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Structure and diversity of SAL dominating tropical deciduous forest of Chhattisgarh, India

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Abstract
The present study was conducted to investigate the stand structure and diversity in four different sites of Sal dominating forest in tropical Deciduous Forest. Vegetation structure, composition, and diversity were recorded in four sites. The forest was characterized with 33.5-46.8 m^2 ha^{-1} trees and 0.31-0.35 m^2 ha^{-1} sapling basal cover. Species richness and diversity for tree, sapling and seedling layer decreased with decreasing quality of sites and follows in order of site I> site II> site III > site IV, respectively. Concentration of dominance was followed in similar trends except beta diversity. However, site quality represents the nature and characteristics of soils which reflects the structure and diversity of forest.

Keywords: beta diversity site quality, species diversity, species richness and tropical deciduous forest etc

Introduction
Tropical forests covers 30% of the world's land area and 50% of the world's forested area which is around 4 billion ha (FAO and JRC, 2012) [1] and one of the richest and complex terrestrial ecosystems supporting a variety of life forms and have a tremendous intrinsic ability for self-maintenance. Forest site quality represents a combination of physical and biological features of the site where the stand is growing and its phytosociological analysis is a prerequisite for understanding the structure and function of any forest tract along with ecological representation of land ecosystems. Similarly, species diversity is another important concept and one of the major attributes of a natural community. Floristic inventory and diversity studies help us to understand the species composition and diversity status of forests and offer vital information for forest conservation (Gordon and Newton, 2006) [2].
Sal is deciduous, light demanding, gregarious and dominant tree species in its stand (Champion and Osmaston, 1962) [3] comes under Dipterocarpaceae family, mainly distributed in Northern, central and eastern region of Indian subcontinents. Sal forests extend into the tropical and subtropical regions and relatively rich in ground flora diversity. Besides tree and shrub, ground flora of Sal forest included fern, herb, grass and liana. Sal tends to regenerate as a mass of seedlings where conditions (light, soil, moisture with good drainage) are favorable, and forms more-or-less even-aged crops, which are relatively pure, or it forms the bulk of the stock in mixed stands (Troup, 1986) [4]. However, this study examines the vegetation structure under varying site qualities.

Material and Methods
The study was conducted in the four sites in large tract of the Sal based mixed, dry deciduous forest located in the Dugli forest range of Dhamtari forest division (20º29'49" to 20º33'12" North latitudes and 81º52' 29" to 81º53' 40" East longitudes with an average elevation of 445 m) situated in Dhamtari district (Chhattisgarh). In each of these sites, one 100 x 100 m plot, visually representative of the overall vegetation, was delineated for detailed study.
The forest stand on each site was analyzed using ten randomly placed quadrats (each 10 x 10 m in size) within the representative plot of 1 ha. Girth (at breast height, GBH) of each individual tree in each quadrat was measured and recorded. The vegetational data were analyzed for frequency, density and abundance (Curtis and Mclntosh, 1950) [5] An importance value was calculated as the sum total of relative frequency, relative density and relative dominance (Phillips, 1959) [6] Species diversity parameters for tree, sapling and seedling layer were determined, using basal cover values, from the Shannon-Wiener information function (Shannon and Weaver, 1963) [7] Concentration of dominance was measured by Simpson's

index (Simpson, 1949) [8], species richness following Margalef (1958) [9], equitability following Pielou (1966) [10], and beta diversity following Whittaker (1972) [11].

Results and Discussion

Forest structure

Data on basal cover and Importance Value Index (IVI) for the trees and sapling are summarized in Table 1. The structural analysis of seedling layer is represented in Table 2. The top storey of the vegetation at Site 1 was dominated by *Shorea robusta*. The second layer was dominated by *Terminalia tomentosa* whereas *Bombax ceiba* and *Schleichera oleosa* as understorey plant community. Total tree and sapling basal cover on this site was 46.8 m^2 ha^{-1} and 0.31 m^2 ha^{-1}, respectively. *Shorea robusta* was recognized as dominant, and *Butea monosperma* as codominant, *Ixora parviflora* and *Catunaregam spinosa* were identified as suppressed plant communities in seedling layer vegetation of this site quality. Site 2 was dominated by *Shorea robusta* in the top layer as dominant plant community, *Terminalia tomentosa* in the second layer as codominant community, whereas *Madhuca latifolia represents* as understorey plant community. Total tree and sapling basal cover values for this site were 43.1 m^2 ha^{-1} and 0.30 m^2 ha^{-1}, respectively. *Shorea robusta* was recognized as dominant, *Emblica officinalis* as codominant, *Ougeinia dalbargiodes,* was identified as suppressed plant communities in seedling layer vegetation of this site quality II. At Site 3, the natural forest cover has been enriched by *Shorea robusta* which comprised the top storey. The second stratum comprised *Ougeinia dalbargiodes* as codominant tree species whereas *Buchanania latifolia* as understorey plant community. Total tree and shrub basal cover values were 41.7 m^2 ha^{-1} and 0.35 m^2 ha^{-1}, respectively. *Emblica officinalis* were recognized as dominant, *Shorea robusta* as codominant, *Madhuca latifolia* was identified as suppressed plant communities in seedling layer vegetation of this site quality III. Site 4 was dominated by Shorea robusta in the top layer as dominant plant community, *Terminalia chebula* in the second layer as codominant community, whereas *Terminalia tomentosa represents* as understorey plant community. Total tree and sapling basal cover values for this site were 33.5 m^2 ha^{-1} and 0.32 m^2 ha^{-1}, respectively. *Shorea robusta* was recognized as dominant, *Anogeissus latifolia* as codominant, *Emblica officinalis, Madhuca latifolia and Catunaregam spinosa* were identified as suppressed plant communities in seedling layer vegetation. In the present study, *Shorea robusta* showed dominant species in all sites which is supported by Poonam *et al*. (2017) [12].

