissoo Roxb. ex DC.	Fabaceae		0.13	0.75		0.014	0.022	0.00	0.22	0.75
Delonix elata (L.) Gamble	Caesalpiniaceae		0.13			0.037		0.00	0.19	
Dichrostachys cinerea (L.) Wight & Arn.	Mimosaceae	5.5	0.63	3.75	0.179	0.037	0.237	2.66	1.08	3.07
Diospyros ebenum Koen.	Ebenaceae	8.13	10.5	14	0.292	0.191	0.857	3.95	4.87	11.73
Diospyros ferrea (Willd.) Bakh.	Ebenaceae	0.13	1.5	1.75	0.004	0.038	0.086	0.09	0.58	1.44
Diospyros montana Roxb.	Ebenaceae	3.63	0.13		0.150	0.006		1.71	0.08	
Dolichandrone falcata (Wall. ex DC.) Seem	Bignoniaceae		0.13						0.08	
Drypetes sepiaria (Wight&Arn.) Pax&Hoffm.	Eubhorbiaceae	4.13	2.38	3.75	0.078	0.035	0.084	2.57	1.69	2.65
Erythroxylon monogynum Roxb.	Erythroxylaceae		3.25	0.25		0.056	0.014		1.43	0.20
Ficus benghalensis L.	Moraceae	0.38	0.75	1.25	0.024	0.147	0.288	4.20	1.00	1.68
Ficus glomerata Roxb.	Moraceae		0.38			0.004			0.17	
Garcinia spicata (Wight & Arn.) Hook.f.,	Rubiaceae	0.75	1.13		0.034	0.020		1.07	0.71	
Gardenia resinifera. Roth.	Rubiaceae		0.38			0.008			0.30	
Gmelina asiatica Linn.	Verbenaceae		0.88	0.25		0.010	0.038		0.28	0.27
Grewia tiliaefolia Vahl.	Tiliaceae	0.13	1	0.75		0.115	0.011	0.05	1.49	0.50
Gyrocarpus jacquinii Roxb.	Hernandiaceae	2.5	12.5	4	0.156	0.835	0.245	1.72	8.41	3.21
Lannea coromandelica (Houtt.) Merr.	Anacardiaceae		2.38			0.395			3.60	
Mallotus philippinensis Muell	Eubhorbiaceae	0.25	0.375	3.25	0.058	0.028	0.030	0.38	0.29	1.14
Manilkara hexandra (Roxb.) Dubard	Sapotaceae		0.25						0.10	
Moringa concanensis Nimmo	Moringaceae		4.63	0.75		0.641	0.124		4.65	1.15
Murraya koenigii (L.) Spreng.	Rutaceae		0.13						0.09	
Pavetta indica L.	Rubiaceae		0.13	3.75		0.001	0.021		0.07	2.23
Pisonia aculeata L.	Nyctaginaceae		0.25			0.005			0.13	
Pongamia pinnata (L.) Pierre	Fabaceae	0.13	10.13	52.5		0.626	5.192	0.05	6.79	41.13
Prosopis chilensis (Molina) Stuntz	Mimosaceae	2.75	1.88	1	0.101	0.099	0.058	1.33	1.29	0.68
Rhus mysorensis G. Don	Anacardiaceae	0.13	0.75		0.001	0.009		0.08	0.40	
Sapindus emarginatus Vahl.	Sapindaceae	1.13	1.25	0.25	0.042	0.058	0.014	1.61	1.43	0.20
Strychnos nux-vomica L.	Strychnaceae			2.25			0.045	0.00		1.35
Strychnos potatorum L.	Strychnaceae	1.75	0.25		0.017	0.032		0.82	0.47	
Syzygium cumini (L.) Skeels	Myrtaceae		0.63	8.25		0.092	2.233		0.88	12.01
Tamarindus indica L.	Caesalpiniaceae		3.5	0.5		0.648	0.058		5.51	0.56
Terminalia arjuna (Roxb.) Wight & Arn.	Combretaceae		0.38	0.5		0.075	0.019		0.63	0.45
Terminalia belerica Roxb.	Combretaceae		0.38			0.004			0.24	
Tricalysia sphaerocarpa (Dalz.) Gamble	Rubiaceae		0.75			0.031			0.48	
Vitex trifolia L.	Verbenaceae		2.25	1.25		0.134	0.014		1.56	0.69
Wrightia tinctoria (Roxb.) R.Br.	Apocynaceae	7.38	3.5	6.75	0.091	0.081	0.155	4.85	2.38	4.50
Ziziphus mauritiana Lam.	Rhamnaceae	0.75	2.25	19.5	0.019	0.097	0.729	0.42	1.54	12.53

