Journal of Applied and Natural Science
10 (4): 1085 -1093 (2018)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Assessment of tree diversity in distinctive deciduous forests of Suruli falls, Southern Western Ghats

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Article Info
DOI: 10.31018/jans.v10i4.1879
Received: August 29, 2018
Revised: September 14, 2018
Accepted: October 4, 2018

How to Cite
Naveenkumar, J. and Sundarapandian, SM. (2018). Assessment of tree diversity in distinctive deciduous forests of Suruli falls, Southern Western Ghats. *Journal of Applied and Natural Science*, 10 (4): 1085 -1093

Abstract
A quantitative inventory was conducted in two distinctive tropical deciduous forests at Suruli falls forest of southern Western Ghats. Two one-hectare plots were established and all trees >10cm DBH measured. Species richness, density, family importance value (FIV) and importance value index (IVI) were calculated and the results varied among the two sites. A total of 777 stems and 52 species were documented in both the sites and moist deciduous forest (MDF) had maximum number species richness and density than dry deciduous forest (DDF). The basal area was higher in MDF (502 stems/ha and 16.52 m^2/ha) than in DDF (275 stems/ha and 7.23 m^2/ha). However, Shannon and evenness indices showed a negative trend (DDF- 2.62, 0.41 and MDF- 2.37, 0.27). Diameter class-wise distribution of trees showed reverse 'J shaped' curve in both the forest types. *Pterocarpus marsupium* was the mono-dominant species holding one-third of the IVI (113), 27% of the stem density and 30% of the total basal area. DDF site is suspected to recurrence of annual fire. *Anogeissus latifolia* and *Strychnos potatorum* were the fire-tolerant species only found in lower diameter class. The maximum species shared contiguous distribution in the deciduous forests. The observed variations in the tree community between the two deciduous forest sites are possibly due to variations in altitude, rainfall, temperature, past disturbance, fire and edaphic characteristics.

Keywords: Tropical forest, Species richness, Forest fire, Distribution, Mono-dominance

INTRODUCTION

Tropical forests are the richest and complex biomes on the earth's surface and it is providing 50% of the world life form (Wilson, 1988) that includes 96% of tree species richness (Poorter *et al.,* 2015). However, these forest ecosystems are losing their ability due to increasing biotic infestation such as anthropogenic perturbations and cattle grazing (Sundarapandian and Swamy, 2000). Tropical forest of Asia, mainly those of Western and Eastern Ghats of southern India are declining at an alarming rate because of pertaining anthropogenic pressure which is either being replaced by inferior species or change in land use pattern (Parthasarathy, 1999). The disappearance of these tropical forest ecosystem comes at a time when information about their structure and dynamics remains inadequate (Hubbell and Foster, 1992). Anthropogenic intervene in this forests is still past and pre-history (Parthasarthy, 1999). Documentation and impacts on genetic tree diversity are quite difficult as quantitative information is lacking (Ledig, 1992). So the inventory of tree species is a vital aspect for the conservation of forest as they are the essential structural characteristics of the forest (Aye *et al.,* 2014).

India is one amongst the tropical countries and concerning 54% and 37% of Indian tropical forests that are classified as dry and moist deciduous forests respectively (Kaul and Sharma, 1971; Krishnamurthy *et al.,* 2010). The Western Ghats are chain hills on the West Coast of India covering around 1500 kilometer of the geographical area which passes through the states of Goa, Maharashtra, Karnataka, Tamil Nadu and Kerala with (Nair and Daniel, 1986; Karuppusamy and Ravichandran, 2016). The environmental condition and elevation gradient has resulted in an exceedingly different form of vegetation types, viz., evergreen, semi-evergreen, moist deciduous and dry deciduous forest types. Deciduousness is the associate adaptive strategy of those forests because of the prolonged dry season, slope and aspects (Singh and Kushwaha, 2016) and species composition vary with seasonality, rainfall, altitude and level of disturbance (Reddy et al. 2008).

Tropical deciduous forests are the foremost vul-

nerable ecosystems in India, because of economic exploitation (Reddy *et al.,* 2008) and recurrence of seasonal fire (Verma and Jayakumar, 2015). Notably, the dry deciduous forests are more susceptible to fire, that accounts more than 40% of all the forest types in India (Wikramanayake *et al.,* 1998; Rodgers *et al.,* 2002; Hiremath and Sundaram, 2005; Krishna and Reddy, 2012; Naveenkumar *et al.,* 2017). In recent years, Western Ghats deciduous forest fire recurrence interval has inflated over 100 years, and therefore now the average recurrence interval is 3.3 years (Kodandapani *et al.,* 2004).

The impact of human disturbance and recurrence of forest fire is continuing for many years, then the primary deciduous forests will be degraded into savanna-woodlands and open scrublands (Saha, 2003) with a regressive alteration of tree communities to grass dominance (Freson *et al*., 1974; Misra, 1983; Murphy and Lugo, 1986; Puyravud *et al*., 1994; Roth, 1999). It envisages a simplification of a climax to the degraded community with a loss of species diversity, canopy cover and a decline in vegetation (Saha, 2003).

The woody plant inventories in Western Ghats have been studied by several researchers (Ramesh and Pascal, 1991; Pascal and Pelissier, 1996; Parthasarathy, 1999; Ayyappan and Parthasarathy, 1999; Swamy et al., 2000; Sundarapandian and Swamy, 2000; Sundarapandian and Karoor, 2013; Sathis*et al*., 2013; Mohandas *et al*., 2016). However, the inventories on deciduous forest ecosystem are inadequate except few studies (Kothandaraman and Sundarapandian, 2017, Verma and Jayakumar, 2015; Padmakumar *et al.,* 2018). Therefore, it is further stressed that there is an urgent need for quantitative inventory in the deciduous forest ecosystem. The primary aim of the study was to evaluate quantitative changes in diversity in different tropical forest types at the various elevations in Megamalai Wildlife Sanctuary, southern Western Ghats. The present study is a part of the large-scale inventory i.e, quantitative inventory of trees in Suruli falls deciduous forest ecosystems, Southern Western Ghats.

