I.J.S.N., VOL.5 (3) 2014: 452-461 ISSN 2229 – 6441

INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

DIVERSITY AND DISTRIBUTION PATTERN OF UNDERSTORY VEGETATION IN TROPICAL DRY FORESTS OF SATHANUR RESERVE FOREST IN EASTERN GHATS, INDIA

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ABSTRACT
Understory plant diversity and its distribution pattern were studied in tropical dry forest in Eastern Ghats. A total of 89 species belonging to 74 genera and 29 families were enumerated in tropical dry forest ecosystem. The species richness was ranged from 66-79 (16-21 in shrubs and 50-58 in herbs). The mean density (No. /ha) were ranged 659676 to 712490. Shannon's index of shrub community ranged 1.74 - 1.92, while in herbaceous community it lies in between 3.04 and 3.22. Fisher's alpha showed greater values in site II for both the forms of understory compared with other study sites. *Lantana camara* and *Tarenna asiatica* were the dominant shrub species in terms of density and IVI values. *Sida cordifolia* and *Ageratum conyzoides* were the dominant species in herbs in terms of density and IVI values. Poaceae was the dominant family in terms of number of genera (10-12) and species (11-13) in all the three study sites followed by Euphorbiaceae, Acanthaceae, Lamiaceae, Rubiaceae and Papilionaceae. Malvaceae was the dominant family in terms of abundance of understory individuals followed by Asteraceae, while the least abundance was observed in Apocynaceae and Flacourtiaceae. The results from the present study indicate that the tropical dry forests here require more attention for conservation for the restoration the understory vegetation as well as expeditious steps should be taken to check the exotic invasion here to manage the native biodiversity.

KEY WORDS: Tropical forest, shrub, herb, species richness, plant diversity

INTRODUCTION
Tropical forests have received much attention in recent years on account of their biological richness, high productivity, and also for their important role in carbon cycle and watershed protection (Bhat et al., 2011). In addition to the trees, the understory of tropical forests has a distinct array of species different from the overstory and is an integral part of the tropical forest community (Bhat and Murali, 2001). They may show different patterns of diversity than tree species due to different responses to light level, nutrient availability, and temperature (Siebert, 2002; Ramadhanil et al., 2008). The understory is an integral component of forest ecosystems generally supporting a large fraction of total community floristic diversity (Gentry and Dodson, 1987, Gentry and Emmons, 1987, Mayfield and Daily, 2005, Tchouto et al., 2006) and providing habitats and food sources for many kinds of animals (Gentry and Emmons, 1987, Hirao et al., 2009). Understory vegetation could also influence community dynamics and succession patterns (Newbery et al., 1999, Royo and Carson, 2006) and contribute to nutrient cycling (Nilsson and Wardle, 2005). Understory composition usually varies considerably among different forest types (Hart and Chen, 2008). Several factors have been suggested to account for this variation, including overstory structure and composition (Hart and Chen, 2008, Sangar et al., 2008), soil nutrient and moisture availability (Poulsen and Pendry, 1995, Newbery et al., 1996), succession history (LaFrankie et al., 2006), forest management strategies (Hart and Chen, 2008, Ares et al., 2009), and fragmentation (Benitez-Malvido and Martinez-Ramos, 2003, Rasingam and Parthasarathy, 2009). However, quantitative inventories on tropical forests have emphasized mainly on tree species and the smaller understory plants are rarely included in such investigations (Poulsen and Pendry, 1995; Annaselvam and Parthasarathy, 1999; Upadhaya et al., 2006). There are a few quantitative studies on understory plants from neotropics (Smith, 1970; Hall and Swaine, 1981; Gentry and Dodson, 1987; Levey, 1988; Poulsen and Balslev, 1991; Poulsen and Nielsen, 1995; Tuomisto and Poulsen, 1996; Tuomisto et al., 1998, 2002; Costa and Magnusson, 2002; Leopold and Salazar, 2008) and old world tropics (Kiew, 1978; Poulsen and Pendry, 1995; Poulsen, 1996a, b; Newbery et al., 1996; Turner et al., 1996; Laska, 1997; Svenning, 2000; Bobo et al., 2006; Ramadhanil et al., 2008). In India, the understory plant diversity inventories were mainly focused in the Western Ghats (Gopisundar, 1997; Annaselvam and Parthasarathy, 1999; Bhat and Utkarsh, 1999; Bhat and Murali, 2001; Muthuramkumar et al., 2006) and little is known from the Eastern Ghats (Chittibabu and Parthasarathy, 2000; Reddy et al., 2009) and Himalayas (Ram et al., 2004; Upadhaya et al., 2006). However, quantitative inventories of understory species in Eastern Ghats are still lacking. Hence, the present investigation was undertaken. The main objectives of the present study are to assess the species richness, abundance and distribution of understory plants in the undisturbed and disturbed tropical dry deciduous forests of Sathanur reserve forest.

