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Understorey diversity of tropical dry deciduous forest of eastern plateau, India

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Abstract

The effort has been made in tropical dry deciduous forest of eastern plateau, Ranchi during the year 2018-2019. The floral composition and diversity in shrub and herb layer were quantified which is mostly ignored all time due to lack of methodologies. The entire region divided into two sites based upon the physiognomy. Randomly selected quadrates of 10x10 m² were taken for shrubs while 0.5x0.5 m² quadrates for herbs were taken. A total of 7540-7740 shrubs 299600-476400 herbs were encountered. The basal area was varied between 1.002- 2.25 m² ha⁻¹ for shrubs and 0.68- 1.35 m² ha⁻¹ for herbs. *Lygodium japonicum* showed highest value of IVI in shrubs and *Cynodon dactylon* showed highest value of IVI in herbs. Shannon index ranged from 1.53-1.65 for shrubs and 3.30-3.39 for herbs. The Concentration of dominance varied between 0.46-0.48 for shrubs and 0.13-0.14 for herbs. Equitability ranged from 0.85-0.86 for shrubs and 1.0 for herbs. Species richness ranged from 0.56-0.67 for shrubs and 1.27-1.6 for herbs. The herbal diversity is more than the shrubs in both the sites, which creates a great scope for wild fauna as well as fodder requirement of local live stock and livelihood for forest dwellers.

Keywords: Understorey, composition, diversity, tropical forest

Introduction

The understorey is an intrinsic treasure of forest ecosystems which consisting a large fraction of diverse floristic community (Gentry & Dodson 1987, Gentry & Emmons 1987, Mayfield & Daily 2005, Tchouto *et al.* 2006) [4, 5, 17, 33]. Inside a forest ecosystem understorey seeks equal importance as overstorey particularly for soil and water conservation and supports the primary food chain. The understorey consists relatively a small portion of overall forest ecosystems, but it plays a crucial role in energy flow and nutrient cycling due to the high gross turnover rates (Nilsson & Wardle 2005, Gilliam 2007, Hubau *et al.* 2019) [20, 9].

Understorey composition considerably differs among various forest types (Hart and Chen 2008) [8] and several reasonable factors are there for this difference including overstorey structure and composition (Xiao-Tao *et al.* 2011) [35]. Several studies have disclosed that the abundance, diversity and vegetation composition of understorey along with temporally change, stand development and stand-replacement (Hart & Chen 2006) [7]. Tropical forests have dragged much attention in recent few years in terms of their vegetational richness, species productivity and sequential carbon storage pattern (Bhat *et al.*, 2011) [1] along with other environmental gradients (Struik and Curtis 1962 and Shirima *et al.* 2015) [31, 28]. Herbaceous vegetation stimulates community dynamics and succession patterns (Newbery *et al.* 1999; Royo and Carson 2006) [19, 25]. In many forest ecosystems, herbaceous vegetation is a key strata and enduring largest population diversity (Oraon *et al.*, 2014) [21] along with the lianas and shrubs (Jhariya & Oraon 2012) [11].

With such importance understorey diversity of tropical forest was dragged our attention for investigation. Generally the lack of methodological accuracy creates difficulty in estimation (Karki, 2002; Khanal, 2001) [13, 14] and establishment of relationship with other forests.

Materials and Methods

The study site is located in Horhap beat of Ranchi the year 2018-2019 and the entire area, spreads over an area of 651.544 ha, is situated on hilly tract, which comes under eastern

plateau at an elevation of around 629 m (2,064 ft) from mean sea level with 23°18'10.072" N to 23°21'18.575" N latitude and 85°26'18.218" E to 85°29'1.539" E longitude.

It experiences tropical climate, which is characterized by hot summer from March to May range from 20 °C to 38 °C and well distributed rainfall during southwest monsoon (965 mm) from June to September. Winter season in the area is marked by dry and cold with temperatures 5 °C to 25 °C weather during the month of November to February.