MATERIALS AND METHODS

The present investigation was carried out at Suruli falls forest of Megamalai Wildlife Sanctuary, southern Western Ghats. The study sites are in the Cumbum forest range of Theni district Tamil Nadu and the dry deciduous forest (DDF) site located at 9˚39'23.98" N & 77˚18'15.0" E, and the moist deciduous forest (MDF) site located at 9˚39'14.08" N & 77˚19'6.59" E. The annual rainfall varied between 500-900 mm. Forest is classified into southern Tropical Dry Deciduous forests and southern Tropical Moist Deciduous forest (Champion and Seth, 1968).

Two tropical deciduous forests namely dry deciduous forest (DDF) and moist deciduous forest (MDF) were selected (Fig. 1, Contour line map prepared and marked the study sites by using freely downloadable QGIS software, https://qgis.org/en/site/forusers/ download.html). They varied in their terrain characteristics MDF is located at a higher elevation (670 m msl) than DDF (420 m msl). Both the sites are located in the Megamali Wildlife Sanctuary. Both the study site are far away from human settlements. DDF is subjected to recurrence of seasonal fire.

Two one-hectare square plots of 100 m × 100 m were laid, one in each forest type. This was further sub-gridded into 10 m × 10 m workable units. All living tree (>10 cm DBH) individuals were enumerated and their girth was measured at breast height (1.37 m). Density, basal area, frequency, importance value index (IVI) and family importance value (FIV) were calculated. The distribution pattern of tree species was calculated by abundance to frequency method (A/F; Curtis and Cotton, 1956). Diversity indices were computed using Past 3.1 software (version 3.1; Øyvind Hammer, Natural History Museum, University of Oslo).

RESULTS

In tropical deciduous forest sites of Suruli falls region, overall 52 tree species were enumerated that were belonged to 35 genera and 21 families (Table 1). The distribution of species richness was more in MDF- moist deciduous forest (39 species) than DDF-dry deciduous forest (34 species). A similar pattern was observed in the case of stem density and basal area is concerned. Shannon's index, Alpha diversity and evenness index showed greater values in DDF, whereas dominance index showed greater values in MDF (Table 1).

The most speciose families in both the studied sites were Fabaceae (10) followed by Rubiaceae (5), Rhamnaceae (4), Ebenaceae (3), Moraceae (3) and Sapindaceae (3). The predominant family Fabaceae alone contributed 32% in terms of cumulative tree density of both the study sites followed by Combretaceae 17% and Loganiaceae 12%. In DDF, Verbenaceae (57 in abundance) was the dominant family in terms of density even though Fabaceae (7 species) and Rubiaceae (4 species) were dominated at the species level. However, Fabaceae was the dominant family in terms of richness as well as density in MDF. Both the forest sites shared 16 common families of which two families (Annonaceae and Hernandiaceae) were only confined to DDF and three families (Apocynaceae, Ebenaceae and Meliaceae) were vested only with MDF (Table 2). As per botanical genera, the maximum members (28) were found in DDF and 27 members were enumerated from the MDF. Contrarily, the highest tree species richness (39) was observed in the MDF and the

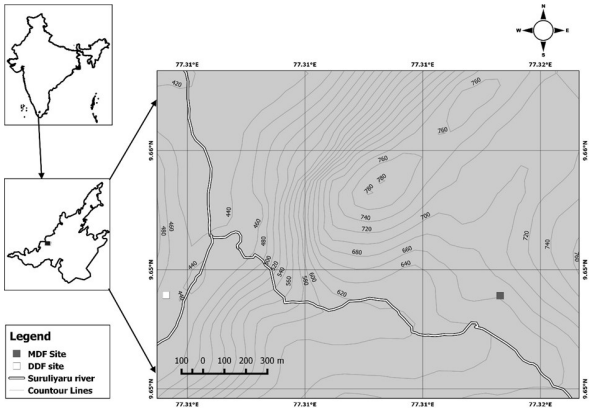

Fig. 1. *Location of the study plots in Tropical deciduous forest of Suruli falls forest, Southern Western Ghats.*

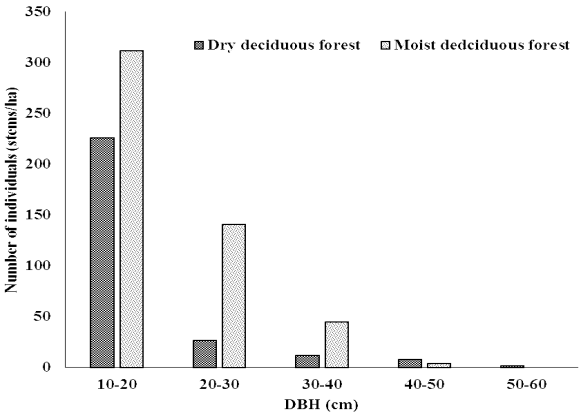

Fig. 2. *Diameter class wise distribution of tree species in tropical deciduous forest of Suruli falls, Southern Western Ghats.*

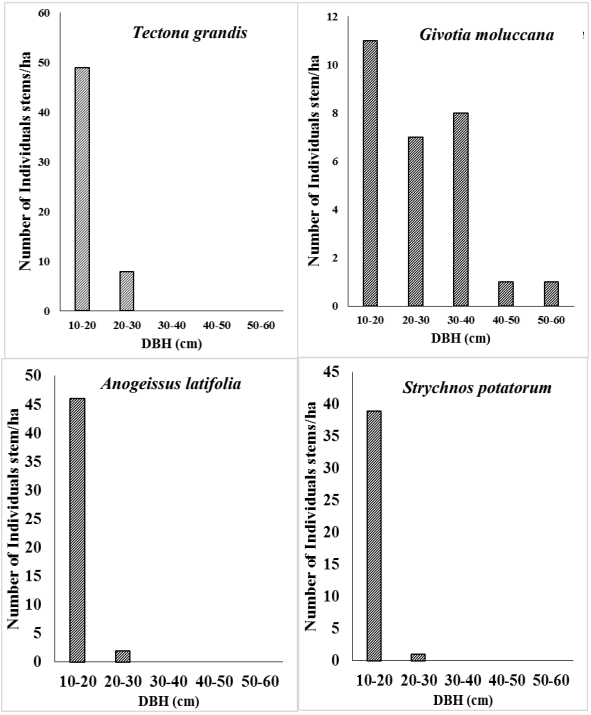

Fig. 3. *Diameter class distribution of dominant tree species in tropical dry deciduous forest of Suruli falls, Southern Western Ghats.*

