Understory vegetation in natural and plantation forest ecosystem of Sarguja (C.G.), India

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Abstract: Understory vegetation serves a special role in maintaining the structure and function of forest ecosystem as they strongly influence regeneration, seedling establishment, growth, nutrient cycling and thus the dynamics of the whole forest ecosystem. The present investigation is aimed to study the composition, structure and diversity of understory vegetation in natural forests and teak plantation of Sarguja forest division of Chhattisgarh. A total of 23 species comprising 5 shrubs and 18 herbs were recorded in natural forest while in teak plantation 3 shrub and 20 herb species were found. In natural forest a total of 4500 shrubs/ha and 8,32,000 herbs/ha were recorded while in plantation site it was 5500 shrubs/ha and 6,96,000 herbs/ha, respectively. In shrub layer the value of species diversity was 1.10 for teak plantation and 2.20 for natural forest. Simpson index was 0.23 for natural forest and 0.57 for teak plantation. The Margalef's index of richness varied from 0.23-0.48, least in plantation site and peak in natural forest, Equitability index varied from 1.00 to 1.37, lowest in plantation site and higher in plantation site and β diversity was 1.20 in natural forest and 2.00 in plantation site. In case of herb layer the value of Shannon index, species richness and equitability values were higher in teak plantation while the Simpsons index and beta diversity were found more in natural forest.

Keywords: Composition, Diversity, Herb, Structure, Shrub, Understory

INTRODUCTION

The ground flora forms a substantial structural component of forest ecosystem and harbors majority of diversity in deciduous forests (Gilliam and Roberts, 2003). Tropical forests are one of the richest, diverse and complex terrestrial ecosystem supporting a variety of life forms and also recognized as most used and threatened ecosystems, especially in India (Shankar, 2001). Anthropogenic disturbances in forests followed by livestock grazing adversely affect the composition of understory vegetation (Jhariya *et al.*, 2012 and 2013). Increased human activities in the forested areas have not only led to depletion of forests but also degrade the quality of the stand (Jhariya, 2014; Jhariya *et al.*, 2014; Pawar *et al.*, 2014a & b).

Understory species in tropical forests respond positively to increased light availability. Ground vegetation might prove to be a key indicator of succession status of forest. Disturbances also have profound effect on the regeneration of non-pioneer understory vegetation (Kwit and Platt, 2003). Herbaceous community varied by disturbance regimes. Disturbances at low severity usually cause little damage to overstorey but affects to understory vegetation directly (Jhariya *et al.*, 2012). Herbaceous layer is essential component for increasing diversity of the region as well as it plays a substantial role in the process of nutrient cycling. Understory

composition is often correlated with micro-climate and site conditions and provides important indications of site quality, overstory regeneration patterns and ecosystem health (Small, 2001; Jhariya and Oraon, 2012a, b, c; Pawar *et al.*, 2012; Kittur *et al.*, 2014a, b; Oraon *et al.*, 2014 and 2015). Shrub layer, an components of tropical forest have important role on the diversity, structure and dynamics of tropical forest ecosystem. Limited work has been done in relation to shrubs in the tropics. But presently more emphasis has been given due to their function and importance.

Anthropogenic disturbances are more frequent in tropical deciduous forests of Chhattisgarh. These factors are causing great loss to biodiversity of the region and ultimately destructing the natural vegetation and habitat of the area. The natural forest and plantation ecosystem varied greatly in terms of strucuture, function and vegetation dynamics. Many studies (Sahu *et al.*, 2013a, b; Sinha *et al.*, 2014 and 2015; Yadav *et al.*, 2015) dealing with the floristic and ecological features of the overstory have been carried out, however, the study on understory vegetation have neither yet been studied or little research work has been done in this area. Understanding the structure and diversity of understory vegetation is necessary to identify their roles and characteristics in a stand and also for the conservation and restoration of degraded environment. Therefore, in the present study an attempt has been made to

synthesize information related to understory vegetation composition, structure and diversity pattern in natural and plantation forest ecosystem of Sarguja foest division of Chhattisgarh.