The whole area was reconnaissance surveyed with field visits and divided into two sites based upon physiognomic factor. A simple random sampling procedure was adopted for characterization of vegetation and phytosociological analysis. Ten sample quadrates of 10×10 m² size were laid down in each site of the forest area for enumerating shrub species and for herbaceous flora twenty sample plots of 0.5×0.5 m² were laid at centre of each quadrates. All the quadrates were marked with Google earth images and GPS device (Garmin 72).

The vegetational data was quantitatively analyzed for frequency, density, abundance (Curtis and McIntosh, 1950) [2]. An importance value index was calculated as the sum total of relative frequency, relative density and relative basal area (Phillips, 1959) [23]. Plant diversity in both the sites was quantified by Shannon Index (Shannon and Weaver, 1963) [23], Concentration of dominance or Simpson's Index

(Simpson, 1949) [29], Equitability (Pielou, 1966) [24] and Species richness (Marglef, 1958) [16].

Results and Discussions

The vegetational composition and diversity in shrub and herb vegetation in both the sites are described below.

Composition of shrub layer

In the site I, a total of 7540 stems ha⁻¹ representing 7 species and 6 families were enumerated. It is evident from the data presented in the table 1 that *Lygodium japonicum* was the most abundant followed by *Clerodendrum infortunatum* and *Lantana camara*, as well as represented the highest density respectively. Lowest density was recorded in case of *Agave sisalana*. Highest basal area was observed in *Woodfordia fruticosa* followed by *Agave sisalana* and *Lantana camara*. Lowest basal area was observed in *Vitex negundo*. Basal area and density of individual shrub species varied from 0.0005m² ha⁻¹ to 1.45 m² ha⁻¹ and 70 to 4960 stems ha⁻¹, respectively. *Lygodium japonicum* showed highest value of IVI (88.97) followed by *Woodfordia fruticosa* (83.39) and *Lantana camara* (46.17). Similarly *Vitex negundo* showed lowest value of IVI (5.9) followed by *Rauvolfia serpentina* (8.8) and *Agave sisalana* (28.8). The total shrub density and basal area of site I was recorded 7540 shrubs ha⁻¹ and 2.25 m² ha⁻¹, respectively.

Table 1: Vegetational Composition of Shrub Layer

Sl. No.	Species	SITE I				SITE II			
		F (%)	D (stems ha ⁻¹)	BA (m ² ha ⁻¹)	IVI	F (%)	D (stems ha ⁻¹)	BA (m ² ha ⁻¹)	IVI
1	<i>Lantana camara</i> L.	100	800	0.223	46.17	90	580	0.132	49.71
2	<i>Lygodium japonicum</i> (Thunb.) Sw.	90	4960	0.003	88.97	80	5150	0.001	92.46
3	<i>Woodfordia fruticosa</i> (L.) Kurz.	50	460	1.451	83.39	20	240	0.520	61.44
4	<i>Vitex negundo</i> L.	10	250	0.001	5.90	40	530	0.002	19.90
5	<i>Clerodendrum infortunatum</i> L.	90	920	0.059	37.91	70	1220	0.066	44.99
6	<i>Rauvolfia serpentina</i> (L.) Benth	20	80	0.060	8.84				
7	<i>Agave sisalana</i> Perrine	30	70	0.454	28.82				
6	<i>Hibiscus rosa-sinensis</i> L.					10	20	0.281	31.50
	Total	390	7540	2.251	300	310	7740	1.002	300.00