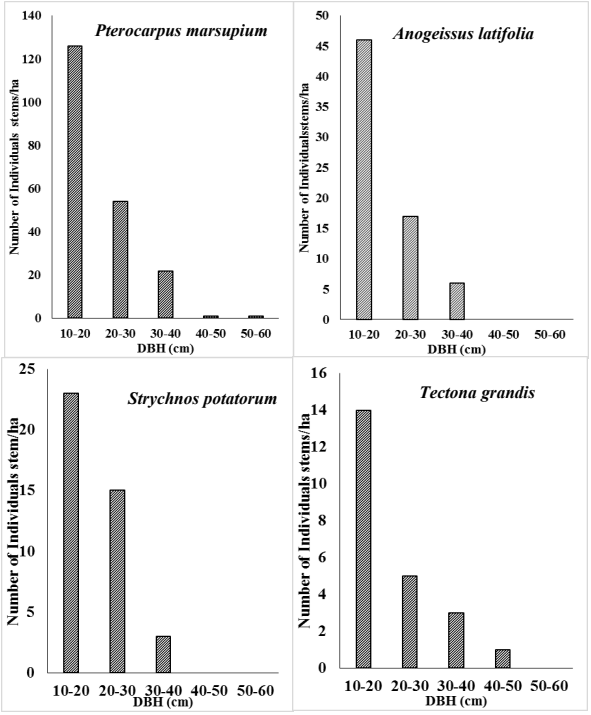

Fig. 4. *Diameter class distribution of dominant tree species in tropical moist deciduous forest of Suruli falls, Southern Western Ghats.*

lowest species richness (34) was found in the DDF (Tables 2 and 3).

A total of 777 tree (≥ 10 cm DBH) individuals were enumerated in both the sites, of which MDF harboured 502 individuals, while DDF had 275 individuals. Similarly, the basal area of both study sites was 23.75 m² and it increased with an increase in abundance. The basal area of MDF (16.52 m^2/ha) was two times higher than DDF (7.23 m^2/ha) (Table 1). *Pterocarpus marsupium* was the only mono-dominant species in MDF which accounted for 27% of the total stem density and 30% of the total basal area in both the sites.

The site DDF was dominated by *Tectona grandis* (IVI) and followed by *Givotia moluccana, Anogeissus latifolia* and *Strychnos potatorum* whereas, *P. marsupium* (IVI) was the dominant species in MDF followed by *A. latifolia, S. potatorum* and *G. moluccana* (Table 3). Interestingly in both sites, eleven species had only one individual. Overall twenty-one species were common to both the sites and 13 species were confined to DDF and 18 species were restricted to MDF alone.

Diameter class distribution of trees (≥10 cm DBH) showed abundance of trees decreases with increasing size class in both the study sites (Fig. 2). Maximum numbers of individuals were restricted to lower diameter class (10-30 cm). Distribution of dominant species were also showed similar pattern except for *G. moluccana* (Fig. 3 and 4). Forty-

Table 1. Consolidated details of Tree species in Tropical deciduous forest of Suruli falls forest, Southern Western Ghats.

Characteristics	Dry Deciduous Forest	Moist Deciduous Forest
Total no of Species (No./ha)	34	39
Genera	28	27
Family	18	19
Density (Stems/ha)	275	502
Basal Area (m^2/ha)	7.23	16.52
Shannon's index	2.652	2.378
Evenness index	0.4173	0.2765
Dominance index	0.11	0.20
Fishers Alpha	10.21	9.879

Table 2. Family Contribution of Genera, species richness and density (No/ha) tree species in Tropical deciduous forest of Suruli falls forest, Southern Western Ghats.

Family	Dry Deciduous Forest			Moist Deciduous Forest		
	Genera	Species	Density	Genera	Species	Density
Anacardiaceae	1	1	2	1	1	2
Annonaceae	1	1	1			
Apocynaceae				1	1	1
Bignoniaceae	1	1	1	1	2	2
Burseraceae	2	2	2	2	3	9
Caesalpiniaceae				1	1	5
Combretaceae	2	2	61	2	2	71
Ebenaceae				1	3	22
Euphorbiaceae	2	2	33	1	1	25
Fabaceae	5	7	26	3	6	216
Hernandiaceae	1	1	2			
Lamiaceae	1	1	2	1	1	1
Loganiaceae	1	1	40	1	2	50
Lythraceae	1	1	2	1	1	4
Malvaceae	1	2	4	1	1	8
Meliaceae				2	2	4
Moraceae	1	2	3	1	1	1
Phyllanthaceae	1	1	4	1	2	6
Rhamnaceae	1	2	4	1	4	26
Rubiaceae	3	4	19	2	2	14
Sapindaceae	2	2	12	2	3	12
Verbenaceae	1	1	57	1	1	23

seven species were contagiously distributed and three were randomly distributed and two species were regularly distributed.

DISCUSSION

The tropical forest ecosystems are rich in biotic community worldwide. The species richness and abundance differ considerably among the tropics, particularly dry and moist tropical forests (Gentry, 1988; Naidu *et al.,* 2018). High species richness is one of the characteristic features of the wet tropical ecosystem (Parsons and Cameron, 1947). The present study harboured high species richness in MDF-Moist deciduous forest (39 species) than that of DDF-Dry deciduous forest (34 species). Generally, tree species richness decreases with increase in altitude (Garibaldi and Linera, 2014), however, mid-altitude (approximately 600-1000 msl) has greater species richness than that of low and high altitude (Sundarapandian and Swamy, 2000; Reddy *et al.,* 2011; Sundarapandian *et al.,* 2015; Kanagaraj *et al.,* 2017; Naveenkumar *et al.,* 2017; Kothandaraman and Sundarapandian, 2017). Our results support the findings of Murphy and Lugo (1986) who reported wet forests are more diverse than dry forests. The species variation between the two forest types in the present study was also influenced by moisture and elevation.