MATERIALS AND METHODS

The present work is carried out to examine the structure, composition and diversity pattern of understory vegetation in natural forest of Chendra and teak plantation (Established in the year 1962) of Sumerpur (Chendra, range Dhaurpur, $23^o05'14.7''$ to $23^o05'16.8''$ north latitude and $83^o16'29.6''$ to $83^o16'31.8''$east longitude, Beat No. 2589, Ganjha-dand, Coupe No. VII and area about 47 ha) of Sarguja forest division. Sarguja district is located in the northern part of Chhattisgarh State of India. This district has over extension between south-eastern parts of Vindhyachal-Baghelkhand region of peninsular India. It lies between $23^o37'25''$ to $24^o6'17''$ north latitude and $81^o31'40''$ to $84^o4'40''$east longitude.

The district Sarguja, is represented by very rich vegetation and biological diversity (Sinha et al., 2014 and 2015). About 58% of the area in the district lies under forests. The flora of Nazzul and other areas are changing frequently with the human activities and land-use. The physiographic division of the regions are: highlands, uplands and central plain. The climate of district is characterized by hot summer and well distributed rainfall during the monsoon season. Soil of Sarguja district can be broadly classified in four major classes: Red and Yellow Soils, Alluvial Soils, Laterite Soils and Medium blue Soils, respectively.

The stratified random sampling was laid out to analyze the understory vegetation for its composition, structure and diversity in natural and plantation forest ecosystem. The shrub layer was analyzed by randomly laying quadrats of 2×2 m. The girth at collar height of all the individual in each quadrat was measured and recorded separately. In each of these quadrat, a sub-quadrat of 50×50 cm were randomly laid for measuring herbs. Vegetational data was quantitatively analysed for frequency, density and abundance (Curtis and McIntosh, 1950). Diversity parameters for shrub and herb layers were determined using the Shannon-Weaver information function (Shannon and Weaver, 1963). Concentration of dominance was measured following Simpson's index method (Simpson, 1949). Vegetations were also measured for species richness (Margalef, 1958), equitability (Pielou, 1966) and Beta diversity (Whittaker, 1972).

RESULTS AND DISCUSSION

Compostion and structure of understory vegetation: In the natural forest, a total of 4500 individual ha^{-1} comprising 5 species with 5 families were recorded for shrub layer (Table 1). The highest density (1500 shrub ha^{-1}), frequency (60) and IVI (87.36) values were recorded for C. spinarum, whereas the peak value of basal area covered by V. calyculata (2.18 m^{2}ha^{-1}). The density, basal area and IVI values of individual species varied from 500-1500 shrub ha^{-1}, 0.23-2.18 m^{2}ha^{-1} and 26.46-87.36, respectively. While in the teak plantation a total of 3 species comprising 3 families were recorded. In plantation site higher density of shrub was found then the natural forest. The highest density (4000 shrubs ha^{-1}), frequency (100), basal area (2.140 m^{2}ha^{-1}) and IVI (208.47) values were recorded for L. camara, whereas it was minimum for V. calyculata. The abundance to frequency ratio indicated that in natural forest C. spinarum only distributed regularly while the other remaining species were distributed randomly and contagiously over the area, whereas in plantation site L. camara distributed regularly while remaining species contagiously (Table 1).

Under the herb layer a total of 8,32,000 individual ha^{-1} representing 18 species with 12 families were recorded in natural forest while in teak plantation a total of 6,96,000 individual ha^{-1} comprising 20 species with 10 families were observed. The density of individual species varied from 8,000-1,76,000 individual ha^{-1} in natural forest, being least for A. paniculata and T. macrodonta while peak for C. rotundus, respectively. In the plantation site, the density of individual species ranged from 8,000-1,20,000 herb ha$^{-1,}$ being lowest for A. indica, C. compressus, D. aegyptium, D. triflorum, D. sanguinalis and S. cordifolia whereas highest for O. burmannii, respectively (Table 2). The IVI value of individual species varied from 5.57-54.72 in natural forest and 6.20-37.15 for plantation site. In natural forest all recorded species were distributed randomly and contagiously whereas regular distribution is absent. Similarly in teak plantation D. pulchellum and R. dentatus distributed regularly while the remaining species showed random and contagious distribution

Table 1. Composition of shrub layer in Sarguja forest division.

