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RESEARCH ARTICLE

Species composition, diversity and distribution of woody species in a tropical dry deciduous Forest of Jalaun district, Uttar Pradesh, India

Ajay Kumar* **and R. K. Verma**

Abstract

Tropical dry deciduous forests serve as essential to managing ecological biogeochemical processes. The present study evaluates the phytosociological traits of the Lohai Forest, that located in the Jalaun district of the Bundelkhand region of Uttar Pradesh. A total of 55 woody species from 29 families were identified throughout the forest, with values for total density, total basal area, diversity (*H'*), and concentration of dominance (*Cd*) ranging from 2090 individuals ha^{-1} to 55.19 m^2 ha^{-1} to 3.23 and 0.08, respectively. In accordance to the IVI, *Prosopis juliflora* was the dominating species, although in the Lohai Forest, *Balanites aegyptiaca, Capparis decidua, Acacia leucophloea*, and *Flacourtia indica* were also recorded as co-dominant woody species. The prevalence of massive grazing by livestock, human interruptions and increasingly frequent drought associated with changing climates were found at the study site, all of which are the primary causes for the degradation of this already scattered forest community.

Keywords: Diversity, Distribution pattern, Jalaun district, Woody species**.**

Introduction

The vital role of structurally broadened forests for the preservation of diversification and the provision of a variety of ecosystem services is widely acknowledged. There is still a need for tools to precisely and statistically quantify structural diversity of forests across a variety of forest types and regions, for example to support biodiversity monitoring. The methods that are currently employed to assess the structural diversity of forests are based on small geographic regions (Storch *et al.* 2018). Understanding the forest structure and tree composition makes it easier to assess the dynamics of a forest ecosystem and safeguard fragile and economically significant species (Naidu *et al.* 2018). A prominent biome in India includes tropical dry deciduous forests, comprising about 46% of the its total forest cover. For the sake of their overall biodiversity, productivity, and sustainability, the bulk of these forests are severely anthropogenically stressed and require management intervention. Although there are many different types of creatures that exist in deciduous forests, this habitat is not believed to be one with many different species.

The several previous studies particularly concentrating on floristic characteristics as well as phytosociological characters have been done in different tropical deciduous forests of India (Khurana 2009, Sahu *et al.* 2012, Thakur and Khare 2015, Ganguli *et al.* 2016, Verma *et al.* 2019). The tropical dry deciduous forests in this region are under an enormous amount of stress due to biotic interferences and climate change. The restoration of tropical deciduous forests has become essential for stopping mass extinctions, reducing the consequences of climate change, and recovering an assortment of ecosystem services given the severity of the loss. Thus, it becomes necessary to understand both the altered ecological structures and regular dynamics of deciduous forests. However, the phytosociological studies related to the forests of Jalaun district have not been carried out so far. The objective of the present study was to assess the species composition, diversity and distribution pattern of woody plant species in a tropical dry deciduous forest of the Jalaun district.

Department of Botany, Bundelkhand University, Jhansi, Uttar Pradesh, India.

***Corresponding Author:** Ajay Kumar, Department of Botany, Bundelkhand University, Jhansi, Uttar Pradesh, India, E-Mail: calotropis11@gmail.com

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Material and Methods

Study area

Jalaun is a district in Uttar Pradesh that is a part of the Bundelkhand region. It is 151 meters above mean sea level and lies at 27° N latitude and 79-52° E longitude. The district is composed of nine blocks: Dakore, Jalaun, Kadaura, Konch, Kuthond, Madhogarh, Mahewa, Nadigaon, and Rampura. The district is split into five tehsils namely Jalaun, Kalpi, Konch, Madhogarh, and Orai. The Lohai Forest of the Jalaun forest range located in the Kuthaund block of the Jalaun district. It is located at 26° 19′ 17.8» N Latitude 79° 29′ 08.9» E Longitude and about 55 km north of the district headquarters on the Yamuna plain (Fig. 1). The reserved forest spread over an area of about 795.87 hectares. According to Champion and Seth (1968), the Jalaun district comprises a range of forests, including tropical riparian forest, dry mixed deciduous forest, *Anogeissus pendula* scrub forest, *Boswellia* forest, and Ravinus thorn forest.