The species richness (>10 cm DBH) at one-hectare scale is varied from across the tropical countries (20-307 species/ha, Campbell *et al.,* 1992; Valencia et al. 1994) and also peninsular southern India (ranged from 4 species/ha, dry forest, Vindayan Hills, Eastern Ghats; Sagar *et al*., 2003 to 85 species/ha, wet forest Kalakad-Mundanthurai, Western Ghats, Parthasarathy, 1999). The range value (34-39 species/ha) obtained from this study is comparable with other dry forests from (26-54/ha: Arulpragasan and Parthasarathy, 2010; 34-45/ha, Srinivas and Sundarapandian, 2018). However, the value is lower than findings of other parts of wet forest ecosystem, 65 species/ha in Varagalayar Anama-

Table 3. Density (A), frequency (F), basal area (BA) and importance value index (IVI) of tree species in Tropical deciduous forest of Suruli falls forest, Southern Western Ghats.

Species	Dry Deciduous Forest				Moist Deciduous Forest			
	A	F	BA	IVI	A	F	BA	IVI
Pterocarpus marsupium Roxb.	4	4	0.11	4.98	204	77	6.98	107.86
Anogeissus latifolia (Roxb. ex DC.) Wall. ex Guill. & Perr.	48	32	0.61	42.02	69	47	2.03	40.90
Tectona grandis L.f.	57	36	1.14	54.55	23	18	0.84	15.33
Givotia moluccana (L.) Sreem.	28	23	1.83	47.10	25	18	0.78	15.37
Strychnos potatorum L.f.	40	27	0.54	35.52	41	30	1.33	25.74
Terminalia elliptica Willd.	13	11	1.08	25.20	2	2	0.07	1.44
Morinda pubescens J.E. Smith.	11	9	0.25	11.94	10	9	0.45	7.55
Schleichera oleosa (Lour.) Oken	8	3	0.13	6.15	9	8	0.45	7.07
Dalbergia lanceolaria ssp. *lanceolaria* L.f	4	4	0.42	9.21	6	6	0.10	3.73
Ziziphus xylopyrus (Retz.) Willd.	3	2	0.03	2.51	13	11	0.33	8.10
Diospyros Montana Roxb.					15	12	0.02	6.93
Acacia catechu (L.f.) Willd.	7	4	0.14	6.49				
Grewia umbellate Roxb.	1	1	0.02	1.10	8	7	0.25	5.29
Garuga pinnata Roxb.	1	1	0.04	1.47	7	7	0.19	4.73
Strychnos nux-vomica L.					9	7	0.33	5.98
Albizia odoratissima (L.f.) Willd.	4	4	0.10	4.83	1	1	0.01	0.59
Cassia fistula L.	5	3	0.15	5.38				
Phyllanthus polyphyllus Willd.	4	4	0.05	4.16	2	2	0.02	1.15
Mallotus philippensis (Lam.) Muell.Arg.	5	5	0.06	5.11				
Ziziphus glabrata Wight	1	1	0.01	1.01	6	5	0.16	4.06
Diospyros melanoxylon Roxb.					6	4	0.40	4.85
Ixora arborea Roxb. ex J. E. Sm.	6	3	0.06	4.46				
Lagerstroemia parviflora Roxb.	2	1	0.02	1.52	4	3	0.18	2.83
Sapindus emarginatus Vahi.	4	3	0.04	3.56	1	1	0.01	0.58
Lannea coromandelica (Houtt.) Merr.	2	1	0.03	1.63	2	2	0.13	1.83
Commiphora caudata Engl.	1	1	0.01	1.06	2	2	0.17	2.09
Grewia tiliaefolia Vahl.	3	3	0.03	3.01				
Bauhinia racemosa Lam.					5	4	0.12	3.00
Ficus religiosa L.	2	2	0.07	2.72				
Gardenia latifolia Ait.					4	4	0.11	2.72
Phyllanthus emblica L.					4	4	0.08	2.57
Premna tomentosa Wild.	2	2	0.05	2.47				
Ziziphus rugosa Lam.					4	3	0.10	2.36
Ficus mollis Vahl.	1	1	0.11	2.34				
Gyrocarpus americanus Jacq.	2	2	0.04	2.26				
Ziziphus jujube Mill.					3	3	0.10	2.15
Albizia lebbeck (L.) Benth.	1	1	0.03	1.27	1	1	0.04	0.75
Stereospermum colais DC.	1	1	0.01	0.99	1	1	0.08	0.99
Ficus callosa Wild.					1	1	0.24	1.95
Chukrasia tabularis A.Juss.					3	3	0.06	1.92
Dalbergia pinnata (Lour.) Prain					1	1	0.14	1.39
Dalbergia latifolia Roxb.					3	2	0.01	1.31
Sapindus trifoliatus L.					2	2	0.02	1.16
Diospyros ovalifolia Wight					1	1	0.09	1.08
Albizia amara (Roxb.) Boiv.	1	1	0.01	1.03				
Canthium parviflorum Lam.	1	1	0.01	1.01				
Canthium coromandelicum (Burm.f.) Alston	1	1	0.01	0.97				
Miliusa Montana ex Hook.f. and Thomson	1	1	0.01	0.97				
Stereospermum tetragonum DC.					1	1	0.04	0.77
Wrightia tinctoria R.Br.					1	1	0.02	0.66
Gmelina arborea Roxb.					1	1	0.02	0.64
Aphanamixis polystachya (Wall.) R.Parker					1	1	0.01	0.59

lai (Ayyappan and Parthasarathy, 1999), 6-31 species (0.1ha) in Periyar Tiger Reserve Kerala (Sundarapandian and Karoor, 2013) and 56 species in Nilgiri (Mohandass *et al.,* 2016). The variation in species composition, families and stand structure may be attributed to the location of the study sites, the surface area of the forest, micro-climate, availability of water, intensity of grazing, the intensity of human activates etc., (Gandhi and Sundarapandian, 2014). However, total species

richness of 52 species/2ha from this study is difficult to compare because of variation in plot dimension and methods employed (Apgaua *et al*., 2015).