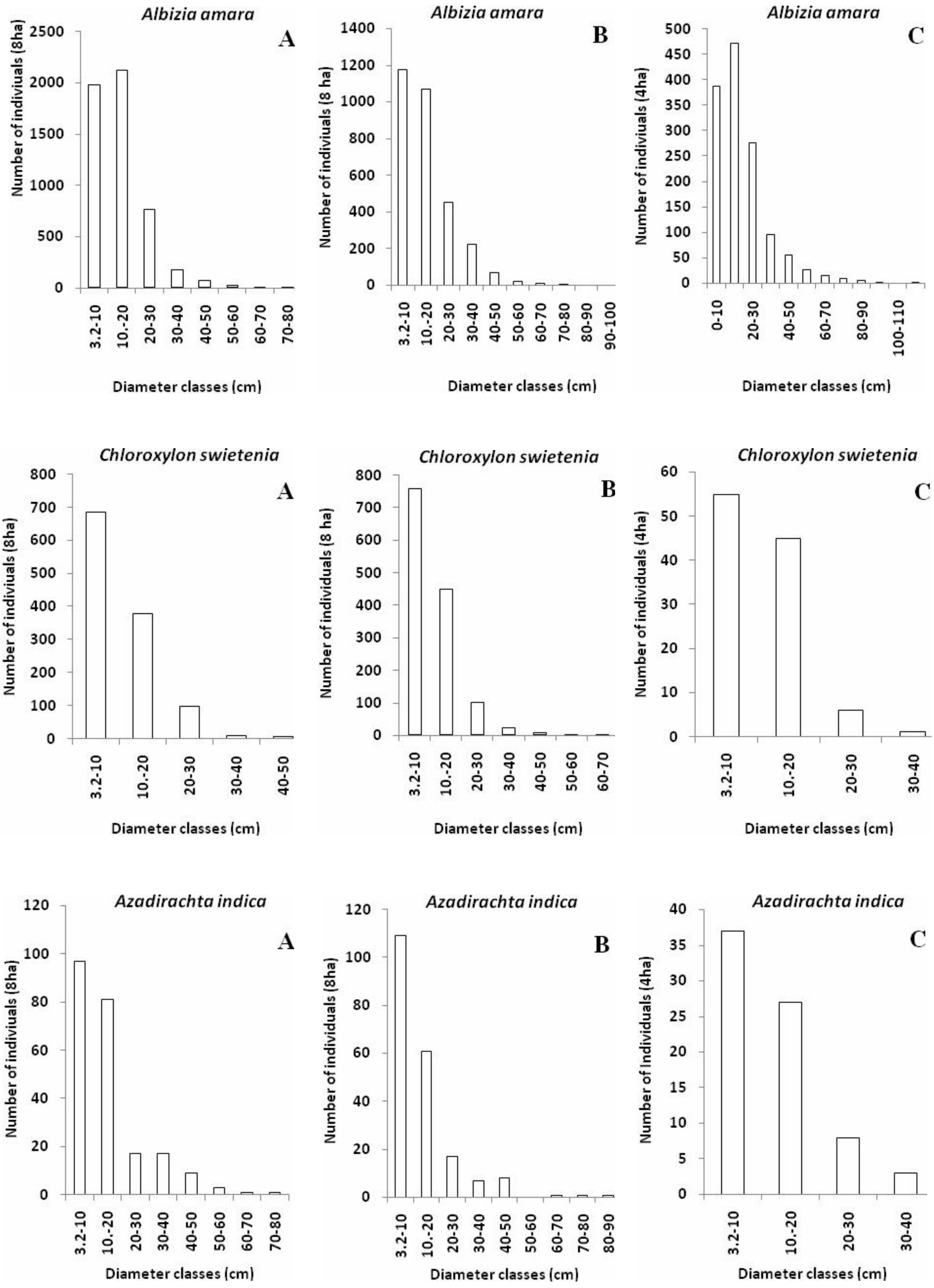

Figure 4. Distribution of dominant tree species in different diameter classes in tropical dry forests at Sathanur reserve forests, Tamil Nadu, India (A. Site I, B. Site II, and C. Site III).