F= Frequency, D=Density, BA= Basal Area, IVI= Important Value Index

In the site II, a total of 7740 stems ha⁻¹ representing 6 species and 5 families were enumerated. It is evident from the data presented in the table 1 that *Lygodium japonicum* was the most abundant followed by *Clerodendrum infortunatum* and *Lantana camara*, as well as represented the highest density respectively. Lowest density was recorded in case of *Hibiscus rosa-sinensis*. Highest basal area was observed in *Woodfordia fruticosa* followed by *Hibiscus rosa-sinensis* and *Lantana camara*. Lowest basal area was observed in *Lygodium japonicum*. Basal area and density of individual shrub species varied from 0.001m² ha⁻¹ to 0.52 m² ha⁻¹ and 20 to 5150 stems ha⁻¹, respectively. *Lygodium japonicum* showed highest value of IVI (92.46) followed by *Woodfordia fruticosa* (61.44) and *Lantana camara* (49.71). Similarly *Vitex negundo* showed lowest value of IVI (19.9) followed by *Hibiscus rosa-sinensis* (31.5) and *Clerodendrum infortunatum* (44.98). The total tree density and tree basal area of site II was recorded 7740 stems ha⁻¹ and 1.002 m² ha⁻¹, respectively.

Composition of herb layer

In the site I, a total of 299600 herbs ha⁻¹ representing 17 species and 8 families were enumerated. The Poaceae family

was represented by 162000 individuals followed by Cyperaceae (36800), Asteraceae (27600) and Fabaceae (16000). It is evident from the data presented in the table 2 that *Leptochloa chinensis* was the most abundant herb followed by *Cynodon dactylon* and *Cyperus rotundus*, as well as represented the highest density respectively. Lowest density was recorded in case of *Xanthium strumarium*, *Digera arvensis*, *Mimosa pudica* and *Amaranthus spinosus*. Highest basal area was observed in *Amaranthus spinosus* followed by *Tridax procumbens*, *Digitaria sanguinalis*, *Parthenium hysterophorus*, *Commelina benghalensis* and *Achyranthes aspera*. Lowest basal area was observed in *Mimosa pudica*. Basal area and density of individual herbs varied from 0.005 m² ha⁻¹ to 0.165 m² ha⁻¹ and 1600 to 69600 stems ha⁻¹, respectively. *Leptochloa chinensis* showed highest value of IVI (39.36) followed by *Cynodon dactylon* (33.09) and *Tridax procumbens* (32.3). Similarly *Mimosa pudica* showed lowest value of IVI (3.85) followed by *Celosia spicata* (3.996) and *Digera arvensis* (4.25). The total herb density and basal area of site I was recorded 299600 herbs ha⁻¹ and 0.68 m² ha⁻¹, respectively.

Table 2: Vegetational Composition of Herb Layer

Sl. No.	Species	SITE I				SITE II			
		F (%)	D (stems ha ⁻¹)	BA (m ² ha ⁻¹)	IVI	F (%)	D (stems ha ⁻¹)	BA (m ² ha ⁻¹)	IVI
1	<i>Phyllanthus niruri</i> L.	30	6800	0.015	11.28	20	11600	0.020	8.06
2	<i>Marsilea minuta</i> L.	20	33200	0.014	17.68	30	74400	0.017	23.16
3	<i>Cynodon dactylon</i> (L.) Pers.	50	50400	0.033	33.09	80	138000	0.040	48.62
4	<i>Leptochloa chinensis</i> (L.) Nees.	60	69600	0.017	39.36	30	34800	0.010	14.27
5	<i>Commelina benghalensis</i> L.	20	7200	0.044	13.34	10	2400	0.016	3.80
6	<i>Tridax procumbens</i> L.	40	22400	0.107	32.30	10	9200	0.031	6.28
7	<i>Cassia tora</i> L.	30	13600	0.035	16.50	40	43600	0.017	18.72
8	<i>Parthenium hysterophorus</i> L.	20	3600	0.057	14.13	20	4800	0.017	6.41
9	<i>Digitaria sanguinalis</i> (L.) Scop.	40	30800	0.079	30.92	30	40800	0.098	22.03
10	<i>Digera arvensis</i> Forsk.	10	1600	0.010	4.25				
11	<i>Amaranthus spinosus</i> L.	20	2400	0.165	29.61	20	2400	0.088	11.15
12	<i>Achyranthes aspera</i> L.	20	3200	0.043	11.97	10	1200	0.022	3.93
13	<i>Cyperus rotundus</i> L.	40	36800	0.035	26.55	10	1200	0.0002	2.35
14	<i>Celosia spicata</i> L.	10	2800	0.005	4.00				
15	<i>Dactyloctenium aegyptium</i> (L.) Willd.	10	11200	0.003	6.51				
16	<i>Mimosa pudica</i> L.	10	2400	0.005	3.85	10	3200	0.009	3.45
17	<i>Xanthium strumarium</i> L.	10	1600	0.013	4.64	20	8400	0.058	10.20
18	<i>Trifolium repens</i> L.					20	8400	0.050	9.62
19	<i>Cleome viscosa</i> L.					20	20000	0.052	12.24
20	<i>Cenchrus ciliaris</i> L.					20	27600	0.045	13.29
21	<i>Phalaris minor</i> Retz.					20	25200	0.073	14.87
22	<i>Leucas aspera</i> (Willd.) Link.					20	2000	0.308	27.31
23	<i>Setaria verticillata</i> (L.) P. Beauv.					20	15600	0.215	23.33
24	<i>Argemone Mexicana</i> L.					10	800	0.009	2.94
25	<i>Datura metel</i> L.					10	800	0.158	13.96
Total		440	299600	0.681	300.00	480	476400	1.353	300.00