Gentry (1988) noted that tropical forest ecosystems are mostly dominated by Leguminosae family members. The results from our study showed that Fabaceae was the most specious family in both the sites. Fabaceae is the sub-family of Leguminosae. The same Fabaceae family was dominant in some parts of Eastern Ghats (Gandhi and Sundarapandian, 2014; Sundarapandian *et al.,* 2015; Kanagaraj *et al.,* 2017). However, mostly Western Ghats forest ecosystem was dominated by Euphorbiaceae members (Ayyappan and Parthasarathy, 1999; Sundarapandian and Karoor, 2103; Sathish *et al.,* 2013; Kothandaraman and Sundarapandian, 2017).

Murphy and Lugo (1986) suggested that the dry tropic forest basal cover ranged from 17-40 m^2/ha and wet forest basal cover ranged from 20-75 m^2/ha. In the present study, both the plots have lesser than above range. Similarly, the basal area value is lower than values reported from other studies in India and elsewhere (25.5m^2/ha, Campbell *et al.,* 1992; 82.67m^2/ha, Strasberg, 1996; 36.26 m^2/ha, Ayyappan and Parthasarathy, 1999; 21.50-47.30 m^2/ha, Lal *et al.,* 2015; 9.96-34.15 m^2/ha, Yadav, 2016; 17.45-37.70 m^2/ha, Naveenkumar *et al.,* 2017; 13-28.42 m^2/ha,Naidu *et al.,* 2018; 20.5-29.4 m^2/ha, Srinivas and Sundarapandian, 2018). This may be past intervention of this forest. However, the MDF (Higher elevation) site basal area value is higher than the DDF (Lower elevation) site. Similar results were also reported from the Eastern Ghats and Western Ghats (Swamy *et al.,* 2000; Sundarapandian *et al.,* 2015; Kothandaraman and Sundarapandian, 2017). The differences in the basal area may be attributed to species composition, the age of the trees and degree of disturbances (Sundarapandian and Swamy, 2000).

The average density of this study (389 stems/ha) and it's range from 275-502 stems/ha is well within the tropical forest range (276-905 stems/ha) reported by Ghate *et al.* (1998). The density value obtained from this study is comparable with several other studies of peninsular India (Ayyappan and Parthasarathy, 1999; Sundarapandian and Swamy, 2000; Arulparagasam and Parthasarathy, 2010; Sundarapandian and Karoor, 2013; Satish *et al.,* 2013; Naveenkumar *et al.,* 2017; Kothandaraman and Sundarapandian, 2017; Naidu *et al*., 2018). This results comparatively lower than other parts of India and elsewhere (Pascal and Pelissier, 1996; Kumar *et al.,* 2010; Lal *et al*., 2015; Yadav, 2016; Srinivas and Sundarapandian, 2018). This may be due to site-specific characters like rainfall, temperature, edaphic conditions etc.

The tropical forest holds a high value of Shannon index (H') and in India, it ranged from 0.83 – 4.0 (Singh *et al.,* 1984). In the present study, Shannon index value ranged 2.38-2.65 lies within the above range and also closer to other Indian forests (Sundarapandian and Swamy, 2000; Sundarapandian and Karoor, 2013; Kothandaraman and Sundarapandian, 2017). However it is lower than other deciduous forests values obtained from various parts of India (3.66, Thakur and Khare, 2006; 3.39, Prakasha *et al,.* 2008; 3.84-4.86, Dash *et al.,* 2009; 4.56-5.18, Reddy *et al.,* 2011; 3.38, Sahu *et al*., 2012). Site MDF has higher dominance index value than DDF is may be subjected to single specific dominance exist in this MDF, Diversity index value higher in DDF than MDF is due to the high value of evenness index in DDF.

Considering the importance value index (IVI) *P. marsupium* was the dominant species (113) followed by *A. latifolia* (83)*, T. grandis* (69), *G. moluccana* (62) and *S. potatorum* (61) in both sites. The dominant species in terms of density was *T. grandis* followed by *A. latifolia* and *S. potatorum* in DDF, but were only found in the lower diameter class and did not reach a larger size. *P. marsupium* was the dominant species holding 204 individuals in MDF, but it only shared 4 individuals in DDF. Verma and Jayakumar (2015) reported that the deciduous forest of Mudumalai was dominated by *P. marsupium* 150 years ago (Cleghorn, 1861) and slowly replaced by *A. latifolia* due to their fire tolerant mechanism. The DDF site is subjected to recurrence of seasonal forest fire due to their prevalent dry environment. *A. latifolia* and *S. potatorum* are more abundant in the fire affected area, which may be due to thick corky bark and re-sprouting mechanisms.

Mono-dominant forest occurs in Asian and American Tropics side by side with the mixed forest as well (Gentry, 1982). *P. marsupium* was the mono dominant species holding one-third of the IVI. Hart *et al*. (1989) suggested that single-dominance in the tropical forest due to major disturbance over a relatively longer period of time. However in India, several researchers are also observed the mono-dominance in tree community (Sundarapandian and Swamy, 2000; Gandhi and Sundarapandian, 2014).

The natural forest ecosystem is always contiguous distribution and it is reported by several others, (Odum, 1971; Armesto *et al.,* 1986; Kour and Sharma, 2014; Sharma and Raina, 2018; Srinivas and Sundarapandian, 2018). This study also showed maximum species incontiguous distribution. This may be due to significant variance in the environment (Odum, 1971).