The stand density of Sathanur reserve forest (mean 638.66 ha^{-1} ranged from 336-1075) is comparable to other tropical dry forests of Eastern Ghats in India such as Shervarayan hills (mean is 815 stems ha^{-1}, range 640-986; Kadavul and Parthasarathy 1999b), Kalrayan hills (367-667; Kadavul and Parthasarathy 1999a), Nallamalais, Seshachalam and Nigidi hill ranges (mean 735stems/ha and range 674-794; Reddy et al. 2008), Niyamgiri hills (mean 735 stems ha^{-1} and range of 674-796; Dash et al. 2009), Malyagiri hills (mean 443 stems ha^{-1} and ranges 276-905; Sahu et al. 2012) and eastern Ghats region of Odisha (mean 353 stems ha^{-1} ranged from 268-655; Panda et al. 2013), dry tropical forests of India (Jha and Singh 1990; Sagar and Singh 2005), in the tropical evergreen forests of southern Western Ghats Kalakkadu (+574-915 stems/ha Parthasarathy et al. 1992), Kodayar (352-1173 stems ha^{-1}; Sundarapandian and Swamy 2000), Uppangala 635 stems ha^{-1} (Pascal and Pelisser 1996) and other tropical forest of the world such as Costa Rica 448-617 (Heaney and Procter 1990). The tree density in deciduous forests of Eastern Ghats as reported in the present study is modest compared to other tropical forest zones. Tree density variation among the stands may be dependent on the efficacy of seed dispersal, survival and establishment and also on the level of resource extraction by humans as suggested by Kadavul and Parthasarathy (1999a).

The mean basal area recorded in the present study ranged from 18.8-27.2 m^2 ha^{-1} and this is well within the range of tropical dry forests in other parts of Eastern Ghats (6.6-23.2 m^2 ha^{-1}, Jha and Singh 1990; 7.792-49.2 m^2 ha^{-1}, Reddy and Prachi 2008; mean 29.0 m^2 ha^{-1}, range 8.15-41.17 m^2 ha^{-1} Sahu et al. 2008; 4.99-7.34 m^2 ha^{-1}, Bijalwan 2010; 0.01-2.88 m^2 ha^{-1}, Sahu et al. 2012; mean 10.47 m^2 ha^{-1}, 6.65 to 22.28 m^2 ha^{-1}, Panda et al. 2013) and in the world tropical forest such as Malaysia (24.2 m^2 ha^{-1}, Poore 1968); Brazilian Amazon (27.6 to 32.0 m^2 ha^{-1}; Campbell et al. 1986; 25.5-27.0 m^2 ha^{-1}, Campbell et al. 1992), Costa Rica forests (27.8 m^2 ha^{-1}; Lieberman and Lieberman 1987) and dry tropics (17-40 m^2 ha^{-1}, Murphy and Lugo 1986) but is lower than that of few regions in Eastern Gats (mean-33.7 m^2 ha^{-1}, Kadavul and Parthasarathy 1999a; mean 34.9 m^2 ha^{-1}, range 21.6 to 44.3 m^2 ha^{-1}; Kadavul and Parthasarathy 1999b; 34.39 m^2 ha^{-1}, Reddy et al. 2008; 26.30-34.3 m^2 ha^{-1}, Reddy et al. 2011), Mylodai, Courtallum reserve forest Western Ghats (42.6 m^2 ha^{-1}, Parthasarathy and Karthikeyan 1997), Uppangala, central Western Ghats, India (39.7m^2 ha^{-1}; Pascal and Pelissier 1996), Kalakkadu southern Western Ghats (53.3-94.6 m^2 ha^{-1}; Parthasarathy et al. 1992), other dry forests in India (36.31 m^2 ha^{-1}, Prakasha et al. 2008; 8-74 m^2 ha^{-1}, Sahu et al. 2008) and pan tropical average (32 m^2 ha^{-1}, Dawkins 1959). The low stand basal area obtained in the present study indicates that the high level of human disturbance in these forests.

Mimosaceae (7), Caesalpiniaceae (7), Fabaceae (5) and Rubiaceae (5) were the dominant families in terms of number of species in all the three study sites while Rubiaceae (5 genera) was the dominant family in terms of number of genera in study site II. Similarly, Fabaceae, Caesalpiniaceae and Mimosaceae was the most diverse families in Chacocene Wildlife refuge, Pacific coast, Nicaragua and Mimosaceae, Lauraceae, Moraceae, Fabaceae, Euphorbiaceae and Rubiaceae were the dominant families in the tropical wet forest of La Selva, Costa Rica (Lieberman and Lieberman 1987) while Euphorbiaceae, Rubiaceae, Moraceae are the most diverse families southern Eastern Ghats sites (Arulpragasan and Parthasarathy 2010).