Species	Natural Forest					Teak Plantation				
	F	D	BA	IVI	A/F	F	D	BA	IVI	A/F
Butea superba Roxb	--	--	--	--	--	20	1000	0.945	60.88	0.10
Carissa spinarum DC.	60	1500	1.12	87.36	0.017	--	--	--	--	--
Lantana camara Linn.	40	1000	0.34	50.64	0.025	100	4000	2.140	208.47	0.02
Ventilago calyculata Tul.	20	500	2.18	62.36	0.050	20	500	0.242	30.65	0.05
Woodfordia floribunda Salist.	20	500	0.23	26.46	0.050	--	--	--	--	--
Ziziphus xylopyra Willd.	40	1000	1.56	73.18	0.025	--	--	--	--	--
Total		4500	5.43	300.00			5500	3.327	300.00	

D= Density (individuals ha^{-1}), BA= Basal area m^2 ha^{-1}, A/F= Abundance to Frequency ratio, IVI= Importance Value Index

Table 2. Composition of herb layer in Sarguja forest division.

Species	Natural Forest				Teak Plantation			
	F	D	IVI	A/F	F	D	IVI	A/F
Achyranthes aspera L.	60	56000	19.63	0.04	60	40000	17.34	0.03
Acmella paniculata (Wall. ex DC.) R.K.Jansen	20	24000	10.25	0.15	40	48000	19.66	0.08
Alternanthera sessilis (L.) R.Br. ex Roem. & Schultz	20	120000	38.34	0.75	--	--	--	--
Andrographis paniculata Burm. f.	20	8000	5.57	0.05	--	--	--	--
Anisomeles indica (L.) Kuntze	--	--	--	--	20	8000	6.20	0.05
Aysicarpus vaginalis (L.) DC.	40	48000	16.36	0.08	40	24000	12.21	0.04
Curculigo orchioides Gaertn.	60	56000	19.63	0.04	--	--	--	--
Cynodon dactylon L.	60	40000	16.78	0.03	--	--	--	--
Cyperus compressus Linn.	--	--	--	--	20	8000	6.20	0.05
Cyperus rotundus Linn.	20	176000	54.72	1.10	40	32000	14.70	0.05
Dectyloctenium aegyptium (L.) Willd.	--	--	--	--	20	8000	6.20	0.05
Desmodium pulchellum DC.	40	16000	9.75	0.03	100	56000	23.69	0.01
Desmodium triflorum (L.) DC.	--	--	--	--	20	8000	6.20	0.05
Digitaria sanguinalis (L.) Scop.	--	--	--	--	20	8000	6.20	0.05
Eragrostis amabilis (L.) Wight & Arn.	20	16000	7.91	0.10	20	16000	10.02	0.10
Eragrostis diarrhena (Schult. & Schult.f.) Steud.	20	24000	10.25	0.15	40	64000	24.63	0.10
Erysimum hieraciifolium L. f.	20	24000	10.25	0.15	--	--	--	--
Evolvulus alsinoides (L.)	40	24000	11.41	0.04	40	48000	19.66	0.08
Malvastrum coromandelianum (L.) Garcke	--	--	--	--	60	48000	19.38	0.03
Oplismenus burmannii (Retz.) P.Beauv	40	24000	11.41	0.04	100	120000	37.15	0.03
Paspalum conjugatum P.J.Bergius	--	--	--	--	40	24000	12.21	0.04
Phyllanthus niruri L.	40	40000	14.71	0.06	20	16000	10.02	0.10
Psoralea corylifolia Linn.	--	--	--	--	20	16000	10.02	0.10
Rumex dentatus L.	60	112000	29.58	0.08	100	96000	32.10	0.02
Sida cordifolia Linn.	--	--	--	--	20	8000	6.20	0.05
Tectaria macrodonta	20	8000	5.57	0.05	--	--	--	--
Vigna pilosa Willd.	20	16000	7.91	0.10	--	--	--	--
Total	620	832000	300		840	696000	300.0	

D= Density (individuals ha^{-1}), F= Frequency, A/F= Abundance to Frequency ratio, IVI= Importance Value Index

pattern (Table 2).