Conclusion

The tropical deciduous forest types of Suruli falls region considerably differs among themselves due to variations in elevation, slope, aspects, moisture,

rainfall, temperature and edaphic characteristics. The tropical moist deciduous forest is the transitional vegetation type between semi-evergreen and dry deciduous forests (Reddy *et al*., 2008). However, these deciduous ecosystems are under vulnerable due to human disturbance (either damage to species or planting with monoculture) and seasonal fire. Therefore, the prolonged disturbance and frequent recurrence of annual fire lead to the degrading of primary forest to savanna woodland and open scrublands (Saha, 2003). Once the savanna woodland or scrublands will be created, then difficult recover the climax forest, it may be due to mono-species, grass community will suppress the other plant structures either by competition or fire. So protection of this deciduous forest ecosystem is necessary for the future maintenance of diversity as well as to increase carbon sink potential.

ACKNOWLEDGEMENTS

The authors thank the Forest Department of Theni, Tamil Nadu for granting permission to conduct this study. JN is grateful to University Grants Commission, Government of India for granting fellowship. We thank Dr. S. Karuppuswamy, Department of Botany, Madura college, Madurai for identification of plants.

REFERENCES

1. Apgaua, D.M.G., Pereira, D.G.S. and Santos, R.M. (2015). Floristic variation within Seasonally Dry Tropical Forests of the Caatinga Biogeographic Domain Brazil and its conservation implications. *International Forestry Review – Special Issue: Global Dry Forests,* 17(S2): 33–43. https://doi.org/10.1505/146554815815834840
2. Armesto, J. J., Mitchell, J. D. and Villagran, C. (1986). A Comparison of Spatial Patterns of Trees in Some Tropical and Temperate Forests. *Biotropica,* 18(1): 1-11. https://www.jstor.org/stable/2388354
3. Arulpragasan, L. and Parthasarathy, N. (2010). Landscape-level tree diversity assessment in tropical forests of southern Eastern Ghats, India. *Flora*. 205: 728-737. https://doi.org/10.1016/j.flora.2010.04.011
4. Aye,Y.Y., Pampasit, S., Umponstira, C., Thanacharoenchanaphas, K. and Sasaki, N. (2014). Floristic composition diversity and stand structure of tropical forests in Popa Mountain Park. *Journal of Environmental Protection*, 5: 1588–1602.http://dx.doi.org/10.4236/jep.2014 .517150
5. Ayyappan, N. and Parthasarathy, N. (1999). Biodiversity inventory of trees in a large-scale permanent plot of tropical evergreen forest at Varagalaiar, Anamalais, Western Ghats, India*. Biodiversity and Conservation*. 8 (1): 1533–1554.
6. Campbell, D.G., Stone, J.L. and Rosas, J.A. (1992). A comparison of the phytosociology and dynamics of three floodplain (varzea) forest of known ages, Rio Jurua, western Brazilian Amazon. *Botanical Journal of the Linnean Society*, 108: 213–237. https://doi.org/10.1111/j.1095-8339.1992.tb00240.x
7. Champion, H.G. and Seth, S.K. (1968). A Revised Survey of the Forest Types of India. Government of India, New Delhi.
8. Cleghorn, H.F.C. (1861). The Forests and Gardens of South India. WH Allen & Company.
9. Curtis, J.T. and Cotton, G. (1956). Plant Ecology Workbook: Laboratory Field Reference Manual. Burgess Publishing Co, Minnesota.
10. Dash, P.K., Mohapatra, P.P. and Rao, G.Y. (2009). Diversity and distribution pattern of tree species Niyamgiri hill Ranges, Orissa, India. *The Indian Forester.* 135(7):927-942.
11. Freson, R., Goffinet, G. and Malaise, F. (1974). Ecological effects of the regressive succession Mururu-MiomboSavanna in upper Shaba (Zaire). Cave, A. J. (ed.), *Proceeding First National Congress of Ecology, PUDOC*, pp. 365- 371.
12. Gandhi, D.S. and Sundarapandian, S.M. (2014). Inventory of trees in tropical dry deciduous forests of Tiruvannamalai district, Tamil Nadu, India. *Biodiversitas,* 15 (2): 169-179. DOI: 10.13057/biodiv/d150208
13. Garibaldi, M.T. and Linera, G.M. (2014). Tree diversity patterns in successive vegetation types along an elevation gradient in the Mountains of Eastern Mexico. *Ecological Research,* 29: 1097-1104. https://doi.org/10.1007/s11284-014-1196-4
14. Gentry, H.A. (1982). Patterns of neotropical plant species diversity. M. K. Hecht, B. Wallace & G. T. Prance, editors. Evolutionary biology, Vol. 15, Plenum Press, New York, pp 1-84.
15. Gentry, H.A. (1988). Tree species richness of upper Amazonian forests*. Proceedings of the National Academy of Sciences of the United States of America,* 85:156-159. https://doi.org/10.1073/pnas.85.1.156
16. Ghate, U., Joshi, N.V. and Gadgil, M. (1998). On the patterns of tree diversity in the Western Ghats of India. *Current Science*, 75: 594−603. https://www.jstor.org/stable/24100563
17. Hart, T.B., Hart, J.A. and Murphy, P.G. (1989). Mono-dominant and species-rich forests in the humid tropics: causes for their co-occurrence. *The American Naturalist*, 133: 613-633. https://www.jstor.org/stable/2462071
18. Hiremath, A.J. and Sundaram, B., (2005). The fire-lantana cycle hypothesis in Indian forests. *Conservation and Society.* 3(1): 26.
19. Hubbell, S.P. and Foster, R.B. (1992). Short-term dynamics of a neotropical forest: why ecological research matters to tropical conservation and management. *Oikos,* 63: 48–61. https://www.jstor.org/stable/3545515
20. Kanagaraj, S., Selvaraj, M., Kangabam, R.D. and Munisamy, G. (2017). Assessment of tree species diversity and its distribution pattern in Pachamalai reserve forest, Tamil Nadu. *Journal of Sustainable Forestry*, 36(1): 32–46. https: // doi.org/10.1080/10549811.2016. 1238768
21. Karuppusamy, S and Ravichandran, V. (2016). Diversity Assessment of Woody Plants of Megamalai Wildlife Sanctuary, Theni District, Tamilnadu. *Bio Bulletin*. 2(1): 74-89.
22. Kaul, O.N, and Sharma, D.C. (1971). Forest type Statistics. *Indian Forester.* 97: 432-436.
23. Kodandapani, N., Cochrane, M.A. and Sukumar, R. (2004). Conservation threat of increasing fire frequencies in the Western Ghats, India. *Conservation*