Data analysis

Broad extensive and intensive field surveys of the study sites were explored during the years 2020-2022. The data were obtained through using quadrat sampling method. The size and total number of studied quadrats were estimated using the species-area curve method (Mishra, 1968) and the minimum quadrat-number method (Kershaw, 1973). Fifty quadrats of 10 x 10 m size were randomly placed at the study site. In each quadrat all the woody species (≥6 cm CBH) were sampled by taking circumferences at breast height (1.37 m above the ground level). The species were identified with the help of different flora (Hooker 1872-1897, Duthie 1903-1915, Singh *et al.* 2016, Khanna 2017). To confirm the species identification various online databases such as (www.plantsoftheworldonline.org, www.ipni.org, and www.flowersofindia.net) were explored. All the data were computed using Microsoft Office Excel 2007 version.

The vegetation data were quantitative analysed for frequency, density, abundance and basal area Curtis and MacIntosh 1950, Mishra 1968, Knight 1975) and after that Relative frequency, Relative density, Relative dominance was calculated (Phillips 1959). The sum of all relative values represented as Importance Value Index (IVI). On the basis of IVI, dominant, co-dominant and main associate species were recognized. Phytosociological parameters indicated below were analysed by the following methods and formulas (Cottam and Curtis 1956, Mueller-Dombois and Ellenberg 1974).

$$\text{Frequency (F)} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of studied quadrats}} \times 100$$

$$\text{Density (D)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of studied quadrats}}$$

$$\text{Abundance (A)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which species occurred}}$$

$$\text{Basal Area (BA)} = \pi r^2 \text{ or } \frac{C^2}{4\pi}$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

$$\text{Relative Density (RD)} = \frac{\text{Density of a species}}{\text{Density of all species}} \times 100$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Importance Value Index (IVI)} = \text{RF} + \text{RD} + \text{RDo}$$

The abundance-frequency ratio is commonly employed to evaluate species distribution patterns (Whitford, 1949). The abundance-frequency ratio indicates a regular distribution if the value A/F ratio is less than 0.025, a random distribution between 0.025 and 0.050, and a contagious distribution if the value greater than 0.050 (Curtis and Cottam 1956).

Shannon-Wiener's index (H′)

Species diversity (*H′*) was estimated using the Shannon-Wiener Index (Shannon and Wiener, 1963).

$$H' = -\sum pi \ln (pi)$$

where, *H′* is Shannon-Wiener diversity index, *pi* is the extent of individuals found in species and ln is regular log

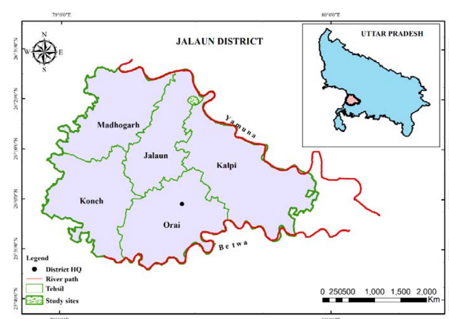

Fig. 1: Location map of the study area

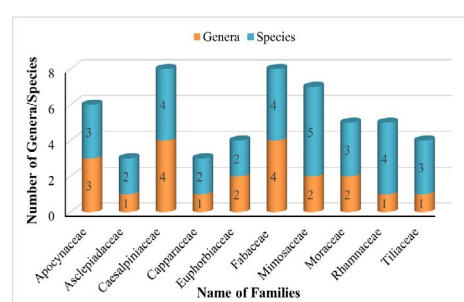

Fig. 2: Ten dominant families of woody species with the number of genera and species