F= Frequency, D=Density, BA= Basal Area, IVI= Important Value Index

In the site II, a total of 476400 herbs ha⁻¹ representing 22 species and 12 families were enumerated. It is evident from the data presented in the table 2 that *Cynodon dactylon* was the most abundant herb followed by *Marsilea minuta* and *Digitaria sanguinalis*, as well as represented the highest density respectively. Lowest density was recorded in case of *Datura metel*, *Argemone Mexicana*, *Xanthium strumarium* and *Trifolium repens*. Highest basal area was observed in *Leucas aspera* followed by *Setaria verticillata*, *Datura metel* and *Digitaria sanguinalis*. Lowest basal area was observed in *Cyperus rotundus*. Basal area and density of individual tree species varied from 0.0002 m² ha⁻¹ to 0.215 m² ha⁻¹ and 800 to 138000 stems ha⁻¹, respectively. *Cynodon dactylon* showed highest value of IVI (48.62) followed by *Leucas aspera* (27.32) and *Setaria verticillata* (23.33). Similarly *Cyperus rotundus* showed lowest value of IVI (2.35) followed by *Argemone Mexicana* (2.94) and *Mimosa pudica* (3.45). The total herb density and basal area of site II was recorded 476400 herbs ha⁻¹ and 1.35 m² ha⁻¹, respectively.

The Shrub and herb density in the present study varied from 7540-7740 and 2, 99,600-4,76,400 which was compared

with other tropical forests described in table 3. From the table we found the shrub diversity was quite higher than other dry deciduous forests (Jharia 2017; Oraon *et. al.* 2015; Sharma & Kant 2014) [26]; however, lesser than the tropical moist deciduous forest (Kumar & Saikia 2018) [15]. If we consider the herbal population a reverse order was found that the herb diversity was quite lesser than other dry deciduous forests (Oraon *et. al.* 2014; Gandhi & Sundarapandian 2014; Jharia & Yadav 2016) [21, 3] however, higher than the tropical moist deciduous forest (Kumar & Saikia 2018) [15].

Lygodium japonicum is the most abundant shrub with IVI values 88.97-92.46, as supported by Watkins & Cardelus (2009), followed by *Woodfordia fruticosa* and *Lantana camara*. However, *Lantana camara* is the most dominant shrub and obnoxious weed of other forest area (Gandhi & Sundarapandian 2014) [3]. *Cynodon dactylon* showed highest value of IVI 33.09- 48.62, and most abundant herb, which is the most common herb of tropical forest and mostly used for cattle grazing.