Albizia amara (7522 number of stems/20ha) was the dominant species in terms of density and basal area (251.16 m^2/20 ha) except one stand in undisturbed forest sites in which *Chloroxylon swietenia* was the dominant species. It indicates that Sathanur reserve forest is a mono-species dominated forest ecosystem. Similarly Mono dominance of trees species have been reported from various tropical forests in tropical Asia (*Shorea curtisii* in Malaysia, Whitmore 1984; *Dryobalanops aromatica* in Sumatra, Whitmore 1984; *Shorea albida* in Baram, Sarawak, Connell and Lowman 1989; *Terminalia paniculata* and *Hopea parviflora* in Western Ghats, Swamy et al. 2000; *Eusideroxylon zwageri* in Borneo and *Poeciloneuron pauciflorum* in Agumbe, India, Srinivas and Parthasarathy 2000; *Tricalysia sphaerocarpa* and *Strychnos nux-vomica* in Southern Eastern Ghats, Anbarashan and Parthasarathy 2013; Terminalia paniculata in Western Ghats, Sundarapandian and Swamy, 2000, and Sundarapandian and Pascal 2013) and elsewhere (*Pentaclethra macroloba* in Costa Rica, Lieberman et al. 1985; *Celaenodendron mexicanum* in Mexico, Martijena and Bullock 1994: *Peltogyne gracilipes* in Maraca Island, Brazil, Nascimento and Proctor 1997). There are two views were explained by the scientist for the mono dominance in forests, (i) disturbance (Newbery et al. 2004) and (ii) little or no disturbance over long period of time (Connell and Lowman 1989; Hart et al. 1989). Mono dominance in the present study may be due to anthropogenic disturbance. In addition to that lower diameter class (≤20 cm DBH) contribution was 82% in disturbed forests sties and 67-77% in other two sites this also supported the above views. Whereas Peh et al. (2011) stated that observational and experimental results were contradictory to several hypotheses related to mono dominance tropical forest systems. However, understating the cause of classical mono dominance is remained elusive (Peh et al. 2011).

Ten tree species (33.33%) were rare in distribution because their presence is less than two individuals in all the 20 stands. This value is lower than that of other tropical forests (50% in West Java, Meijer 1959; 38% in Malaysia, Poore 1968; 55% in New guinea, Paijmans 1970; 40% in Barro Colorado Island, Panama, Thorington et al. 1982; 59% in Jengka forest reserve Malaysia, Ho et al. 1987; 40%, in Malaysian forests, Manokaran and Kochumen 1987; 43% in Kalrayan hill, Eastern Ghats, Kadavul and Parthasarathy 1999a; 60-62.5% in Western Ghats, Swamy et al. 2000: 46-73% in Periyar Wild life sanctuary, Western Ghats, Sundarapandian and Pascal 2013) while it is comparable with the values of Shervarayan hills (22.5%) of Eastern Ghats (Kadavul and Parthasarathy 1999b) and Coromandel coast26-31% of South India (Parthasarathy and Karthikeyan 1997). Twenty one tree species were commonly present in all the three study sites while 18 species occurred only in one of the three study sites and not in other two. Similarly, 12 common species and seven species were represented by only one individual in each plot was observed by Sukumar et al. (1992) in tropical deciduous forests of Mudumalai.

The stems density decrease with increase in size class of trees observed in the present study is in agreement with other reports (Ho et al. 1987; Lieberman et al. 1985; Swaine et al. 1987; Campbell et al. 1992; Chandrashekara and Ramakrishnan 1994; Brokaw et al. 1997; Sundarapandian and Swamy 2000; Sundarapandian and Pascal 2013). This indicated that this forest have good regeneration potentials. Similarly, species richness also decreased with increase in diameter class. Similar observation was also made by Parthasarathy and Karthikeyan (1997), Swamy et al. (2000) and Sundarapandian and Pascal (2013). Dominant species in these study sites also showed a similar trend. However, greater proportion (81.9%) stems in disturbed site belonging to lower diameter class (≥3.2 cm - <10 cm) this may be attributed to illegal cutting of adult trees for fuel wood and domestic usage. Even though the undisturbed study plots were far away from the canal, have good regeneration potential. Since plots in undisturbed sites are adjacent to the agriculture field, the trees here obtain the water and resources from the crop field with a help of extensive root system.

Human disturbances and cattle grazing in natural forest ecosystems have alter the structure and species composition and natural functions of ecosystems (Sundarapandian and Swamy 2000; Swamy et al. 2000; Kalabokidis et al. 2002, Arunachalam et al. 2004; Mishra et al. 2004; Anbarashan and Parthasarathy 2012). The impact of anthropogenic perturbation on forest characteristics would be site-specific (Htun et al. 2011). The tree species richness was observed to be lower in disturbed site compared to other two study sites. The lower number could be attributed to anthropogenic disturbance and cattle grazing. Even though it is a reserve forest, local people here are regularly collecting fire wood, felling, lopping and herding cattle for grazing. The disturbed sites are near to the road and agriculture field. Illegal selective felling of *Chloroxylon swietenia* for fence posts, house construction and other agricultural implements, and *Albizia amara* for fuel wood are quite common in this forest. Such a selective cutting may helpful as coppicing of those species which could affect forest species composition and stand structure. This has resulted in more density both species in the disturbed forests sites. The site near the canal has lower species richness than the undisturbed forests sites. This also may be due to human disturbance and edaphic factors. This study site has rocky surface area here and there which would alter the structure of the forests. However, this study site has greater basal area compared to disturbed and undisturbed forests sites which may be due to availability of water over long period in a year than other study sites. This is consistent with many of other dry forests, which are characterized by the presence of large number of low diameter-class individuals. Such a high density of small-sized individuals may also be attributed to the open canopy and lower densities of the larger individuals as suggested by Manokaran and Lafrankie (1990).