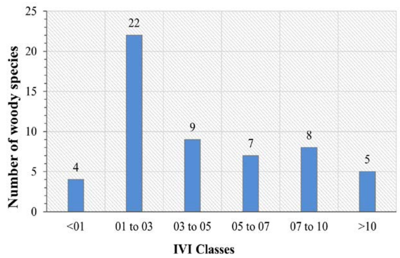

Fig. 3: Distribution of woody species with IVI classes in Lohai Forest community

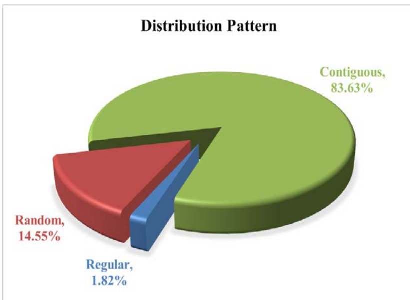

Fig. 4: Distribution pattern of woody species in the Lohai Forest community

Concentration of dominance (Cd)

Concentration of dominance was calculated following the equation of Simpson (1949).

$$Cd = \sum (pi)^2$$

where, *pi* is the same as Shannon-Wiener diversity index

Equitability or Evenness (E)

The equitability or species evenness index (range 0-1) was calculated following Pielou (1966).

$$E = H' / \log s$$

where, E = Species evenness index, *H'* = Shannon's diversity index, and S = Total number of species

The dominance-diversity (d-d curve) curves were constructed to examine how resources were distributed among different species in different types of forests. According to Whittaker (1965), the relative significance value serves as an illustration of the relative niche size that represents the species' niche.

Results and Discussions

The current study reveals the identification of 55 species of woody plants, including trees, shrubs, and lianas, spread throughout 44 genera and 29 families, Mimosaceae was the most dominant family among them, representing 2 genera with 5 species, followed by Caesalpiniaceae, Fabaceae (4 genera with 4 species each) and Rhamnaceae (1 genus with 4 species), Apocynaceae (3 genera with 3 species),

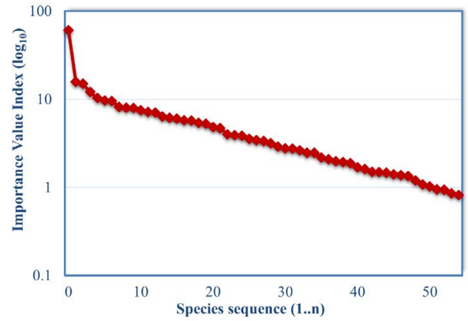

Fig. 5: Dominance-diversity curve for all woody species in the Lohai Forest

Moraceae (2 genera with 3 species), Tiliaceae (1 genus with 3 species), Asclepiadaceae (1 genus with 2 species), Capparaceae (1 genus with 2 species), Euphorbiaceae (2 genera with 2 species), Lytharaceae, Myrtaceae, Rutaceae, Verbenaceae (2 genera with 2 species each) and remaining 15 families are representing only one species (Figs 1 and 2). The most prominent genus, *Ziziphus*, possessed 4 species. The next two top genera were *Acacia* and *Grewia,* each of having 3 species. *Calotropis*, *Capparis*, *Ficus*, and *Prosopis* each comprised 2 species, while the remaining 37 genera offered a single species.

The density is an indication of the population of a species number in a particular area. In the Lohai Forest community, the density of woody species ranged from 2 to 484 individuals ha^{-1} (Table 1). *Prosopis juliflora* had the highest density (484 individuals ha^{-1}) whereas, *Ficus religiosa* had the lowest density (2 individuals ha^{-1}). The total stand density in the present study *i.e.,* 2090 individuals ha^{-1} was found to be higher than the previously reported values as 550-1875 trees ha^{-1} from other tropical dry deciduous forests of India (Visalakshi 1995; Krishnamurthy *et al.* 2010, Chaturvedi *et al.* 2011). However, this stand density value was found within the range of other tropical dry deciduous forests in India *i.e.,* 1875-3412 stem ha^{-1} (Joshi and Dhyani 2018, Singh *et al.* 2021). This range of stand density was higher than that which was observed in the Servarayan and Kalrayan hills (Kaduvul & Parthasarathy, 1999 a, b), the tropical montane evergreen forest (Shola) of the Nilgiri Mountains (Mohandass and Davidar 2009) and the Eastern Ghats of northern Andhra Pradesh (Reddy *et al.,* 2011). The stand density indicates that the existence of higher number of trees per hectare can be ascribed to closely spaced trees with thinner stems and a higher number of species of ground flora. Tree diversity fluctuates in tropical forests because of variances in biogeography, habitat adequacy, climate change responses and individual stresses (Whitmore 1993).