MATERIALS AND METHODS

Study area

Sathanur reserve forest is about 870 ha and is located in Chennakesava hills of Tiruvannamalai district of Tamil Nadu, India. It is a part of Eastern Ghats, located between 78° 51' 10" longitude and 12° 4' 48" latitude (Fig 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. This forest area falls under the tropical belt. The climate is generally hot. The annual rainfall during the study period was ranged from 464 mm to 1613 mm (PWD data set, Fig 2).

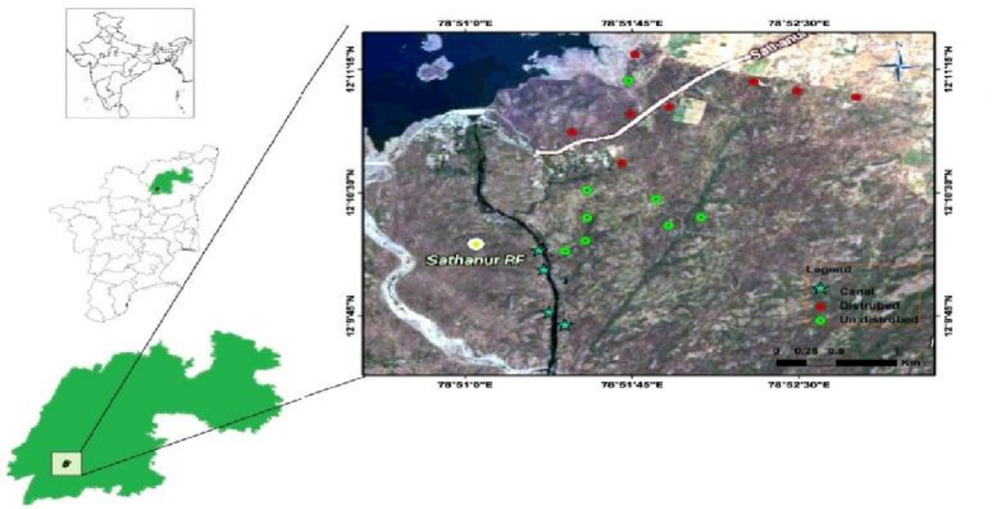

FIGURE 1. Map showing the location of the study area in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

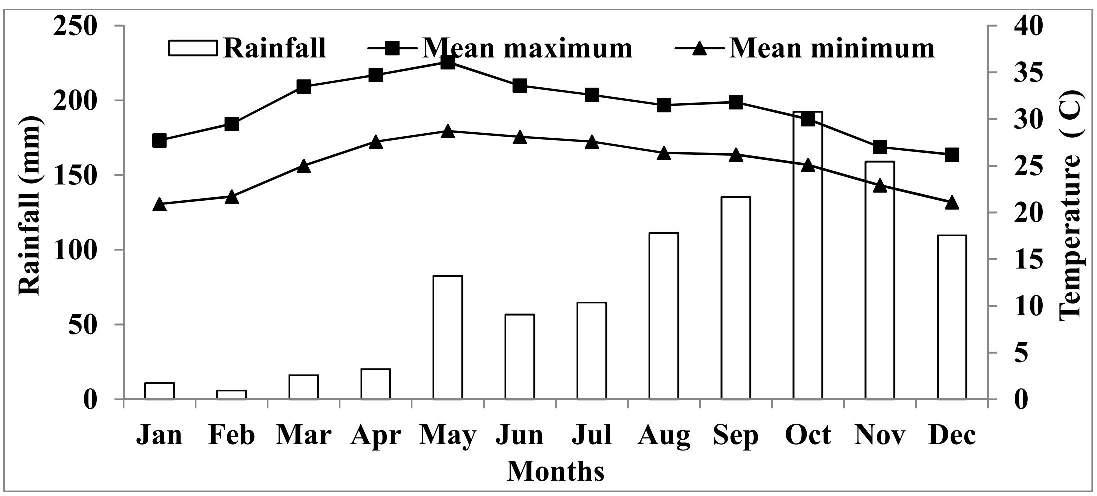

FIGURE 2. Patterns in monthly distribution of rainfall and temperatures for Sathanur dam, the nearest station to the study sites, based on 22 years of data

In total, 20 plots (of 1 ha each) were laid randomly (approximately at 500 m intervals) in the Sathanur Reserve forest which are grouped under three categories based on the level of disturbance *i.e.* Site I (8 plots, are adjacent to road and agriculture field, grazing and illegal collection of fuel wood is common in these plots- disturbed forests), site II (8 plots, far away from the human settlement, grazing is uncommon and very rare only during peak summer, since it is away from the settlements, illegal cutting is almost nil - undisturbed forest site) and Site III, canal-side forest site (4 plots, human disturbance is common in these area; soil in these are also rocky in nature). The field work was carried out during November and December 2012 and 2013, peak growth period in seasonal forest. In each 1 ha plots, fifty quadrats of 5 m x 5 m (shrubs) and 1 m x 1 m (herbs) sizes were placed in a systematic random sampling method and enumerated the number of individuals and measured its basal area (Kershaw, 1973, Misra, 1968). The plant samples were collected for confirming species identity and were deposited in the herbarium of department of Ecology and Environmental Sciences, Pondicherry University. The vegetation data of each plot, thus gathered were analyzed for frequency, density, abundance and importance value index (IVI). The diversity indices and cluster analysis were done by using PAST software.

