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Diversity Assessment and Phytosociological Study of Tree Species of Tropical Dry Deciduous Forest of Jharkhand, India

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Abstract—*Tropical forests in India, which are mostly deciduous, are poorly understood in terms of phyto-diversity, phytosociology, and quantification regimes. The forests of Ranchi are the study area for the current work which is located in Jharkhand, India. It is one of the significant biodiversity rich areas in the state to study the phytosociological attributes of tree species from the sampled inventory of different tree taxa. The study revealed that average tree density per hectare for the forest as 1311 individual ha^{-1}. The Marglef's index (SR) and Menhinick index (MeI) were 13.81 and 8.94 respectively. The obtained values for Shannon-Wiener index (H') and Simpson diversity (D) were 3.057 and 0.936 respectively, which shows good diversity. Pielou's evenness index (J) was 0.9 which demonstrates the balanced evenness for Ranchi Forest. Tropical deciduous forests are rich in diversity and needs continuous conservation due to recent threats. This study should be useful to the conservationists, researchers and scientists and also to the forest managers for the effective management of the forest ecosystem.*

Keywords*: Phytosociology, density, tropical dry deciduous forest, Shannon-Weiner index, Simpson diversity index.*

1. Introduction:

Tropical forests are characterized by high species richness, standing biomass and productivity [1] and their diversity has attracted much attention in recent years [2,3]. Tropical forest plant diversity mainly focuses on trees [4]. Diversity of tree species takes pivotal role in determining diversity of forest ecosystem [5]. At the same time distribution of trees is also a key element of forest diversity [6]. Decline in global biodiversity is an immediate result of loss of tropical forest. Both natural and human disturbances influence forest dynamics and tree diversity at local and regional scales [7,8,9] and affect ecosystem stability [10]. In most developing countries, including India, even protected forests experience extensive anthropogenic disturbance due to grazing, extraction of fuel wood and collection of non-wood forest products which contribute to the livelihood of forest dwelling populations [11,12,13]. The anthropogenic disturbances greatly affect the biodiversity and structural characteristics of a community [14,15]. Since trees are fundamental structure of a tropical forest [16], as well an identifying feature of vegetation types, continuous monitoring and management is essential towards maintaining species and habitat diversity [17,18].

Phytosociology is the study of quantification of forest vegetation [19], it classifies and describes the pattern of vegetation and predicts its distribution pattern in future [20]. Phytosociological studies in forest help to understand forest dynamics, and also an essential tool to assess the effects of disturbance and climate change on plant diversity [21, 22, 23]. Thus, quantitative floristic analysis aids the planning of further ecological research and interpreting the effect of disturbances [24]. The development of inventories to provide information on diversity as well as distribution of stand structure of a forest will be an important tool to maximize biodiversity conservation that results from deforestation and degradation and sustainable utilization [25]. Phytosociological analysis is important to understand the functioning of any community [26]. Proper monitoring and management are required for maintaining species and habitat diversity of trees [18, 17] for direct successional processes these aspects are very important [5]. The present investigation, attempts to analyze the impact of human interference in the structure of tree communities, composition and diversity of tropical dry deciduous forest Ranchi district, Jharkhand, which will help in conservation and sustainable utilization of forest vegetation in future.

2. MATERIAL AND METHODS

2.1 Study site

The present study was carried out in Ranchi which is located on southern part of the Chota Nagpur plateau. It is located at23°21′N 85°20′E/ 23.35°N 85.33°E and its average elevation is 651 m above sea level. Relative humidity of the region remains low. December is the coldest month with minimum temperature of 10.3°C and May is the hottest month with

maximum temperature of 37.2°C. Average annual rainfall of the district is 1375 mm and more than 80 percent precipitation received during monsoon months. From June to September the rainfall is about 1,100mm.

Ranchi has a hilly topography and is surrounded by dense tropical dry deciduous forests [27]. The forests come under the Dry peninsular sal-Type 5B/C -IC. The characteristic composition of this type of forest consists of trees mostly of *Shorea robusta, Anogeissus latifolia, Terminalia tomentosa, Scheichera trijuga, Adina cordifolia, Boswellia serrata, Terminalia belerica, Eugenia jambolana, Terminalia chebula, Diospyros melanoxylon, Buchania latifolia, Butea monosperma, Aegle marmelos, Lagerstromia parviflora, Emblica officinalis, Nyctanthes arbortristis, Zizyphus jujuba,* etc.

Forest department has divided the forest into 4 ranges i.e., Burmu range, Bero range, Kanke range and Mahilong range. The research was conducted in the two ranges i.e., Kanke and Mahilong range. From each range two blocks and from each block six forest sites were selected for the study.

2.2 Sampling

Twenty-four plots were made in the forest which was distributed in the 4 blocks of the district. In each plot one hectare area was covered. It was done by laying 5 quadrats of 20 x 100 m size i.e., 2000 m^2 area was covered in one quadrat. In this area community analysis was done. Plots were randomly selected to reduce bias caused by within site differences in soil conditions.