The total basal area of the Lohai Forest was 55.19 m^2 ha^{-1}, which ranged from 0.03 to 15.39 m^2 ha^{-1}. This value of total basal area was found to be within the range of the other tropical dry forests, *i.e.,* 36.90-78.61 m^2 ha^{-1} (Visalakshi 1995, Verma and Pal 2019). *Prosopis juliflora* (15.39 m^2 ha^{-1}) was

Table 1: Phytosociological attributes of Lohai Forest community in the Jalaun district

S. No.	Name of species	Family	Frequency	Density	Total basal area	A/F ratio	IVI
1	*Prosopis juliflora* (Sw.) DC.	Mimosaceae	94	484	15.39	0.055	60.66
2	*Balanites aegyptiaca* (L.) Delile	Balanitaceae	48	152	2.06	0.066	15.91
3	*Capparis decidua* (Forssk.) Edgew.	Capparaceae	68	126	1.15	0.027	15.06
4	*Acacia leucophloea* (Roxb.) Willd.	Mimosaceae	38	62	2.91	0.043	12.12
5	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	56	78	0.49	0.025	10.34
6	*Ziziphus nummularia* (Burm.f.) Wt. and Am.	Rhamnaceae	36	94	0.87	0.073	9.75
7	*Ziziphus oenoplia* (L.) Mill.	Rhamnaceae	42	96	0.38	0.054	9.57
8	*Capparis sepiaria* L.	Capparaceae	38	72	0.49	0.05	8.21
9	*Acacia catechu* (L.f.) Willd.	Mimosaceae	36	64	0.7	0.049	8.01
10	*Lantana camera* L.	Verbenaceae	32	78	0.52	0.076	7.94
11	*Carissa carandas* L.	Apocynaceae	44	46	0.43	0.024	7.48
12	*Lawsonia inermis* L.	Lytharaceae	34	58	0.51	0.05	7.17
13	*Acacia nilotica* (L.) Willd. ex Delile	Mimosaceae	24	28	1.83	0.049	7.12
14	*Pongamia pinnata* (L.) Pierre.	Fabaceae	24	28	1.44	0.049	6.40
15	*Ficus racemosa* L.	Moraceae	6	6	2.9	0.167	6.16
16	*Woodfordia fruticosa* (L.) Kurz	Lytharaceae	26	64	0.18	0.095	6.05
17	*Cassia fistula* L.	Caesalpiniaceae	20	26	1.38	0.065	5.78
18	*Madhuca longifolia* (Roxb.) A. Chev.	Sapotaceae	6	14	2.46	0.389	5.74
19	*Holoptelea integrifolia* (Roxb.) Planch.	Ulmaceae	14	16	1.78	0.082	5.42
20	*Prosopis spicigera* L.	Mimosaceae	24	30	0.76	0.052	5.27
21	*Ziziphus mauritiana* Lam.	Rhamnaceae	14	20	1.36	0.102	4.85
22	*Abutilon indicum* (L.) Sweet	Malvaceae	18	42	0.46	0.129	4.68
23	*Nyctanthes arbor-tristis* L.	Oleaceae	20	32	0.26	0.08	4.04
24	*Tamarindus indica* L.	Fabaceae	4	4	1.84	0.25	3.93
25	*Bombax ceiba* L.	Bombacaceae	6	14	1.42	0.389	3.85
26	*Syzygium cuminii* L.	Myrtaceae	6	6	1.47	0.167	3.57
27	*Tinospora cordifolia* (Willd.) Miers	Menispermaceae	16	34	0.1	0.133	3.45
28	*Peltophorum pterocarpum* (DC.) K. Heyne	Caesalpiniaceae	14	14	0.69	0.071	3.36
29	*Abrus precatorius* L.	Fabaceae	12	36	0.14	0.25	3.20
30	*Azadirachta indica* A. Juss.	Meliaceae	6	8	1.06	0.222	2.91
31	*Parkinsonia aculeata* L.	Caesalpiniaceae	10	18	0.49	0.18	2.77
32	*Grewia rothii* DC.	Tiliaceae	12	26	0.15	0.181	2.75
33	*Aegle marmelos* (L.) Corr.	Rutaceae	8	8	0.8	0.125	2.65
34	*Grewia hirsuta* Vahl.	Tiliaceae	10	26	0.12	0.26	2.48
35	*Grewia asiatica* L.	Tiliaceae	10	24	0.17	0.24	2.47
36	*Bauhinia racemosa* Lam.	Caesalpiniaceae	8	8	0.55	0.125	2.19
37	*Ficus religiosa* L.	Moraceae	2	2	0.99	0.5	2.09
38	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	6	12	0.44	0.333	1.98
39	*Feronia limonia* (L.) Swingle	Rutaceae	4	4	0.74	0.25	1.95
40	*Sterculea urens* Roxb.	Sterculiaceae	8	8	0.38	0.125	1.88
41	*Calotropis procera* (Aiton) Dryand.	Asclepiadaceae	6	16	0.17	0.445	1.69
42	*Calotropis gigantia* (L.) Dryand.	Asclepiadaceae	6	14	0.18	0.389	1.61
43	*Mangifera indica* L.	Anacardiaceae	4	6	0.44	0.375	1.50
44	*Nerium indicum* Mill.	Apocynaceae	6	14	0.12	0.389	1.49
45	*Phyllanthus emblica* L.	Euphorbiaceae	6	6	0.31	0.167	1.47