CONCLUSION

It is evident from the results that in general, species diversity of tropical dry forests comparable with dry forest and is lower than most other wet and evergreen forest. The present study reveals that the variation in species richness and structure among study sties could be attributed to physical heterogeneity and anthropogenic perturbation. Our results indicate that the vegetation still possesses comparatively substantial species diversity and have good regeneration potential in spite of being under continuous biotic influences.

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REFERENCES

Anbarashan M, Parthasarathy N. 2012. Tree diversity and forest stand structure along disturbance gradients in India tropical dry evergreen forest. Ecotropica 18: 119-136.

Anbarashan M, Parthasarathy N. 2013.Tree diversity of tropical dry evergreen forests dominated by single or mixed species on the Coromandel coast of India. Trop Ecol 54(2): 179-190.

Anonymous 1992. World Conservation Monitoring Centre (WCMC). Global Biodiversity: Status of the Earths Living Resources. Chapman & Hall, London.

Anonymous 2009. India forestry outlook study, Working paper. The Ministry of Environment and Forest, Government of India, New Delhi.

Armentaras D, Rodriguez N, Retana J. 2009. Are conservation strategies effective in avoiding the deforestation of the Colombian Guyana Shield? Biol Conserv 42: 1411-1419.

Arulpragasan L, Parthasarathy N. 2010. Landscape-level tree diversity assessment in tropical forests of southern Eastern Ghats, India. Flora 205: 728-737.

Arunachalam A, Sarmah R, Adhikari D, Majumder M, Khan ML. 2004. Anthropogenic threats and biodiversity conservation in Namdapha nature reserve in the Indian Eastern Himalayas. Curr Sci 87: 447-454.

Ayyappan N, Parthasarathy N. 2001. Patterns of tree diversity within a large scale permanent plot of tropical evergreen forest, Western Ghats, India. Ecotropica 7: 61-76.

Baithalu MS, Anbarashan M, Parthasarathy N. 2013. Two-decadal changes in forest structure and tree diversity in a tropical dry evergreen forest on the Coromandel Coast of India, Trop Ecol 54(3): 397-403.