In tree layer and sapling layer higher basal area values were measured under the site I. Our present finding lie between the range (25.4-77.6 m^2 ha^{-1} for trees and 0.12-5.44 m^2 ha^{-1} for saplings) of finding by Adhikari *et al*. (2017) [13] in Sal mixed forest and higher than the value of 9-14.79 m^2 ha^{-1} for dry tropical forests of Vindhyan region, India (Singh and Singh,1991) [14]. Therefore, highest density of Sal in all sites revealed that Sal is dominant in its stand and it is one of the dominant tree species in the both tropical moist as well as dry deciduous forests in India (Raj, 2018) [15].

Vegetation index

Diversity parameters in all sites of Sal mixed forests are summarized in the Table 3. Shannon index values in the present study in different sites were ranged from 1.61- 1.86 for tree, 1.42-1.68 for sapling, 1.46-1.75 for seedling. Concentration of dominance ranged from 0.18-0.58 for tree, 0.28-0.79 for sapling, 0.21-0.62 for seedling layer. Species richness ranged from 1.71-2.23 for tree, 0.89-1.48 for sapling, 1.20-1.67 for seedling layer. Equitability ranged from 0.60-0.82 for tree, 0.67-0.96 for sapling, 0.48-0.71 for seedling layer. Beta diversity ranged from 1.57-2.87 for tree, 1.26-3.21 for sapling, 1.64-2.35 for seedling layer, respectively. Concerning the species richness, a high number of species results in higher community stability or rather resilience (Guo, 2001) [16]. This wide diversity takes the advantage of heterogeneity and increases their diversity. The good sites quality showed the highest species richness, species diversity and was lowest in the disturbed stand, which is in the line of agreement with present study.

Table 1: Species structure of tree and sapling layer in Sal mixed forest in different forests sites:

Species	Tree layer								Sapling layer							
	SQ 1		SQ 2		SQ 3		SQ 4		SQ 1		SQ 2		SQ 3		SQ 4	
	BA	IVI	BA	IVI	BA	IVI	BA	IVI	BA	IVI	BA	IVI	BA	IVI	BA	IVI
Anogeissus latifolia Wall.	4.6	32.1	0.8	6.7			1.2	16.0								
Bombax ceiba L.	0.4	4.8														
Buchanania latifolia Spreng.					0.2	4.9			0.01	37.8			0.02	29.7	0.01	31.2
Butea monosperma Lam.	0.5	4.9					0.5	9.1								
Cleistanthus collinus Roxb.			1.5	10.7	1.1	8.2			0.04	60.1			0.13	87.8	0.03	34.7
Diospyros melanoxylon Roxb.	5.0	28.2	2.2	19.8	4.6	31.4			0.03	33.1	0.11	79.8				
Emblica officinalis Gaertn.	1.2	12.2	4.1	31.2	2.9	29.6	2.3	33.0			0.12	105.8			0.02	31.5
Madhuca latifolia Roxb.			0.5	4.9	2.6	17.4										
Mitragyna parviflora Roxb.			1.8	11.2			1.8	11.4								
Ougeinia dalbargiodes Benth.			3.8	37.6	4.8	36.2										
Pterocarpus marsupium Roxb.	3.4	29.5									0.02	29.2				
Schleichera oleosa Willd.	0.5	4.8			2.2	20.7	1.8	22.4	0.02	29.9	0.03	30.7				
Semecarpus anacardium L.f.	2.6	18.2			0.7	7.2					0.02	28.2				
Shorea robusta Gaertn.f.	23.6	123.5	20.0	115.3	19.7	121.9	19.5	135.2	0.20	106.7			0.17	124.1	0.14	110.5
Tectona grandis Linn. f.							2.3	28.6								
Terminalia chebula Retz.			2.6	16.9	3.0	22.5	3.7	35.5								
Terminalia tomentosa W&A.	5.078	41.9	5.9	45.8			0.4	8.7								
Cassia fistula Linn.											0.01	26.0				
Sterculia urens Roxb.															0.04	40.7
Lannea coromandelica (Houtt.) Merr.									0.03	32.3			0.02	30.1	0.08	51.1
Syzigium cumini (L.)													0.01	28.1		
Total	46.8	300.0	43.1	300.0	41.7	300.0	33.5	300.0	0.33	300.0	0.31	300.0	0.35	300.0	0.32	300.0