2.3 Phytosociology Analysis

Different varieties of trees were counted, and the diameter was measured at breast height i.e., 1.37m above the ground. The tree diameter at breast height was collected. The vegetation data were quantitatively analyzed for abundance, density, frequency according to the formula given by Curtis and McIntosh [28]. The relative values of frequency, density and dominance were determined following Philips [29]. These three quantities were summed to represent Important value index (IVI) of individual species.

- $Density = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total no.of Quadrats studied}}$
- Relative Density (%) $= \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100$
- Frequency (%)$= \frac{\text{No. of quadrats of occurrence of a species}}{\text{Total no. of Quadrats sampled}} \times 100$
- Relative Frequency (%)$= \frac{\text{Frequency of a species}}{\text{Total Frequency of all species}} \times 100$
- Dominance = Basal area of average tree of the species multiplied by its density
- Basal area = $0.7854 \times DBH^2$
- Relative Dominance (%) $= \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$
- Abundance $= \frac{Total\ no.of\ individuals\ of\ the\ species\ in\ all\ the\ sampling\ units}{No.of\ sampling\ units\ in\ which\ the\ species\ occurred}$
- $IVI = Relative\ Density(\%) + Relative\ Frequency(\%) + Relative\ Dominance(\%)$

2.3 Diversity Index

Six different diversity indices were calculated to study the dominance and richness of the ecosystem (Table 1). Diversity pattern in the area is described by calculating the species richness and the species evenness. Richness is the number of taxa attributes such as species or families that present in the community. For this study, species richness is measured by Margalef's and Menhinick's diversity indices. The diversity indices that were used in this study are Shannon-Weiner diversity index and Simpson's diversity index. Species evenness was measured by Pielou's evenness index.

Table 1. Formulae for various diversity indices used in the study.

Diversity index	Formula	Reference
Margalef index of species richness (SR)	$SR = \frac{S-1}{\ln(N)}$	Margalef, 1958 [30]
Menhinick's index of species richness (MeI)	$MeI = \frac{S}{\sqrt{N}}$	Whittaker, 1977 [31]
Shannon-Wiener diversity index (H')	$H' = -\sum \frac{n_i}{n} \times \ln(\frac{n_i}{n})$	Shannon and Weaver, 1963 [32]
Simpson's concentration of dominance (Cd)	$C_d = \sum(\frac{n_i}{n})^2$	Simpson, 1949 [33]
Simpson's diversity index (D)	$D = 1\text{-}C_d$	Simpson, 1949 [33]
Pielou's evenness index (J)	$J = \frac{H'}{\ln(n)}$	Pielou, 1966 [34]

*S= no. of species, N= total no. of individuals, ln= natural log, n_i= IVI value of species, n= sum of total IVI values of all species.

3. Results and Discussion

3.1 Phytosociology

Phytosociological data help in understanding forest structure. The population dynamics, forest composition and structure are an indication of the degree of disturbance and factors that influence
in change of forest structure. Trees are the basis of tropical forest ecosystem and are therefore the

important indicator of abiotic or biotic changes of the forest. Phytosociological analysis revealed that the total tree density per hectare was found to be 1311, the maximum values of number of trees/ha, basal area and IVI were of *Shorea robusta* (515, 31.44 m^2 and 52.51, respectively) (Table 2). Based on IVI values the dominant and co-dominant species were *Shorea robusta* and *Butea monosperma*, respectively. *Semecarpus anacardium* was the rare species of the forest (Figure 1). It clearly showed the dominance of *Shorea robusta* in the forest of Ranchi. A total of 30 different tree species distributed in 14 families were found in the sampled area. Fabaceae was the dominant family having 15 number of tree species. The findings of this study are in accordance with that of different ecosystems under tropical climates. Studies of Thakur [35] in tropical dry deciduous forest in Sagar district, Madhya Pradesh reported a total of 36 trees. Similarly, tree species diversity in Hulikal state forest was reported to be 96 [36].

Table 2. Table showing values for various phytosociological parameters of the study.