RESULTS

Understory plant diversity in the three study sites of tropical dry deciduous forest in Sathanur reserve forest was 89 species from 74 genera belonging to 29 families in 2.5 hectare (Table 1). Of these 89 species of understory community, 22 were shrubs, 52 were herbs and 15 were grasses (Fig 3). A total of 2062300 individuals (11450 shrubs and 2050850 herbs) of understory vegetation were enumerated in 2.5 ha of 20 plots in three different study sites. The species richness of understory community in the study sites were ranged from 66-79 (16-21 in shrubs and 50-58 in herbs). Species richness was showed greater value in site II (undisturbed site) compared to other study sites. The mean density (No./ha) of understory community of the tropical dry forest ecosystem in the study sites were ranged 659676 to 712490. The shrub and herb species richness were showed greater values in study site II (undisturbed site) compared to other study sites. However, stand species richness and stand density of both forms of understory varied considerable within the study sites (Table 1).

TABLE 1. Summary of understory diversity inventory in tropical dry forests at Sathanur Reserve forest, Tamil Nadu, India

Variables	Site I	Site II	Site III
Species richness			
Understory	75	79	66
Shrubs	18	21	16
Herbs	57	58	50
Number of families	27	28	26
Number of genera	66	67	62
Number of Individuals			
Understory (No./ha)	659676	712490	690134
Shrubs (No/ha)	3926	4040	3484
Herbs (No/ha)	655750	708450	686650
Dominance index			
Shrubs	0.199	0.209	0.229
Herbs	0.074	0.056	0.082
Shannon's index			
Shrubs	1.915	1.901	1.742
Herbs	3.196	3.223	3.038
Fisher's_alpha			
Shrubs	2.44	2.90	2.17
Herbs	4.82	4.88	4.16
Number of species per stand			
Shrubs	5 -14	6 - 14	9-13
Herbs	28 – 36	17- 33	28 - 32
Stand density range (No./ha)			
Shrubs	1896-7752	2136-6976	2568-4576
Herbs	516200-902800	175000-12516000	592000-894800

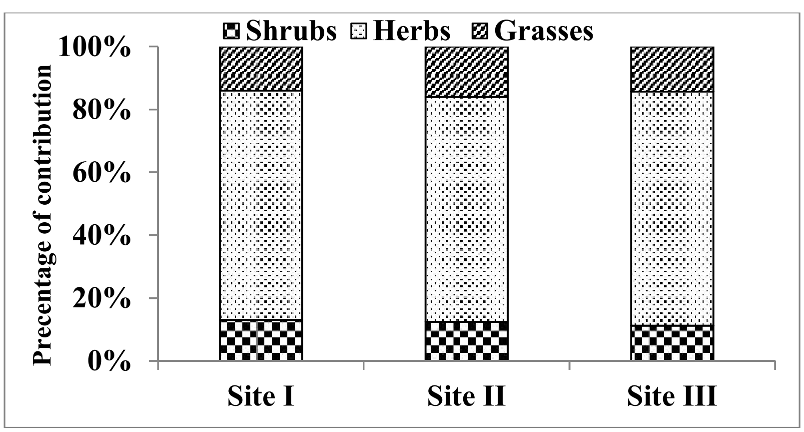

FIGURE 3. Site –wise percentage of understory vegetation (shrubs, herbs and grasses) in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

Shannon's index of shrub community in the tropical dry forests of Sathanur reserve forest ranged 1.74 - 1.92, while in herbaceous community it lies between 3.04 and 3.22. Greater value of herbaceous community's Shannon's index was observed in site II than in other study sites, while it showed more value in site I than in other study sites for shrubs. In contrast, dominance index value showed greater in site III compared to other study sites for both shrubs and herbs. However, Fisher's alpha showed greater values in site II for both forms of understory compared with other study sites. The family-wise contribution of understory vegetation in the tropical dry forests was 29 (Table 2). Poaceae was the dominant family in terms of number of genera (10-12) and species (11-13) in all the three study sites followed by Euphorbiaceae, Acanthaceae, Lamiaceae, Rubiaceae and Papilionaceae. Eleven families in site I, 11 families in site II and 12 families in site III were represented by only one species. Malvaceae was the dominant family in terms of abundance of understory individuals followed by Asteraceae, while the least abundance was observed in Apocynaceae and Flacourtiaceae.