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

Table 2: Species structure of seedling layer in Sal mixed forest in different forests sites:

	Site quality 1				Site quality 2				Site quality 3				Site quality 4			
Species	**F**	**D**	**A**	**IVI**	**F**	**D**	**A**	**IVI**	**F**	**D**	**A**	**IVI**	**F**	**D**	**A**	**IVI**
Shorea robusta Gaertn.f.	70	4000	3.14	59.31	60	2500	3.12	52.43	50	1500	2.10	36.73	40	2250	2.75	50.51
Cleistanthus collinus Roxb.	20	500	1.00	12.99	30	1000	1.60	24.42	10	1000	1.00	15.88	20	500	1.13	17.48
Bombax ceiba L.	30	750	1.47	19.35	20	500	1.03	14.76								
Terminalia tomentosa W&A.	20	500	1.03	13.13	30	750	1.10	19.89	20	500	1.00	14.66	20	500	1.00	16.76
Terminalia chebula Retz.					30	750	1.23	20.55	30	750	1.45	21.74	40	1000	1.25	29.34
Ougeinia dalbargiodes Benth.					20	500	1.00	14.61	20	500	1.27	15.97				
Diospyros melanoxylon Roxb.	20	500	1.10	13.46	20	500	1.24	15.82	40	1000	2.25	30.52	20	500	1.00	16.76
Emblica officinalis Gaertn.	30	2000	2.17	31.24	40	1750	2.51	37.79	50	2500	3.10	49.76	10	250	1.00	11.16
Anogeissus latifolia Wall.	30	750	1.25	18.32	30	2000	2.75	38.23					30	1000	2.13	31.21
Madhuca latifolia Roxb.	20	500	1.20	13.93	30	750	1.50	21.91	10	250	1.00	9.76	10	250	1.00	11.16
Catunaregam spinosa Thunb.	10	250	1.00	8.83	20	500	1.04	14.81	20	500	1.20	15.63	10	250	1.00	11.16
Buchanania lanzan					30	1000	1.67	24.77					20	500	1.10	17.31
Pterocarpus marsupium Roxb.	30	750	1.14	17.81												
Gardenia latifolia Ait.	20	500	1.20	13.93												
Semecarpus anacardium L.f.	20	1000	1.40	18.31					30	1000	1.50	24.02	30	750	1.20	23.46
Butea monosperma	50	1500	2.00	31.87					10	500	1.20	12.77	20	500	1.10	17.31
Schleichera oleosa Willd.	30	750	1.33	18.70					30	1500	2.40	32.48	40	1000	1.20	29.06
Tectona grandis Linn. f.									30	750	1.11	20.09	20	500	1.10	17.31
Mitragyna parviflora Roxb.																
Ixora parviflora Lam.	10	250	1.00	8.83												
Total	410	14500	21.43	300.00	360	12500	19.79	300.00	350	12250	20.58	300.00	330	9750	17.96	300.00

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

Table 3: Vegetation index estimations of Sal mixed forest in different forests sites:

	Tree layer				Sapling layer				Seedling layer			
	SQ 1	**SQ 2**	**SQ 3**	**SQ 4**	**SQ 1**	**SQ 2**	**SQ 3**	**SQ 4**	**SQ 1**	**SQ 2**	**SQ 3**	**SQ 4**
Parameters												
Species richness												
(d)	2.23	1.9	1.82	1.71	1.48	1.27	1.01	0.89	1.67	1.45	1.35	1.20
Shannon index												
(H')	1.86	1.72	1.69	1.61	1.68	1.59	1.47	1.42	1.75	1.68	1.53	1.46
Concentration of												
dominance	0.58	0.42	0.29	0.18	0.79	0.52	0.36	0.28	0.62	0.40	0.32	0.21
(Cd)												
Equitability												
(e)	0.82	0.74	0.66	0.60	0.96	0.85	0.72	0.67	0.71	0.65	0.52	0.48
Beta diversity												
(βd)	1.57	1.78	2.12	2.87	1.26	1.31	2.45	3.21	1.64	1.37	2.02	2.35

Conclusions

Quality of sites including varying soil characteristics, topography and prevailing weather majorly affects the nature and type of tree species and their abundance. Stand structure did show a clear trend toward higher density and basal areas of trees, sapling and seedling on nutrient-rich soil of better site quality. Efforts are needed to conserve the forest for their diversity and existence.

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