Bijalwan A. 2010. Structure, composition and diversity of degraded dry tropical forest in Balamdi Watershed of Chhattisgarh plain, India. J Biodiv 1 (2): 119-124.
Blackie R, Baldauf C, Gautier D, Gumbo D, Kassa H, Parthasarathy N, Paumgarten F, Sola P, Pulla S, Waeber P, Sunderland T. 2014. Tropical dry forests: The state of global knowledge and recommendations for future research. Discussion Paper. CIFOR, Bogor, Indonesia.
Brokaw NVL, Grear JS, Tripplett KJ, Whitman AA, Mailtory EP. 1997. The Quebrada de Oro forest of Belize: Exceptional structure and high species richness. Trop Ecol 38: 247-258.
Campbell DG, Daly DC, Prance GT, Maciel UN. 1986. Quantitative ecological inventory of terra firm and varzea tropical forest on the Rio Xingu, Brazilian Amazon. Brittonia 38: 369-393.
Campbell DG, Stone JL, Rosas AJR. 1992. A comparison of the phytosociology and dynamics of three floodplain (Varzea) forest of known ages, Rio Jurua, western Brazilian Amazon. Bot J Linnaean Soc 108: 213237.
Champion HG, Seth SK. 1986. Revised survey of forest types of India. Oxford and IBH Publishers, New Delhi.
Chandrashekara UM, Ramakrishnan PS. 1994. Vegetation and gap dynamics of a tropical wet evergreen forest in the Western Ghats of Kerala, India. J Trop Ecol 10: 337-354.
Chittibabu CV, Parthasarathy N. 2000. Attenuated tree species diversity in human-impacted tropical evergreen forest sites at Kolli hills, Eastern Ghats, India, Biodiv Conserv 9: 1493-1519.
Condit R, Hubbell SP, Lafranke JV, Sukumar R, Manokaran N, Foster RB, Ashton PS. 1996. Species area and species individual relationships for tropical trees: a comparison of three 50-ha plots. J Ecol 84: 549-562.
Condit R. 2000. Spatial patterns in the distribution of tropical tree species. Science 288, 1414-1418.
Connell JH, Lowman MD. 1989. Low-diversity tropical rain forests: some possible mechanisms for their existence. Am Nat 134: 88-119.
Dash PK, Mohapatra PP, Giri Rao Y. 2009. Diversity and distribution pattern of tree species Niyamgiri hill Ranges, Orissa, India. The Indian For 135: No.7.
Dawkins HC. 1959. The volume increment of natural tropical high-forest and limitations of improvements. Empire For Rev 38: 175-180.
Ganesh T, Ganesan R, Soubadradevy M, Davidar P, Bawa KS. 1996. Assessment of plant biodiversity at a mid - elevation evergreen forest of Kalakad-Mundanthurai Tiger reserve, Western Ghats, India. Curr Sci 71: 379-92.
Gentry HA. 1988. Tree species richness of upper Amazonian forests. Proc Nat Acad Sci (USA) 85, 156-159.
Gentry HA. 1995. Diversity and floristic composition of neotropical dry forests. In: Bullock SH, Harold AM, Medina E (eds). Seasonally Dry Tropical Forests. Cambridge University Press, Cambridge.
Hart TB, Hart JA, Murphy PG. 1989. Mono dominant and species-rich forests in the humid tropics: causes for their co occurrence. Am Nat 133: 613-633.
Heaney A, Proctor J. 1990. Preliminary studies on forest structure and floristics on Volcan Barva, Costa Rica. J Trop Ecol 6: 307-320.
Hegde R, Enters T. 2000. Forest products and household economy: a case study from Mudumalai Wildlife Sanctuary, Southern India. Environ Conserv 27: 250-259.
Ho CC, Newbery DMcC, Poore MED. 1987. Forest composition and inferred dynamics in Jengka Forest Reserve, Malaysia. J Trop Ecol 3: 25-56.
Htun NZ, Mizoue N, Yoshida S. 2011. Tree species composition and Diversity at different levels of disturbance in Popa Mountain Park, Myanmar. Biotropica 43 (5): 597-603.
Janzen DH. 1998. Tropical dry forests: the most endangered major tropical ecosystem. In: ed. Wilson EO, Biodiversity National. Academy Press, Washington DC.
Jayakumar S, Arockiasamy DI, Britto SJ. 2002. Conserving forests in the Eastern Ghats through remote sensing and GIS - A case study in Kolli hills. Curr Sci 82: 1259-1267.
Jha CS, Singh JS. 1990. Composition and dynamics of dry tropical forest in relation to soil. J Veg Sci 1: 609-614.
Kadavul K, Parthasarathy N. 1999a. Structure and composition of woody species in tropical semi-evergreen forest of Kalrayan hills, Eastern Ghats, India. Trop. Ecol 40: 77-90
Kadavul K, Parthasarathy N. 1999b. Plant biodiversity and conservation of tropical semi-evergreen forest in the Shervarayan hills of Eastern Ghats, India. Biodiv Conserv 8: 421-439.
Kalabokidis D, Gatzojannis S, Galatsidas S. 2002. Introducing wildfire into forest management planning towards a conceptual approach. For Ecol Manage 158: 41-50.
Knight DHA. 1975. Phytosociological analysis of species rich tropical forest on Barro Colorado Island, Panama. Ecol Monogr 45: 259-284.
Kobe RK. 1999. Light gradient partitioning among tropical tree species through differential seedling mortality and growth. Ecology 80 187-201.
Kochumen KM, Lafrankie JV Jr, Manokaran N. 1990. Floristic composition of Pasoh forest reserves, a lowland rainforest in peninsular Malaysia. J Trop For Sci 3: 1-13.
Krishnamurthy YL, Prakasha HM, Nanda A, Krishnappa M, Dattaraja HS, Suresh, HS. 2010. Vegetation structure and floristic composition of a tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka, India. Trop Ecol 51 (2): 235-246.
Kumar SR, Kalavathy S. 2012. Status and Diversity of Tree, Seedlings and Saplings in Tropical Dry Deciduous Forest of North Gujarat Region (Ngr) Gujarat India Inter J Geol Ear Environ Sci 2 (3): 103-112.
Li YD, Zhou GY, Zeng QB, Wu ZM, Luo TS. 2003. The values for ecological service function of tropical natural forest in Hainan Island, China. For Res 16: 146-152.
Lieberman D, Lieberman M, Hartshorn G, Peralta R. 1985. Growth rates and age-size relationships of tropical wet forest trees in Costa Rica. J Trop Ecol 1: 97-109.
Lieberman D, Lieberman M. 1987. Forest tree growth and dynamics at La Selva. Costa Rica (1969-1982). J Trop Ecol 3: 347-369.
Mani S, Parthasarathy N. 2005. Biodiversity assessment of trees in five inland tropical dry evergreen forests of peninsular India. Syst Biodiv 3: 1-12.
Manokaran N, Kochumen KM. 1987. Recruitment, growth and mortality patterns and stand turnover of Dipterocarp forest in Peninsular In: Ecological Theory. University of Chicago Press, Chicago
Manokaran N. La Frankie JV. Jr. 1990. Stand structure of Pasoh forest reserve, a lowland rain forest in Peninsular Malaysia. J Trop For Sci 3: 14-24.
Martijena NE, Bullock SH. 1994. Monospecific dominance of a tropical deciduous forest in Mexico. J Biogeogr 21: 63-74.
Medina E. 1995. Neotropical dry forests. In: eds. Bullock SH, Mooney H.A and Medina, E, Seasonally Dry Tropical Forests. Cambridge University Press Cambridge, 146-194.
Meijer W. 1959 Plant sociological analysis of montane rain forest near Tji bodes, West Java. Acta Bot Neerlandica 8: 277-291.
Mishra N, Tripathi OP, Tripathi RS, Pandey HN. 2004. Effect of anthropogenic disturbance on plant biodiversity and community structure of a sacred grove in Meghalaya, northeast India. Biodiv Conserv 13: 421-436.
Mooney HA, Bullock SH, Medina E. 1995. Introduction. In: Bullock SH, Mooney HA, Medina E (eds.). Seasonally Dry Tropical Forests. Cambridge Univ. Press, Cambridge.
Murphy PG, Lugo AE. 1986. Ecology of dry tropical forest. Ann Rev Ecol Syst 17: 67-88.
Nascimento MT, Proctor J. 1997. Soil and plant changes across a monodominant rain forest boundary on Maraca Island, Roraima, Brazil. Glob Ecol Biogeogr 6: 387-395.
Natarajan D, Britto SJ, Balaguru B, Nagamurugan N, Soosairaj S, Arockiasamy DI. 2004. Identification of conservation priority sites using remote sensing and GIS - A case study from Chitteri hills, Eastern Ghats, Tamil Nadu. Curr Sci 86: 1316-1323.
Newbery DM, van der Burgt X M, Moravie MA. 2004. Structure and inferred dynamics of a large glove of *Microberlinia bisulcata* trees in central African rain forest: the possible role of periods of multiple disturbance events. J Trop Ecol 20: 131-143.
Paijmans K. 1970. An analysis of four tropical rainforest sites in New Guinea. J Ecol 58: 77-101.
Panda PC, Mahapatra AK, Acharya PK, Debata AK. 2013. Plant diversity in tropical deciduous forests of Eastern Ghats, India: A landscape level assessment. Inter J Biodiv Conserv 5 (10): 625-639.
Parthasarathy N, Karthikeyan R. 1997. Biodiversity and population density of woody species in a tropical evergreen forest in Courtallum Reserve Forest, Western Ghats, India. Trop Ecol 38: 297-306.
Parthasarathy N, Kinkal V, Praveen Kumar L. 1992. Plant species diversity and human impacts in the tropical wet evergreen forests of Southern Western Ghats. In: Indo-French workshop on tropical forest ecosystems: natural functioning and anthropogenic impact. November 1992. Pondicherry French Institute, Pondicherry.