TABLE 2. Contribution of families to understory genera, species richness and understory density in tropical dry forests at Sathanur Reserve forests, Tamil Nadu, India

Family	Site I			Site II			Site III		
	Genus	Species	Abundance	Genus	Species	Abundance	Genus	Species	Abundance
Acanthaceae.	6	7	48659	6	6	33342	5	5	49114
Agavaceae	0	0	0	1	1	50	1	1	150
Amaranthaceae.	4	4	8675	3	3	9500	3	3	2750
Apocynaceae	0	0	0	1	1	1	1	1	2
Asclepiadaceae	1	1	100	2	2	152	0	0	0
Asteraceae	4	4	104550	4	4	70350	3	3	131600
Boraginaceae	1	1	135	1	1	75	1	1	154
Cactaceae	1	1	26	1	1	35	1	1	56
Caesalpiniaceae	1	3	92	1	3	32	1	2	18
Capparidaceae	1	1	2550	0	0	0	1	1	450
Commelinaceae	1	1	725	1	3	19250	1	1	2150
Convolvulaceae	2	2	37587	2	2	41193	2	2	51508
Cyperaceae	2	2	20375	2	3	32325	2	2	25700
Euphorbiaceae.	6	8	32564	7	8	64826	7	7	65812
Flacourtiaceae	1	1	5	1	1	13	0	0	0
Lamiaceae	5	5	23625	4	5	13875	4	4	37350
Leguminosae	0	0	0	1	1	325	0	0	0
Malvaceae	1	3	209475	1	3	262025	1	3	198700
Molluginaceae	1	2	16550	1	2	18700	1	1	3350
Nyctaginaceae	1	1	15500	1	1	350	0	0	0
Papilionaceae	3	3	14000	4	4	28575	4	4	20200
Poaceae.	11	12	89125	10	11	101050	12	13	88200
Rubiaceae.	4	4	4039	4	4	3514	4	4	3302
Rutaceae	1	1	716	1	1	1158	1	1	888
Sapindaceae	1	1	150	1	1	300	1	1	300
Solanaceae	3	3	874	2	3	201	2	2	106
Tiliaceae	2	2	4500	2	2	3475	1	1	4850
Verbenaceae	1	1	1579	1	1	1148	1	1	1374
Violaceae	1	1	23500	1	1	6650	1	1	2050

Lantana camara and *Tarenna asiatica* were the dominant shrub species in terms of density and IVI values in study site I while *Clausena heptaphylla* and *Tarenna asiatica* were the dominant shrub species in site II (Table 3). However, *Lantana camara* and *Clausena heptaphylla* were the dominant shrubs in site III. *Calotropis gigantea, Cassia didymobotrya, Phyllanthus reticulatus, Solanum torvum* and *Carissa* sp. were the rare (≤4 individuals) species. The three dominant shrub species i.e. *Lantana camara, Clausena heptaphylla* and *Tarenna asiatica* were hold 60% -85% of total density and 70-81% of total IVI values in all the three study sites. Stand shrub density varied within the study sites in all cases.

TABLE 3. List of understory species with its density (No./ha) and IVI in tropical dry forests at Sathanur reserve forest, Tamil Nadu, India

Name of the species	Mean Density			IVI		
	Site I	Site II	Site III	Site I	Site II	Site III
Shrubs						
*Barlerialongiflora*L.f.	34	17	14	2.4	1.7	1.7
Calotropisgigantea (L.) R. Br.	0	2	0	0.0	0.1	0.0
Canthiumcoromandelicum(Burm.f.) Alston.	98	135	86	9.7	9.4	12.3
Carmona retusa (Vahl) Masam.	135	75	154	12.9	9.9	19.7
Cassia auriculata L.	76	19	14	9.7	3.3	1.4
*Cassia didymobotrya*Fresn.	1	2	4	0.1	0.3	0.8
Cassia hirsuta L.	15	11	0	1.8	0.4	0.0
Catunaregamspinosa (Thunb.) Tirveng	17	23	8	1.6	2.0	1.2
Clausenaheptaphylla (Roxb.) Wight &Arn.	716	1158	888	62.0	86.1	86.0
*Dodonaeaangustifolia*L. f.	16	100	24	2.6	8.2	2.2
*Euphorbia antiquorum*L	0	5	0	0	0.6	0.0
Flacourtiaindica (Burm. f.) Merr.	5	13	0	1.1	1.0	0.0
*Ipomoea carnea*Jacq.	12	18	8	0.7	11.3	1.0