46	*Ziziphus xylopyrus* Sedgw.	Rhamnaceae	8	8	0.12	0.125	1.42
47	*Dalbergia sissoo* DC.	Fabaceae	4	6	0.37	0.375	1.37
48	*Salvadora oleoides* Decne.	Salvadoraceae	6	10	0.14	0.278	1.35
49	*Jatropha gossypiifolia* L.	Euphorbiaceae	4	12	0.12	0.75	1.20
50	*Artocarpus heterophyllus* Lam.	Moraceae	4	4	0.27	0.25	1.08
51	*Polyalthia longifolia* (Sonner) Thwaites	Annonaceae	4	4	0.24	0.25	1.03
52	*Cordia sinensis* Lam.	Boraginaceae	4	4	0.2	0.25	0.96
53	*Vitex negundo* L.	Verbenaceae	4	10	0.03	0.625	0.95
54	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	4	4	0.14	0.25	0.86
55	*Callistemon lanceolatus* (Sm.) Sweet	Myrtaceae	4	4	0.12	0.25	0.82

the dominating species at the study area, comprising up a total of about 27.88% of the total forest's basal area. It was followed by *Acacia leucophloea* 5.27% (2.91 m^2 ha^{-1}), *Ficus racemosa* 5.25% (2.90 m^2 ha^{-1}), *Madhuca longifolia* 4.45% (2.46 m^2 ha^{-1}) and *Balanites aegyptiaca* 3.73% (2.06 m^2 ha^{-1}). The differences in altitude, species composition, tree age, degree of disturbance, and successional phases of the stands could all be contributing factors to the variations in basal area of tree layer among the study site (Mishra *et al.,* 2008). Although the severity of disruptions has an impact on the succeeding species succession and consequent changes in basal area values, the variances in basal area values of trees throughout various forest types were predominantly impacted by species composition, age, and growth patterns for individual trees (Rao *et al.* 1990).