Biology, 18 (6): 1553–1561. DOI: 10.1111/j.1523-1739.2004.00433.x
24. Kothandaraman, S. and Sundarapandian, S.M. (2017). Structure of plant community in tropical deciduous forests of Kanyakumari Wildlife Sanctuary, *India. Biodiversitas*, 18(1): 391-400. https:// doi.org/10.1111/j.1523-1739.2004.00433.x
25. Kour, K. and Sharma, S. (2014). Diversity and phyto-sociological analysis of tree species in sacred groves of Vijaypur block, Samba (J&K). *International Journal of Science and Research*. 3(6): 859-862.
26. Krishna, P.H. and Reddy, C.S. (2012). Assessment of increasing threat of forest fires in Rajasthan, India using multi-temporal remote sensing data (2005–2010). *Current Science,* 102(9). https://www.jstor.org/ stable/44721845
27. Krishnamurthy, Y.L., Prakasha, H.M., Nanda. A., Krishnappa, M., Dattaraja, H.S. and Suresh, H.S. (2010). Vegetation structure and floristic composition of a tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka, India. *Tropical Ecology*. 51(2): 235-246.
28. Kumar J.I.N., Kumar, R.N., Bhoi1, R.K. and Sajish, P.R. (2010). Tree species diversity and soil nutrient status in three sites of tropical dry deciduous forest of western India. *Tropical Ecology*. 51(2): 273-279.
29. Lal, C., Singh, L., Attri, V. and Sarvade, S. (2015). Tree species diversity, distribution and population structure in a tropical dry deciduous forests of Chhatisgarh. India *Journal of Applied and Natural Science,* 7 (2): 681- 685. https://doi.org/10.31018/ jans.v7i2.666
30. Ledig, F.T. (1992). Human impact on genetic diversity in forest ecosystems. *Oikos,* 63: 87-108. https:// www.jstor.org/stable/3545518
31. Misra, R. (1983). Indian savanna. Bourliere, F. (ed.), Ecosystems of the world-tropical savannas. Elsevier, pp 151-166.
32. Mohandass, D., Hughes, A.C., Mackay, B., Davidar, P. and Chhabra, T. (2016). Floristic species composition and structure of a mid-elevation tropical montane evergreen forests (sholas) of the western ghats, southern India. *Tropical Ecology*. 57(3): 533-543.
33. Murphy, P.G. and Lugo, A.E. (1986). Ecology of dry tropical forest. *Annual Review of Ecology Evolution and Systematics*, 17: 67-88. https: //doi.org/10.1146/ annurev.es. 17.110186.000435
34. Naidu, M.T., Premavani, D., Suthari, S. and Venkaiah, M. (2018). Assessment of tree diversity in tropical deciduous forests of north central Eastern Ghats, India. *Geology, Ecology and Landscapes,* 2(3): 216-227. https://doi.org/10.1080/24749508. 2018. 1452479
35. Nair, N.C. and Daniel, P. (1986). Floristic diversity of the Western Ghats and its conservation: a review. *Proceeding of Indian Academy of Science Supplementary.* 127-163.
36. Naveenkumar, J., Arunkumar, K. S. and Sundarapandian, SM. (2017). Biomass and carbon stocks of a tropical dry forest of the Javadi Hills, Eastern Ghats, India. *Carbon Management*, 8(5-6):351-361. https:// doi.org/10.1080/17583004.2017.1362946
37. Odum, E.P. (1971). Fundamentals of Ecology. 3rd ed. W.B. Saunders Company, Philadelphia.
38. Padmakumar, B., Sreekanth, N.P., Shanthiprabha, V., Paul, J., Sreedharan, K., Augustine, T., Jayasooryan, K.K., Rameshan, M., Mohan, M., Ramasamy, E.V. and Thomas, A.P. (2018). Tree biomass and carbon density estimation in the tropical dry forest of Southern Western Ghats, India. *iForest*,11: 534-541. doi: 10.3832/ifor2190-011
39. Parsons, R.F. and Cameron, D.S. (1974). Maximum plant species diversity in terrestrial communities. *Biotropica*, 6:202-203. https://www.jstor.org/ stable/2989653
40. Parthasarathy, N. (1999). Tree diversity and distribution in undisturbed and human-impacted sites of tropical wet evergreen forest in southern Western Ghats, India. *Biodiversity and Conservation,* 8:1365–1381. https://doi.org/10.1023/A:1008949407385
41. Pascal, J.P. and Pelissier, R. (1996). Structure and floristic composition of a tropical evergreen forest in south-west India. *Journal of Tropical Ecology,* 12: 191–214. https://www.jstor.org/stable/2560093
42. Poorter, L., van der Sande, M. T., Thompson, J., Arets, E. J. M. M. et al. (2015). Diversity enhances carbon storage in tropical forests. *Global Ecology and Biogeography*, 24:1314-1328. https://doi.org/10.1111/ geb.12364
43. Prakasha, H.M., Nanda, A. and Krishnamurthy, Y.L. (2008). Stand structure of a tropical dry deciduous forest in Bhadra wildlife sanctuary, Karnataka southern India, *Bulletin of the National Institute of Ecology*. 19: 1-7.
44. Puyravud, J. P., Pascal, J. P. and Dufour, C. (1994). Ecotone structure as an indicator of changing forest-savanna boundaries (Linganamakkl region, southern India). *Journal of Biogeography.* 21: 591-593. https:// www.jstor.org/stable/2846033
45. Ramesh, B.R. and Pascal, J.P. (1991). Distribution of endemic, arborescent evergreen species in the Western Ghats. Proceedings of the Symposium on Rare, Endangered and Endemic Plants of the Western Ghats. Kerala Forest Department, India. Kerala: Department of Forest, pp 20-29.
46. Reddy, C.S., Babar, S., Amarnath, G. and Pattanaik, C. (2011). Structure and floristic composition of tree stand in tropical forest in the Eastern Ghats of northern Andhra Pradesh, India. Journal of Forestry Research, 22(4): 491-500. DOI: 10.1007/s11676-011-0193-5
47. Reddy, C.S., Ugle, P., Murthy, M.S.R. and Sudhakar, S. (2008). Quantitative Structure and Composition of Tropical Forests of Mudumalai Wildlife Sanctuary, Western Ghats, India. *Taiwania,* 53 (2): 150-156. DOI: 10.6165/tai2008.53(2).150
48. Rodgers, W.A., Panwar, H.S. and Mathur, V.B. (2002). Wildlife Protected Area Network in India, A Review: Executive Summary, Wildlife Institute of India, Dehradun, pp. 44.
49. Roth, L.C. (1999). Anthropogenic change in subtropical dry forest during a century of settlement in Jaiqui Picado, Santiago, Dominican Republic. *Journal of Biogeography*, 26:739-759. https://doi.org/10.1046/ j.1365-2699.1999.00328.x
50. Sagar, R., Raghubanshi, A.S., and Singh, J.S. (2003). Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. *Forest Ecology and Management*, 186: 61–71. https://doi.org/10.1016/S0378-1127(03)00235-4
51. Saha, S. (2003). Patterns in woody species diversity, richness and partitioning of diversity in forest commu-