*Jatrophagossypifolia*L.	1	13	8	0.2	1.1	1.1
Lantana camara L.	1579	1148	1374	81.0	68.8	93.3
Opuntiastricta (Haw.) Haw.var. dillenii	26	35	56	6.6	6.6	9.1
Phyllanthusreticulatus Poir.	4	0	0	0.4	0.0	0.0
Securinegaleucopyrus (Willd.)Muell.	34	33	4	4.5	3.2	0.4
Solanumnigrum L.	333	99	82	21.4	6.9	7.9
*Solanum torvum*L.	0	2	0	0	0.3	0.0
Tarennaasiatica (Linn.) Alston.	824	1131	758	81.5	78.7	61.6
Carissa sp.	0	1	2	0.0	0.1	0.3
Herbs						
*Acalyphaindica*Linn.	1025	11125	550	0.52	7.66	0.38
*Achyranthesaspera*Linn.	5200	9325	2500	4.28	5.60	2.99
*Aervalanata*Juss.	75	50	50	0.06	0.09	0.13
*Agave americana*L.	0	50	150	0.00	0.10	0.20
Ageratum conyzoides L.	91300	66750	125400	34.12	27.05	43.31
Alysicarpusmonilifer(L.) DC	0	25	0	0.00	0.04	0.00
*Amaranthusspinosus*L.	25	0	0	0.04	0.00	0.00
Andrographispaniculata(Burm. f.) W. ex Nees	1325	21800	10500	0.83	10.74	5.57
Anisomelesindica (L.) Kuntze.	0	1700	0	0.00	1.78	0.00
Anisomelesmalabarica(L.) R.	475	525	14900	0.41	0.41	5.12
*Apludamutica*Linn.	4125	4025	3250	1.69	2.60	1.88
*Aristidahystrix*L.f.	15500	34325	8300	5.43	14.04	3.53
*Aristidasetacea*Retz.	5125	3025	7300	3.40	0.16	4.90
Asystasiagangetica(L).T.	325	1275	2750	0.38	1.42	1.00
Blepharismaderaspatensis(L.)Roth	25950	10175	29200	16.89	6.58	15.84
*Boerhaaviadiffusa*Linn.	15500	350	0	6.71	0.38	0.00
Brachiariaramosa(L.) Stapf.	11650	3625	29850	7.27	1.43	8.78
Bulbostylisdensa(Wall.) Hand.-Mazz.	17350	19550	19000	8.17	12.05	12.20
*Chlorisinflata*Link.	0	0	450	0.00	0.00	0.37
*Cleome viscosa*Linn.	2550	0	450	1.90	0.00	0.30
*Commelinabenghalensis*L. var.	0	2400	0	0.00	4.88	0.00
*Commelinaelegans*Kunth	725	900	2150	0.74	0.69	2.21
*Commelinapaleata*Hassk. Pl. Jungh.	0	15950	0	0.00	11.40	0.00
*Corchorusacutangulus*Lam.	2125	1625	4850	1.95	2.21	2.85
*Crotalaria spectabilis*Roth.	0	325	0	0.00	0.57	0.00
*Croton bonplandianus*Baill	2725	200	1050	1.22	0.29	0.89
Cynodondactylon (L.) Pers.	6575	2975	1700	3.34	1.12	1.16
*Cyperusrotundus*Linn.	3025	6950	6700	2.05	6.17	3.33
*Cyperustenuispica*L.	0	5825	0	0.00	0.94	0.00
Cyrtococcumtrigonum(Retz.) A. Camus	19450	10675	800	7.41	2.57	0.71
Dactylocteniumaegyptium(L.) P.Beauv.	2425	300	500	2.55	4.08	0.65
*Daturametel*L.	150	300	300	0.20	0.36	0.41
*Desmodiumtriflorum*DC	0	450	1700	0.00	0.44	0.53
Dipteracanthuspatulus(Jacq.) Nees	11600	50	0	6.43	0.08	0.00
Dipteracanthusprostratus(Poir.) Nees	6375	0	0	3.77	0.00	0.00
Eragrostistenella(L.) Beauv.	9075	21150	13050	4.87	8.04	6.13
*Euphorbia hirta*L	27750	52950	34900	12.35	17.44	16.19
*Euphorbia thymifolia*L	50	0	0	0.53	0.00	0.00
Evolvulusalsinoides L.	37575	41175	51500	14.99	22.91	27.77
*Gomphrenadecumbens*Jacq.	3375	125	200	2.40	0.12	0.18
*Hemidesmusindicus*R. Br.	100	150	0	0.16	0.22	0.00
Heteropogoncontortus(L.) P.Beauv. Ex. R. &Schu.	8950	15375	2800	3.19	4.32	1.17
Hybanthusenneaspermus (L.) F. Muell.	23500	6650	2050	7.68	3.83	1.77
Hyptissuaveolens(L.) Poit.	100	0	0	0.09	0.00	0.00
*Indigoferaastragalina*DC.	850	0	1250	0.51	0.00	0.59
Leonotisnepetifolia(L.) R. Br.	3250	825	1200	4.06	0.74	0.82
Leucasaspera(Willd.) Link.	13125	6650	8400	9.45	5.64	5.18
*Mollugonudicaulis*Lam.	525	50	0	0.23	0.04	0.00
*Mollugopentaphylla*L	16025	18650	3350	5.99	8.23	2.12
Ocimumcanum. Sims	6675	4175	12850	4.21	3.66	6.36
Partheniumhysterophorus L.	3600	175	0	1.63	0.19	0.00
Paspalidiumflavidum(Retz.) A.Camus	625	4475	1700	0.31	1.17	1.42
Perotisindica(L.)Kuntze	5600	1100	9800	2.25	0.37	5.96
*Phyllanthusamarus*Schum. &Thonn.	975	100	2350	0.65	0.14	1.20
Physalis minima Linn.	525	0	0	0.23	0.00	0.00
Pseudarthriaviscida(L) Wight and Arn.	1175	50	3500	0.60	0.04	2.26
Rostellularia simplex Wight	3050	25	6650	1.35	0.05	2.52
*Sidaacuta*Burm. F.	15550	124925	30550	7.01	30.06	14.12
Sidacordata(Burm. f.) Borss.-Waalk	23550	25825	4000	13.75	12.17	3.04
*Sidacordifolia*L.	170375	111275	164150	61.73	34.69	58.08