IVI values for different woody species in the Lohai Forest ranged from 0.82 to 60.66 (Table 1), with *Prosopis juliflora* having the highest IVI value (60.66) followed by *Balanites aegyptiaca* (15.91), *Capparis decidua* (15.06), *Acacia leucophloea* (12.12), and *Flacourtia indica* (10.34) however, *Callistemon lanceolatus* (0.82) having the lowest value of IVI. The computed values of IVI were found to be less than one with 04 species; between 1-3 for 22 species; between 3-5 for 09 species; 5-7 for 07 species and remaining 13 species recorded above these values and represent the dominating woody species (Fig. 3).

The results indicate that the most abundant tree species, *Prosopis juliflora,* shares the highest basal cover and IVI and responds successfully to water stress conditions. The availability of water and the susceptibility of species to drought are two key structural factors that influence the distribution of species dynamics in tropical forests (Engelbrecht *et al.* 2007).

The Shannon-Wiener diversity index (*H′*), a measure of species diversity, was 3.23 for woody species in the Lohai Forest. According to Knight (1975), young stands of tropical forests have a diversity index of 5.06, but older stands have a diversity index of 5.40. The species diversity value for this forest, however, was within the range of 3.50-4.05 reported from different tropical dry deciduous forests in India (Thakur and Khare 2015, Naidu *et al.* 2018, Verma and Pal 2019).

The Lohai Forest community recorded a concentration of dominance (*Cd*) of 0.08 for woody species on an individual basis. This value was found to be on average compared to the reported Cd values of 0.053-0.068 from the various temperate and tropical deciduous forests in India (Kumar and Bhatt 2006, Thakur and Khare (2015). In tropical forests, the concentration of dominance was previously found to be 0.06 on average (Knight 1975).

The equitability or evenness value in the present study, which has been calculated to be 0.81, was found to be within the reported range of values in tropical dry deciduous forests of India (Naidu *et al.* 2018, Verma *et al.* 2019, Joshi *et al.* 2022).

The abundance to frequency (A/F) ratio of the distributions of woody species clearly demonstrated an abundance of contiguous distribution pattern (83.63%). However, a few species exhibited rarities of random distribution (14.55%) and regular distribution pattern (1.82%) (Fig. 4). Contiguous distribution is common in nature, random distribution only occurs in biological communities that are comparatively homogenous, and regular distribution occurs only when intense interindividual competition is reduced (Odum, 1971). Various studies have reported a general prevalence of contiguous dispersion in natural vegetation (Thakur and Khare 2015, Sahu *et al.* 2016).

Assessments of community composition in terms of resource sharing and niche space have commonly employed dominance-diversity (d-d) curve (Fig. 5). This is based on the concept that a species' usage of a community's resources and the percentage of that community's niche space that it has share a connection (Whittaker 1975). The community effectively uses its resources in circumstances with a lot of diversity.

The d-d curve for the woody species in the Lohai Forest was developed based on IVI (log_{10}). The d-d curve of extant communities closely approximated Preston's normal distribution model (Preston, 1948), which included fewer species in the higher IVI range. Similarly, Khurana and Saxena (2009), Thakur and Khare (2015) and Verma and Pal (2019) also observed lognormal dominance diversity curves for tree species.

Conclusion

The present study revealed that certain native woody species in this forest are more tolerant to pressures brought on by human activity and have more potential for regeneration. It is essential to prevent biotic interruptions such logging, trampling, and illegal harvesting so as to protect these species. The distinctive woody species with high plant densities and little base cover, where the majority of the species have younger plants, clearly indicate the changing nature of forest. The primary objective of this study is to record and maintain the phytodiversity of tropical dry deciduous forests in Uttar Pradesh along with other regions with similar types of forests. In order to preserve and protect phytodiversity, the current study will be of utmost importance. It could also offer ideas for conservation initiatives and aid in comprehending the dangers facing tropical forests.

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Declaration

The authors declare that there is no conflict of interest.

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