Family wise distribution of herb species in natural forest revealed that most frequent families were found in the order of Poaceae (4 species of 22.22%) > Fabaceae (3 species of 16.67%) > Amaranthaceae (2 species of 11.11%) > Acanthaceae, Asteraceae, Brassicaceae, Convolvulaceae, Cyperaceae, Euphorbiaceae, Hypoxidaceae, Polygonaceae, Tectariaceae (each 1 species of 5.57%), respectively. While in plantation site it follow the order, Poaceae (6 species of 30.00%) > Fabaceae (4 species of 20.00%) > Cyperaceae, Malvaceae (each 2 species of 10.00%) > Amaranthaceae, Asteraceae, Convolvulaceae, Euphorbiaceae, Lamiaceae, Polygonaceae (each 1 species of 5.00%).

Diversity indices: Diversity indices provide the information on species richness, distribution and rate of change in species composition. Both structure and diversity of vegetation have strong functional role in controlling ecosystem process. Table 3 summarized the diversity pattern of the understory species found in both the sites. In natural forest Shannon index value and Species richness value for shurb layer was twice then the plantation site, while contrary to this Simpsons index value was twice in teak plantation then natural forest. The value of equitibility was found higher in natural forest while beta diversity was more in plantation site under the shrub layer (Table 3). In case of herb layer the value of Shannon index, species richness and equitability values were higher in teak plantation while the Simpsons index and beta diversity were found more in natural forest, respectively.

The species established in understory of natural forest and plantation sites were quite different in terms of composition, structure and diversity. The community of an ecosystem is regulated by various natural or biotic factors/forces which ultimately influence the overall structure of the community, resulting in variations of the population dynamics. Vegetational structure inventory entail the composition, stratification and community types, while diversity provides key information on species richness, distribution and rate of change in species composition. The concept of diversity is commonly considered as an important attribute of an organized community (Hairston *et al*., 1964). Both structure and diversity of vegetation have an important functional role in the regulation of ecosystem process. Shrubs can affect the growth of desired species, through competition for sharing of resources, or by delaying regeneration of trees following disturbance. The density of shrubs was found higher in the plantation site and least in natural forest. The reason of higher shurbs occurance in plantation site may be due to the open canopy which gives opportunities for regeneration and growth of shrubs species. Various factors are responsible for variation in understrory vegetation, including overstory composition and struc-

Table 3. Species diversity of understory vegetation in Sarguja forest division.

Diversity Index	Shrub Layer		Herb Layer	
	Natural Forest	Teak Plantation	Natural Forest	Teak Plantation
Shannon index (H)	2.20	1.10	3.64	3.83
Simpsons index (Cd)	0.23	0.57	0.11	0.10
Species richness (d)	0.48	0.23	1.25	1.41
Equitability (e)	1.37	1.00	1.26	1.28
Beta diversity (βd)	1.20	2.00	1.50	1.35

ture (Sangar *et al.*, 2008; Hart and Chen, 2008), soil moisture and nutrient dynamics (Siebert, 2002; Ramadhanil *et al.*, 2008), succession history (LaFrankie *et al.,* 2006), management strategies (Hart and Chen, 2008), and fragmentation (Rasingam and Parthasarathy, 2009). Similar findings were also reported by Gianoli *et al.* (2010), Schnitzer *et al.* (2012) and Jhariya *et al.* (2012). Similarly, Mishra *et al.* (2008) also reported the maximum number of shrubs in the buffer area of biosphere reserve having the most anthropogenic disturbance (Sahu *et al.*, 2008). Jhariya *et al.* (2012) reported that shrub species ranged between 6-10 and density varied from 1120-2480 individual/ha with the basal area of 0.59-1.11 m^2 ha^{-1} during pre-fire season while during the post-fire shrub species varied from 12-15 with the density of 1920-3360 individual/ha and basal area of 0.11-0.23 m^2 ha^{-1}, respectively. Gerwing and Vidal (2002) have reported 2500 individuals/ha for liana and shrubs species for Amazonia forest.