*Spermacoceocymoides*Burm.f.	3100	2225	2450	2.28	0.74	1.38
Sporobolusvirginicus (L.) Kunth.	25	0	8700	0.04	0.00	2.51
Tephrosiapurpurea(Linn.) Pers.	11975	28050	13750	9.24	10.87	7.60
*Tragiainvolucrata*L.	0	400	26950	0.00	0.33	7.98
*Tridaxprocumbens*L	1025	25	700	0.76	0.04	0.48
*Triumfettarhomboidea*Jacq	2375	1850	0	0.60	2.83	0.00
Vernoniacinerea(L.) Less.	8625	3400	5500	5.10	3.15	3.93

Herbaceous community was dominated by *Sida cordifolia* in study sites I and III followed by *Ageratum conyzoides* and *Evolvulus alsinoides* while in site II was dominated by *Sida acuta* followed by *Sida cordifolia* and *Ageratum conyzoides* in terms of density. Similarly, *Sida cordifolia* was the dominant species in herbaceous community in all the three study sites in terms of IVI value. *Aerva lenata, Alysicarpus monilifer, Euphorbia thymifolia* and *Hyptis suaveolens* showed low abundance (≤ 100 individuals) in distribution in three study sites. Stand herb density varied within the study sites in all cases. Fifty-eight (65.17%) species were commonly distributed among all the three study sites. Sixty-six species were common between sites I and II. Similarly, 60 species are common between sites II and III while 61 species were common between site I and III. Six species in site I, 9 species in site II and one species in site III occur only in the respective sites not in other sites. Bray-Curtis cluster analysis based on density and species composition indicated that the study sites I and III are more closure and form a similar group (87.5% in shrubs and 73.7% in herbs) in both shrubs and herbs (Fig. 4).

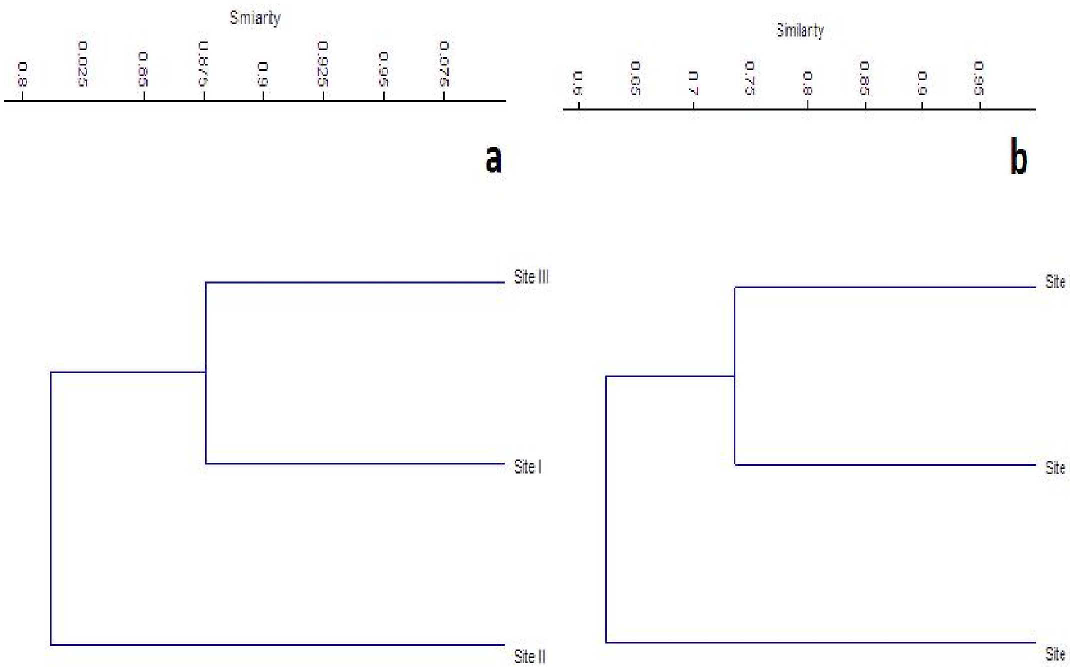

FIGURE 4. Bray-Curtis cluster analysis based on abundance of shrub (a) and herb (b) species in three different study sites in tropical dry forests at Sathanur reserve forests, Tamil Nadu, India

A/F ratios of species in stands provide the idea of distribution patterns of species in a community. In the shrub community, 81.7% of species in site I, 84.1% of species in site II and 82.2% of species in site III showed a contagious distribution whereas 18.3% of species in site I and 9.8% of species in site II indicated Random distribution (Fig 5). However, 6.1% of species in site II and 17.8% of species in site III have regular distribution. Similarly, in herbaceous community, 98.8% in site I, 98% in site II and100 % of species in site III have a contagious distribution while 0.8% of species in site I and 1.5% of species in site II showed random distribution and 0.4% of species in site I and 0.5% of species in site II have regular distribution.