S.No.	SPECIES	Family	No. of trees per ha	TBA ha^{-1}	IVI
1	*Acacia catechu* (L.f) Willd	Fabaceae	18	0.74	7.78
2	*Acacia nilotica* L.	Fabaceae	12	0.41	5.65
3	*Acacia pinnata* (L.) Willd	Fabaceae	8	0.23	3.85
4	*Adina cardifolia* (Roxb.) Brandis	Rubiaceae	50	1.83	13.32
5	*Albizia stipulata* (DC.) Boivin	Fabaceae	3	0.05	2.28
6	*Anthocephalus cadamba* Roxb.	Rubiaceae	10	0.82	7.75
7	*Bauhinia purpurea L.*	Fabaceae	9	0.15	4.38
8	*Bauhinia tomentosa* L.	Fabaceae	4	0.13	2.70
9	*Butea monosperma* (Lam.) Taub.	Fabaceae	102	6.01	19.77
10	*Cassia fistula* L.	Fabaceae	10	0.24	3.56
11	*Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm	Lauraceae	11	1.04	8.61
12	*Dalbergia latifolia* Roxb.	Fabaceae	15	0.56	6.22
13	*Dalbergia sissoo* Roxb.	Fabaceae	71	3.17	16.31
14	*Diospyros melanoxylon* Roxb.	Ebenaceae	104	2.84	18.98
15	*Ficus benghalensis* L.	Moraceae	5	0.67	10.47
16	*Ficus hispida* L.f.	Moraceae	22	0.62	8.73
17	*Ficus racemosa* L.	Moraceae	6	0.47	3.87
18	*Gmelina arborea* Roxb.	Lamiaceae	26	1.00	10.41
19	*Bridelia retusa* (L.) A. Juss	Phyllanthaceae	65	1.63	15.14
20	*Madhuca longifolia* (J.Konig) J.F. Macbr.	Sapotaceae	43	1.55	15.02
21	*Pongamia pinnata* (L.) Pierre	Fabaceae	90	3.34	18.15
22	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	24	0.97	8.93
23	*Semecarpus anacardium* L.f.	Anacardiaceae	2	0.13	1.00
24	*Shorea robusta* Gaertn.	Diptercarpaceae	515	**31.44**	**52.51**
25	*Syzygium cumini* (L.) Skeels	Myrtaceae	8	0.96	4.10
26	*Tamarindus indica* L.	Fabaceae	2	0.10	2.22
27	*Tectona grandis* L.f.	Lamiaceae	37	1.55	13.25
28	*Terminalia alata* Heyne ex Roth	Combretaceae	4	0.15	1.70
29	*Terminalia arjuna* (Roxb.) Wight & Arn.	Combretaceae	4	0.19	1.83
30	*Ziziphus jujuba* Mill.	Rhamnaceae	31	0.66	11.63
	Total		1311	63.64	300

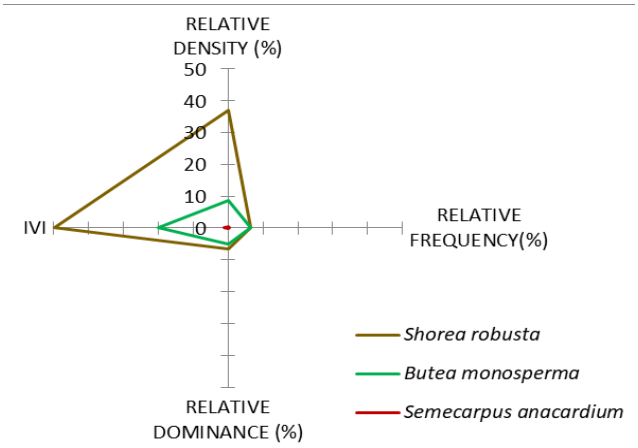

Figure 1. Phytograph showing dominant, co-dominant and rare tree species.

3.2 Diversity analysis

The Marglef's index (SR) and Menhinick index (MeI) were 13.81 and 8.94 respectively. The Marglef's index and Menhinick index is >5 which indicates the integrated and undisturbed richness of the area. The obtained values for Shannon-wiener index (H') and Simpson diversity (D) were 3.057 and 0.936 respectively, which shows good diversity. Pielou's evenness index (J) was 0.9 which demonstrates the balanced evenness for Ranchi Forest (Table 3). Phytograph analysis revealed that the influence of basal area, frequency and density on the dominant species was analyzed by plotting a phytograph (Figure 1). It clearly showed that the dominance of *Shorea robusta* in tropical dry deciduous forest.

Table 3. Table showing distribution pattern and diversity for the study sites of the forest.

Study Site	TSR	Margalef Index (SR)	Menhinick Index (MeI)	Shannon-Wiener Index (H')	Simpson Conc. of Dominance (C_d)	Simpson Diversity (D)	Pielou's Evenness Index (J)
Ranchi	30	13.81	8.94	3.057	0.064	0.936	0.90

*A/F= abundance/frequency, TSR= total species richness

The diversity parameters of these forests are comparable with the diversity indices reported in different tropical forests [37]. Similar findings were also made by Sahu *et al*. [38], whose findings for tropical dry deciduous forests of Malyagiri hill ranges, Eastern Ghats were, Shannon-Wiener index (H′) 3.38 and Simpson's index (C) 1.0 indicating high tree species diversity. Singh *et al.* [39] reported Shannon index value between 3.4 to 4.8 for tropical rain forests of Silent valley in Western Ghats, India. Diversity indices give an important insight on the conservation strategies for human welfare. The regional patterns of species richness are a collaborative effect of different interacting factors, such as plant productivity, competition, regional species dynamics and species pool, historical development, environmental variables and human activity [40].

4. Conclusion

The total tree density in the tropical dry deciduous forest of Ranchi was 1311 trees per ha, the value for Shannon wiener index obtained was 3.057 which showed good diversity in the forest. The total number of species in the forest were 30 which and the dominant species was *Shorea robusta*. This study paves the way for integration of this baseline data with the biomass studies and satellite data of the forest. In the future it can save time for forest inventory as time and cost-effective method for forest studies. Tree species diversity, distribution and population structure analyzed in this study should be useful to the conservationists, researchers and scientists and also to the forest managers for the effective management of the forest ecosystem.

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