Canopy openness is one of the vital indicators for herbaceous species richness and composition in an ecosystem (Roberts, 2004). The degree of removal of upper canopy lessens competition of the herb layer vegetation with this higher strata, but may result in higher competition with the shrub layer or within the herb layer itself (Roberts, 2004). The herb increases immediately after the disturbance due to general reduction in tree cover that eventually supportive to growth and development of herbaceous vegetation due to availability of resources (Jhariya *et al.* 2012 and 2013; Kittur *et al.*, 2014a; Oraon *et al.*, 2014). In the present study the total herb density varied from 696000-832000 individuals ha^{-1}. These figures are closer and/ or well within the range of herb density measured by Jhariya *et al.* (2012, i.e., 112000 to 668000 individuals ha^{-1} during pre-fire season whereas, 230000 to 510000 after fire season) and Jhariya *et al.* (2013, i.e., 502000 to 724000 individuals ha^{-1}). Oraon *et al.* (2014) reported a total of 33-39 herb species in Bhoramdeo wildlife sanctuary, Kawardha (C.G.). The total density of herbs across the circle varied from 67800-146900 individuals ha^{-1}. Sinha *et al.* (2015) reported the total 27 herbaceous species comprising 15 families with the total density of 776000 herbs ha^{-1} which are comparable with the present estimated values.

In the present findings the A/F ratio revealed that most of recorded species followed contiguous and random distribution pattern while regular distribution was found virtually insignificant in natrual forest and plan-

tation sites of the study area. Odum (1971) explained that the most common distribution in nature is contagious due to small but significant variation in environmental conditions whereas random distribution was found under similar environmental conditions. Shadangi and Nath (2005) also reported that maximum species followed contagious distribution in the site. In line agreement with the present statements various studies also reported that the distribution of the species in a stand or sites followed contagiously and random distribution pattern while the regular distribution pattern was found almost negligible or insignificant (Oraon *et al.*, 2014; Kittur *et al.*, 2014a; Jhariya, 2014; Jhariya *et al.*, 2012 & 2013; Sinha *et al.*, 2015).

Diversity of an area is related to variety of factors. Jhariya and Oraon (2012c) reported that the diversity indices for shrub layer varied greatly. The Shannon index varied from 2.35-3.13, equitability 1.28-1.37, species richness 0.71-1.17, concentration of dominance 0.12-0.22 and beta diversity 1.10-1.83 during pre-fire season. Whereas during post-fire season it was 3.34-3.69 (Shannon index), 1.29-1.40 (equitability), 1.45-1.72 (species richness), 0.083-0.114 (Simposon's index) and 1.33-1.66 (Beta diversity), respectively. Sinha *et al.* (2015) reported that the Shannon index (H') of herbaceous species was 4.606, Simpson index (Cd) was 0.045, species richness (d) was 1.917 and equitability (e) was 1.397, respectively for plantation site of Sarguja (C.G.). Oraon *et al.* (2014) reported the diversity indices of natural forest which showed that Shannon index value for herb layer in different forest circle along the disturbance gradient varied from 2.50-4.25, concentration of dominance 0.06-0.37, species richness 1.35-2.19, equitability 0.76-1.34 and beta diversity 1.44-2.44. Jhariya and Oraon (2012b) reported the diversity parameters of herbaceous species which showed that the value of Shannon index in different sites ranged from 1.69-3.39, equitability 0.92-1.33, species richness 0.33-1.48, concentration of dominance 0.11-0.37 and beta diversity 1.50-3.80 of the herb layer in Bhoramdeo wildlife sanctuary, Kawardha (C.G.). Jhariya *et al.* (2013) reported that the Shannon index values ranged from 2.66-3.17, Simpson's index ranged from 0.14-0.23, species richness from 0.67-1.06, equitability from 1.09-1.33 and beta diversity from 2.40-3.60 for different sites of Rowghat (C.G.). Kittur *et al.* (2014a) measured the diversity parameters of herb layer and reported the Shannon index in different sites varied from 2.21-2.57, equitability from 1.02-1.24, species richness from 0.34

-0.67, concentration of dominance from 0.21-0.31 and beta diversity from 1.81-3.33 which are closer to the present study.

Conclusion

We observed important differences in the character, composition and diversity of understory vegetation between the natural forest and plantation sites. In a nutshell, this study has demonstrated that the understory could contribute a lot to the total species richness of forests. All these results suggest that the understory vegetation should be given important consideration for the assessment of biodiversity patterns in tropical forests. Understory vegetation is important strata from the floral and founal diversity point of view which ultimately increase the biodiversity of the region. However, due to various pressure, stability of these regions is slowly decreasing. Understory vegetation is considered good for natural forest but in the plantation site it compete with the economic species and cause deletorius effect on growth, increment and ultimately on the production of stand/site. The improvement and conservation of understory cover is possible through systematic monitoring of livestock grazing and disturbance in these areas.

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