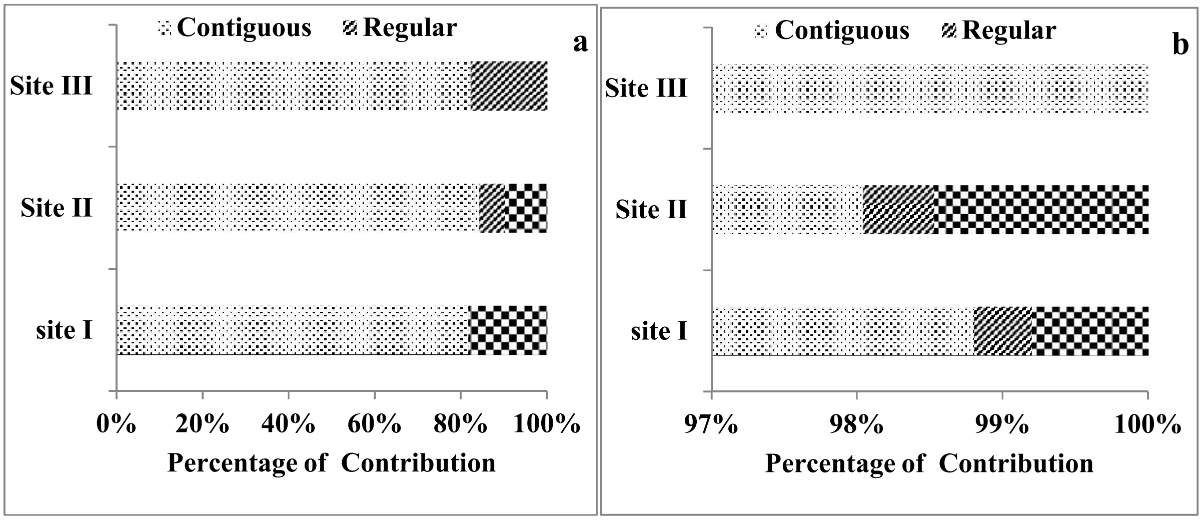

FIGURE 5. Distribution pattern of understory species (shrubs (a) and herbs (b)) species in three different study sites in tropical dry forests at Sathanur reserve forests, Tamil Nadu, India

DISCUSSION

The species diversity of understory plants in 20 one hectare plots of tropical dry deciduous forest of Sathanur reserve forest was 89 (fifty 25 m^2 quadrats for shrubs and fifty 1 m^2 quadrats for herbs in each plot). The value obtained in the present study is moderately higher when compared to other parts of Eastern Ghats and elsewhere (52 species/0.32ha (eight hundred 4 m^2 quadrats) in tropical evergreen forest in the Kolli hills, Chittibabu and Parthasarathy 2000; 84/4 ha tropical dry deciduous forest in Boudh district Orissa, Sahu et al. 2007; 32-93 species (twenty 25 m^2 quadrats) in riparian environments of Atlantic forests in Rernambuco, Brazil, Gomes-Westphalen et al., 2012; 59/0.16ha (four hundred 4 m^2 quadrats) species in tropical dry evergreen forest on the Coromandel Coast of India, Anbarashan and Parthasarathy, 2013). However, which is lower than several reports of tropical forests in India (155/1.2 ha (three thousand 4 m^2 quadrats in 30 ha plots) in tropical evergreen forest in the Anamalais, Western Ghats, Annaselvam and Parthasarathy, 1999; 170 species/ 3 ha in tropical dry deciduous forest in Eastern Ghats of Nallamalai, Seshachalam and Nigidi hills, Southern Andhra Pradesh, India Reddy et al., 2008; 107 species/2.04 ha in tropical dry deciduous forest in Similipal Biosphere Reserve Orissa, Reddy et al., 2008; 108/0.8ha (eight hundred 1 m^2 quadrats in 8 ha plots) species in tropical low land forest of Andaman island India, Rasingam and Parthasarathy 2009; 269 species in tropical forests tract of Sileur-Maredumilli hills of North Eastern Ghats, Reddy et al., 2011). The wide variations in understory species richness depends on ecosystem processes and functions such as soil formation, nutrient cycling, maintenance of hydrological cycle, canopy cover, overstory species composition, light intensity available for ground vegetation, kind of disturbances and organic matter decomposition as suggested by Singh et al. (2013). Comparison of understory diversity is very difficult because, the variations in the area of sampling, size of quadrats, number of quadrats etc as suggested by Chittibabu and Parthasarathy (2000). However, the value obtained in the present study is well within the range (Annaselvam and Parthasarathy, 1999) of 50 species/ha in moist tropical forest at Cuyabeno, Amazonian Ecuador (Poulsen and Nielsen, 1995) to 121 species/ha in 0.75 ha of evergreen forests in Brunei (Poulsen and Nielsen, 1995). The population density of understory species (shrubs and herbs) varied considerably among the species as well as among the sites. In shrub community, the three dominant species occupy 60 % to 85% of populations. *Lantana camara* population contributed 29.4 - 40.2 % of shrub composition. In herbaceous community, three dominant species were represented by >100000 individuals in all the study sites. Similarly, 10 species population showed >20000 individuals while 14 species contains >10000 to <20000 population size. In the herbaceous community, annuals dominated than that of perennials. Similarly, annuals dominated the herbaceous community in tropical evergreen forests in the Anamalais, Western Ghats (Annaselvam and Parthasarathy, 1999) while perennials were dominant in the understory community in Amazonian rainforest (Poulsen and Balslev, 1991) and in Ghana (Hall and Swaine, 1981). The prevalence of annuals in the herbaceous community in the present study could be attributed to seasonal variation i.e. hot summer (herbaceous vegetation is completely dried off and rejuvenate in rainy season) and anthropogenic perturbations.