Pascal JP, Pelissier R. 1996. Structure and floristic composition of a tropical evergreen forest in south-west India. J Trop Ecol 12: 191-214.

Pattanayak S, Sills EO, Mehta AD, Kramer RA. 2003. Local uses of parks: uncovering patterns of household production from forests of Siberut, Indonesia. Conserv Soc 1: 209-222.

Pearson TR, Burslem DFRP, Goeriz RE, Dalling JW. 2003. Interactions of gap size and herbivory on establishment, growth and survival of three species of neotropical pioneer trees. Ecology 91: 785-796.

Peh, KSH, Lewis SL, Lloyd J. 2011. Mechanism of mono dominance in diverse tropical tree-dominated systems. J Ecol 99: 891-898.

Pitman NCA, Terborgh JW, Silman MR, Percy NV, Neill DA, Ceron CE, Palacios WA, Aulestia M. 2002. A comparison of tree species diversity in two upper Amazonian forests. Ecology 83: 3210-3224.

Poore MED. 1968. Studies in Malaysian rainforest. 1. The forest on Triassic sediments in Jengka forest reserve. J Ecol 56: 143-196.

Prakasha HM, Nanda A, Krishnamurthy YL. 2008. Stand structure of a tropical dry deciduous forest in Bhadra wildlife sanctuary, Karnataka southern India, Bull Nation Inst Ecol 19: 1-7.