Table 3: Comparison of vegetational composition with other forests

Location	Layers	Density (stems ha ⁻¹)	Basal area (m ² ha ⁻¹)	Source
Tropical dry forest, Eastern Ghats	Shrub	3484-4040	--	Gandhi & Sundarapandian (2014) [3]
	Herb	655750-708450	--	
Tropical moist deciduous forest, Ranchi	Shrub	11,047	--	Kumar & Saikia (2018) [15]
	Herb	232,553	--	
Tropical deciduous forest	Shrub	1250-3750	2.79-4.92	Jharia (2017)
Tropical forest, Boramdeo WLS	Shrub	760-3080	0.39-2.49	Oraon <i>et. al.</i> (2015)
Tropical forest, Boramdeo WLS	Herb	67800- 119200	--	Oraon <i>et. al.</i> (2014) [26]
Sarguja forest, Chhattisgarh	Shrub	4500	5.43	Jharia & Yadav (2016)
	Herb	8,32,000	--	
Subtropical dry deciduous forest	Shrub	376	--	Sharma & Kant (2014) [26]
Himalayan subtropical Pine forest	Shrub	163	--	

Tropical dry deciduous forest, Ranchi	Shrub Herb	7540-7740 299600-476400	1.00- 2.25 0.68- 1.35	Present Study
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Species Diversity

Species diversity, the number of species in a community, is ecologically important to ensure the population structure of the ecosystem. Since, it seems to increase as more stable community.

Shannon index was found to be variable in both the sites in different vegetational layers. The Shannon index values recorded in site I were 1.65 for shrubs layer and 3.297 for herbs layer. Similarly in site II, 1.53 for shrubs layer and 3.39 for herbs layer, was calculated. The values recorded for Concentration of dominance in different vegetational layers of site I were 0.46 for shrubs layer and 0.13 for herbs layer. Similarly in site II, 0.48 for shrubs layer and 0.14 for herbs layer was recorded. Equitability (e) values were 0.85 for shrubs layer and 1.0 for herbs layer found in site I. Similarly in site II equitability values were 0.86 for shrubs layer and 1.0 for herbs layer. In site I species richness values were 0.67 for shrubs layer and 1.27 for herbs layer. Similarly species richness values were 0.56 for shrubs layer and 1.6 for herbs layer found in site II.

Maximum diversity as found in herb layer with Shannon index ranged from 3.30-3.39 followed by shrubs 1.53-1.65 which indicates the more diversity in herbs than shrubs that shows the stability of the communal succession. The

Concentration of dominance was found higher in shrub layer 0.46-0.48 than herbs 0.13-0.14; indicating less dominance of the dominant shrub species and least dominance of the dominant herb species; which evident very less colonization of single species. Highest evenness was found higher in herb with equitability 1.0 than shrubs (0.85-0.86) that shows all the species are evenly distributed and this condition helps to reduce the intra-specific competition. The species richness was found higher in herbs (1.27-1.6) and shrubs (0.56-0.67); this indicating lesser available of all species in all the quadrates. If we considered both the sites in terms of diversity indices both had similar pattern of diversity in understory. It indicates narrow difference in pattern of succession in the entire area of eastern plateau consider for investigation.

The comparisons of diversity of the said forest area with other tropical forests were described in table 4. Particularly for shrubs has lesser Shannon index, concentration of dominants, species richness and with moderate evenness among the species. In case of herbs all the values comes under the range of other tropical dry deciduous forest but comparison with tropical moist deciduous forest all the entities comes almost similar except the species richness. It may be caused by forest fragmentation and cattle grazing.