Poaceae, Euphorbiaceae, Acanthaceae, Lamiaceae, Rubiaceae and Papilionaceae were the dominant families in the present study. Similarly Poaceae was dominant in tropical lowland forest of Little Andaman (Rasingam and Parthasarathy, 2009) and Kolli hills of Eastern Ghats (Chittibabu and Parthasarathy, 2000) whereas, Acanthaceae, Euphorbiaceae and Papilionaceae were dominant families in Anamalais of Western Ghats (Annaselvam and Parthasarathy, 1999) and tropical dry evergreen forests on the Coromandel coast of India (Anbarashan and Parthasarathy, 2013). According to Richards (1996) Acanthaceae and Poaceae were the predominant families in herbaceous community in tropical rain forests. The dominance of monocot and ruderal weedy families here may be due to cattle grazing, open canopy and anthropogenic pressures.

In the present study, 81.7% - 84.1% of species and 98% - 100 % of species showed a contagious distribution pattern respectively in shrub and herbaceous communities. According to Odum (1971), contagious distribution is the most pervasive pattern in nature; random distribution is confined only in very uniform environments whereas regular distribution occurs in those areas where competition among several individuals exists. Distribution of species depends on the local habitat, daily and seasonal weather change and reproductive process (Kandari et al., 2011).

In our study, the three sites represented more or less similar communities with species composition and dominants and co-dominants. This indicated that these three sites are mostly represented by similar edaphic and environmental conditions. However, species composition in the study site III have little bit different compared to other two study sites and this may be due to several rocky stones here and there and also plots of this site are nearer to the water canal. More herbaceous species richness (21) was observed in study site II than in other two sites which could be attributed to lesser disturbance.

Human activities and cattle grazing in tropical dry deciduous forests create niche space for ruderal weeds and invasive species to colonize and establish. In all the study sites of the present study were dominated by ruderal weeds such as *Lantana camara* and *Ageratum conyzoides*, which indicated that these sites are either under disturbance or have canopy opening. Several studies agreed that the natural or anthropogenic perturbations provide a good shelter for the establishment and growth of exotic weeds (Whitmore and Burslem, 1996; Denslow et al., 2001, Anitha et al, 2009, Sundarapandian and Pascal, 2013). In shrub community, 28% - 40% of population is contributed by exotic invasive species. Similarly, in herbaceous community, exotic invasive species contribution is from 9.5% to 18.3%. However, exotic invasive plant contribution is low in the study site II compared to other two study sites. This indicated that this study site is far better or less disturbed when compared to other two sites. The plots in study site I are nearer to the roads or the agricultural fields. So they are easily accessible to human exploitation. Similarly, study site III is located on both sides of water canal. People regularly use the canal for day to day activities. In addition to that, this is a drinking water source for cattle, so this site is also under anthropogenic pressure. Native ruderal species *Sida cordifolia, Sida cardata* and *Sida acuta* were dominant population in herbaceous community here. Generally these native ruderal species occur abundantly in wastelands, both sides of roads, first year of the fallow-land in agroecosystems and moderate shaded open areas of forests. This indicated that these study sites are still under certain level of disturbance. The present study reveals that the understory vegetation of tropical dry deciduous forest at Sathanur Reserve forest is dominated by ruderal weeds and exotics. It is an indicator to say that this forest is under anthropogenic pressure even though it has been declared as a Reserve forest. Still it contains rich understory flora similar to other tropical dry forests of Eastern Ghats and central India. Conservation measure is required here to retain and restore the native diversity. Utmost care should be taken to check or eliminate invasive species in these forest ecosystems.

ACKNOWLEDGEMENTS

First author thank the University Grants Commission (UGC), Government of India for the fellowship. We appreciate the help of Dr. N. Parthasarathy, Professor in Department of Ecology and Environmental Sciences for species identification. We are grateful to Tamil Nadu Forest Department for permission to conduct field work.

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