Reddy CS, Prachi Ugle. 2008. Tree species diversity and distribution patterns in tropical forest of Eastern Ghats, India: a case study. Forestry & Ecology Division, National Remote Sensing Agency, Balanagar, Hyderabad 500037, India. Life Sci J 4: 87-93

Reddy CS, Shipha Babar A, Giriraj KN, Reddy and K, Thulsi Rao. 2008. Structure and Floristic Composition of Tree Diversity in Tropical Dry Deciduous Forest of Eastern Ghats, Southern Andhra Pradesh, India. Asia J Sci Res1: 57-64.

Reddy CS, Babar S, Amarnath G, Pattanaik C. 2011. Structure and floristic composition of tree stand in tropical forest in the Eastern Ghats of northern Andhra Pradesh, India. J For Res 22(4): 491-500.

Reddy CS, Pattanaik C, Mohapatra A, Biswal AK. 2007. Phytosociological observations on tree diversity of tropical forest of Similipal Biosphere Reserve, Orissa, India. Taiwania, 52: 352-359.

Sagar R, Raghubanshi AS, Singh JS. 2008. Comparison of community composition and species diversity of understorey and overstorey tree species in a dry tropical forest of northern India. J Environ Manag 88 1037-1046.

Sagar R, Singh JS. 2005. Structure, diversity, and regeneration of tropical dry deciduous forest of northern India. Biodiv Conserv 14: 935-959.

Sahu SC, Dhal NK, Mohanty RC. 2012. Tree species diversity, distribution and population structure in a tropical dry deciduous forest of Malyagiri Hill ranges, Eastern Ghats, India. Trop Ecol 53(2): 163-168.

Sahu PK, Sagar R, Singh JS. 2008. Tropical forest structure and diversity in relation to altitude and disturbance in a Biosphere Reserve in central India. Appl Veg Sci 11: 461-470.

Singh JS, Singh SP, Saxena AK, Rawat YS. 1984. India's Silent valley and its threatened rain forest ecosystem. Environ Conserv 11: 223-233.

Singh SP, Rawat YS, Garkoti SC. 1997. Failure of brown oak (*Quercus semecarpifolia*) to regenerate in the Central Himalaya: a case of environmental semi-surprise. Curr Sci 73: 371-374.

Srinivas V, Parthasarathy N. 2000. Comparative analysis of tree diversity and dispersion in the tropical lowland evergreen forest of Agumbe, central Western Ghats, India. Trop Biodiv 7: 45-60.

Sukumar R, Dattaraja HS, Suresh HS, Radhakrishnan J, Vasudeva R, Nirmala S, Joshi, NV. 1992. Long-term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India. Curr Sci 62: 608-616.

Sundarapandian SM, Pascal J, Karoor. 2013. Edge effects on plant diversity in tropical forest ecosystems at Periyar Wildlife sanctuary in the Western Ghats of India. J For Res 24 (3): 403-418.

Sundarapandian SM, Swamy PS. 2000. Forest ecosystem structure and composition along the altitudinal gradient in the Western Ghats, South India. J Trop For Sci 12: 104-123.

Swaine MD, Lieberman D, Putz FE. 1987. The dynamics of tree populations in tropical forest: a review. J Trop Ecol 3: 359-366.

Swamy PS, Sundarapandian SM, Chandrasekar P, Chandrasekaran S. 2000. Plant species diversity and tree population structure of a humid tropical forest in Tamil Nadu, India. Biodiv Conserv 9: 1643-1669.

Thakur AS, Khare PK. 2006. Species diversity and dominance in tropical dry deciduous forest ecosystem. J Environ Res Dev 1(1): 26-31.

Thorington Jr, RW, Tannenbaum B, Tarak A, Rudran R. 1982. Distribution of trees on Barro Colorado Island: A five hectare sample. In: Leigh EG, Jr, Rand AS, Windsor DM (eds). The ecology of a tropical forest-seasonal rhythms and long-term changes. Smithsonian Institution Press, Washington, DC.

Uma Shankar. 2001. A case of high tree diversity in a Sal (*Shorea robusta*) - dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. Curr Sci 81: 776-786.

Waeber P, Ramesh B, Parthasarathy N, Pulla S, Garcia C. 2012. Seasonally dry tropical forests in South Asia: A research agenda. A research agenda to contribute to the discussions on "Key Issues for the Global Dry Forests" workshop organized by CIFOR/For Dev in Zurich, 28–30th October 2012.

Wang XC. 2003. Problems and relevant strategies on natural forest protection in Changobai Mountain forest area. J For Res 14: 259-262.

Whitmore, TC. 1984. Tropical rain forests of the Far East, second edition. Clarendon Press, Oxford, U.K.

Yosi C, Keenan R, Fox J. 2011. Forest dynamics after selective timber harvesting in Papua New Guinea. For Ecol Manage 262: 895-902.