Table 4: Comparison of diversity indices with other forests

Location	Layers	H'	Cd	e	d	sources
Sal mixed forest	Under storey	3.64	1.45	0.939	24.76	Thakur (2018)
Tropical moist deciduous forest, Ranchi	Shrub	2.72	1.1	0.76	4.88	Kumar & Saikia (2018) ^[15]
	Herb	2.98	0.08	0.78	5.85	
Tropical deciduous forest	Shrub	2.32-3.77	0.08- 0.2	1.41-1.44	0.56-1.58	Jhariya (2017)
Sarguja Forest	Herb	4.606	0.045	1.397	1.917	Sinha <i>et. al.</i> (2015)
Tropical forest, Boramdeo WLS	Herb	2.50-4.25	0.06-0.37	0.76-1.34	1.35-2.19	Oraon <i>et. al.</i> (2014) ^[21]
Tropical forest, Boramdeo WLS	Shrub	0.71-5.27	0.13-0.77	0.52-2.12	0.27-1.37	Oraon <i>et. al.</i> (2015)
Eastern ghats, Andhra Pradesh	Under storey	3.76-3.96	0.96-0.97	0.6-0.78	10.0-11.2	Naidu & Kumar (2016)
Subtropical forest Siwaliks	Shrub	2.68	0.89	0.75	10.27	Sharma & Kant (2014) ^[26]
Tropical deciduous forest, Ranchi	Shrub	1.53-1.65	0.46-0.48	0.85-0.86	0.56-0.67	Present Study
	Herb	3.30-3.39	0.13-0.14	1.0	1.27-1.6	

H'= Shannon index, Cd= Concentration of dominance, e=Equitability, d= Species Richness

Conclusion

The understory keeps a very crucial role due to their medicinal and production values. The herbal diversity of the eastern plateau plays an efficient role in soil moisture conservation as well as improvement of the soil life in terms of humus generation. Intensive cattle grazing create a threat for long term although it helps in dissemination of seeds but it can be well regulated with stall feeding method. The herb diversity is more over the shrubs which indicate a healthy forest ecosystem. Shrubs are primary preference of the browsing animals along with much suitable for fire wood, so control cutting helps in conservation and control of crown fire.

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References

1. Bhat DM, Hegde GT, Shetti DM, Patgar SG, Hegde GN, Furtado RM *et. al.* Impact of Disturbance on Composition, Structure, and Floristics of Tropical Moist Forests in Uttara Kannada District, Western Ghats, India. *Ecotropica*. 2011; 17:1-14
2. Curtis JT, McIntosh RP. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*. 1950; 31:434-455.
3. Gandhi DS, Sundarapandian S. Inventory of trees in tropical dry deciduous forests of Tiruvannamalai district, Tamil Nadu, India; *Biodiversitas*. 2014; 15(2):169-179.
4. Gentry AH, Dodson CD. Contribution of non-trees to species richness of a tropical rain forest. *Biotropica*. 1987; 19:149-156.
5. Gentry AH, Emmons LH. Geographical variation in fertility, phenology, and composition of the understory of Neotropical forests. *Biotropica*. 1987; 19:216-227.
6. Gilliam FS. The ecological significance of the herbaceous layer in temperate forest ecosystems. *Bioscience*. 2007; 57:845-858.