nities of tropical deciduous forest biome. *Ecography,* 26: 80-86. https://www.jstor.org/stable/3683528

52. Sahu., S.C., Dhal, N.K. and Mohanty, R.C. (2012). Tree species diversity, distribution and population structure in a tropical dry deciduous forest of Malyagiri Hill ranges, Eastern Ghats, India. *Tropical Ecology*. 53(2): 163- 168.
53. Sathish, B.N., Viswanath, S., Kushalappa C.G., Jagadish, M.R. and Ganeshaiah, K.N. (2013). Comparative assessment of floristic structure, diversity and regeneration status of tropical rainforests of Western Ghats of Karnataka, India. *Journal of Applied and Natural Science, 5 (1): 157-164.* https:// doi.org/10.31018/jans.v5i1.300
54. Sharma, J. and Raina A.K. (2018). Quantitative analysis, distributional pattern and species diversity of woody plant species of Lamberi Forest Range, Rajouri, J&K, India. *Journal of Applied and Natural Science,* 10 (1): 522 - 527. https://doi.org/10.31018 / jans. v10i1.1661
55. Singh, J.S., Singh, S.P., Saxena, A.K. and Rawat, Y.S. (1984). India's Silent valley and its threatened rain forest ecosystem. *Environmental Conservation*, 11: 223- 233. https://doi.org/10.1017/ S0376892900014247
56. Singh, K.P. and Kushwaha, C.P. (2016). Deciduousness in tropical trees and its potential as indicator of climate change: A review. *Ecological Indicators,* 69: 699-706. https://doi.org/10.1016/ j.ecolind.2016.04.011
57. Srinivas, K. and Sundarapandian, SM. (2018). Diversity, Population Structure and Distribution of Trees in Tropical Dry Forests, East Godavari District, Eastern Ghats, India. *International Journal of Ecology & Development*. 33(2): 13-32.
58. Strasberg, D. (1996). Diversity, size composition and spatial aggregation among trees on a one-hectare rainforest plot at La Reunion. *Biodiversity and Conservation*, 5: 825–840. DOI: 10.1007/BF00054737
59. Sundarapandian, SM. and Karoor, P.J. (2013). Edge effects on plant diversity in tropical forest ecosystems at Periyar Wildlife sanctuary in the Western Ghats of India. *Journal of Forestry Research,* 24 (3): 403-418. https://doi.org/10.1007/s11676-013-0373-6
60. Sundarapandian, SM. and Swamy, P.S. (2000). Forest ecosystem structure and composition along the altitudinal gradient in the Western Ghats, South India. *Journal of Tropical Forest Science*, 12: 104-123. https://www.jstor.org/stable/23616407
61. Sundarapandian, SM., Naveenkumar, J, and Arunkumar, K.S. (2015). Tree diversity in tropical forest in the Javadi Hills in the Eastern Ghats India. *Journal of Global Ecology and Environment*. 3(4): 272-288.
62. Swamy, P.S., Sundarapandian, SM., Chandrasekar, P. and Chandrasekaran, S. (2000). Plant species diversity and tree population structure of a humid tropical forest in Tamil Nadu, India. *Biodiversity and Conservation,* 9: 1643-1669. https://doi.org/ 10.1023/ A: 1026511812878
63. Thakur, A.S. and Khare, P.K. (2006). Species diversity and dominance in tropical dry deciduous forest ecosystem. *Journal of Environmental Research and Development.* 1(1): 26-31.
64. Valencia, R., Balslev, H. and Paz Y Miño, C.G. (1994). High tree alpha-diversity in Amazonian Ecuador. *Biodiversity and Conservation,* 3(1): 21–28. https://doi.org/10.1007 /BF00115330
65. Verma, S. and Jayakumar, S. (2015). Post-fire regeneration dynamics of tree species in a tropical dry deciduous forest, Western Ghats, India. *Forest Ecology and Management*, 341: 75-82. https:// doi.org/10.1016/j.foreco.2015.01.005
66. Wikramanayake, E.D., Dinerstein, E., Robinson, J.G., Karanth, K.U., Rabinowitz, A., Olson, D., Mathew, T., Hedao, P., Conner, M., Hemley, G. and Bolze, D. (1998). An ecology-based method for defining priorities for large mammal conservation: the tiger as case study. *Conservation Biology,* 12: 865–878. https://doi.org/10.1111/j.1523-1739. 1998.96428.x
67. Wilson, E.O. (1988). The current state of biological diversity. In: Wilson, E.O. (Ed.). Biodiversity. The National Academic Press, Washington DC, pp 3-88.
68. Yadav. D. K. (2016). Species structure and diversity in Achanakmar-Amarkantak Biosphere Reserve, Central India. *Journal of Applied and Natural Science,* 8 (3): 1241 – 1248. https://journals. ansfoundation.org/index.php/jans/article/view/948