7. Hart SA, Chen HYH. Understory vegetation dynamics of North American boreal forests. *Crit. Rev. Plant Sci.* 2006; 25:381-397.
8. Hart SA, Chen HYH. Fire, logging and overstory affect understory abundance, diversity, and composition in boreal forest. *Ecol. Monogr.* 2008; 78:123-140.
9. Hubau W, De Mil T, Van den Bulcke J, Phillips OL, Angoboy Ilondea B, Van Acker J *et al.* The persistence of carbon in the African forest understory. *Nat. Plants.* 2019; 5:133-140.
10. Jhariya MK. Vegetation ecology and carbon sequestration potential of shrubs in tropics of Chhattisgarh, India. *Environ Monit Assess.* 2017; 189:518.
11. Jhariya MK, Oraon PR. Analysis of herbaceous diversity in fire affected areas of Boramdeo Wildlife Sanctuary, Chhattisgarh. *The Bioscan.* 2012; 7(2):325-330.
12. Jhariya MK, Yadav DK. Understory vegetation in natural and plantation forest ecosystem of Sarguja (C.G.), India. *Journal of Applied and Natural Science.* 2016; 8(2):668-673.
13. Karki D. Economic Assessment of Community Forestry in Inner Terai of Nepal: A Case Study from Chitwan District. Asian Institute of Technology, Thailand, 2002.
14. Khanal KP. Economic Evaluation of Community Forestry in Nepal and its Equity Distribution Effect. The Royal Veterinary and Agricultural University, Denmark, 2001.
15. Kumar R, Saikia P. Floristic analysis and dominance pattern of sal (*Shorea robusta*) forests in Ranchi, Jharkhand, eastern India; *Journal of Forestry Research*, 2018.
16. Margalef DR. Information theory in Ecology. *Gen. Syst.* 1958; 3:36-71
17. Mayfield MM, Daily GC. Countryside biogeography of neotropical herbaceous and shrubby plants. *Ecol. Appl.* 2005; 15:423-439.
18. Naidu MT, Kumar OA. Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *Journal of Asia-Pacific Biodiversity.* 2016; 9(3):328-334.
19. Newbery DM, Kennedy DN, Petol GH, Madani L, Ridsdale CE. Primary forest dynamics in lowland dipterocarp forest at Danum Valley, Sabah, Malaysia, and the role of the understorey. *Philos Trans R Soc Biol.* 1999; 354:1763-1782.
20. Nilsson MC, Wardle DA. Understory vegetation as a forest ecosystem driver: Evidence from the northern Swedish boreal forest. *Front. Ecol. Environ.* 2005; 3:421-428.
21. Oraon PR, Singh L, Jhariya MK. Variations in Herbaceous Composition of Dry Tropics Following Anthropogenic Disturbed Environment. *Current World Environment.* 2014; 9(3):967-979.
22. Oraon PR, Singh L, Jhariya MK. Shrub species diversity in relation to anthropogenic disturbance of Boramdeo Wildlife Sanctuary, Chhattisgarh. *Environment and Ecology.* 2015; 33(2):996-1002.
23. Phillips EA. Methods of vegetation study. Holt Rinehart and Winston New York, USA 1959, 105
24. Pielou EC. The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology* 1966; 13:131-144.
25. Royo AA, Carson WP. On the formation of dense understory layers in forests worldwide: consequences and implications for forest dynamics, biodiversity, and succession. *Can J For Res.* 2006; 36:1345-1362.
26. Sharma N, Kant S. Vegetation structure, floristic composition and species diversity of woody plant communities in sub-tropical *Kandi* Siwaliks of Jammu, J & K, India; *International Journal of Basic and Applied Sciences* 2014; 3(4):382-391.
27. Shannon CE, Weiner W. The Mathematical Theory of Communication; University of Illinois Press, Urbana USA. 1963, 117.
28. Shirima DD, Pfeifer M, Platts PJ, Totland Ø, Moe SR. Interactions between Canopy Structure and Herbaceous Biomass along Environmental Gradients in Moist Forest and Dry Miombo Woodland of Tanzania. *PLoS One.* 2015; 10(11):e0142784.
29. Simpson EH. Measurement of Diversity Nature. 1949; 163:688.
30. Sinha R, Jhariya MK, Yadav DK. Assessment of Sal Seedlings and Herbaceous Flora in the Khairbar Plantation of Sarguja Forest Division, Chhattisgarh. *Current World Environment.* 2015; 10(1):330-337.
31. Struik GJ, Curtis JT. Herb distribution in an *Acer saccharum* forest. *Am Midl Nat.* 1962; 68:285-296
32. Thakur TK. Diversity, composition and structure of understorey vegetation in the tropical forest of Achanakmaar Amarkantak Biosphere Reserve, India. *Environmental Sustainability.* 2018; 1:279-293
33. Tchouto MGP, De Boer WF, De Wilde J, Van der Maesen LJG. Diversity patterns in the flora of the Campo-Ma'an rain forest, Cameroon: do tree species tell it all? *Biodivers. Conserv.* 2006; 15:1353-1374.
34. Watkins JEJ, Cardelus C. Habitat Differentiation of Ferns in a Lowland Tropical Rain Forest *American Fern Journal.* 2009; 99(3):162-175.
35. Xiao-Tao L, Jiang-Xia Y, Jian-Wei T. Diversity and composition of understory vegetation in the tropical seasonal rain forest of Xishuangbanna, SW China. *Rev Bio Trop.* 2011; 59:455-463.