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Structure, composition and biodiversity of tree species inside Guru Ghasidas Vishwavidyalaya (GGV) Campus, Bilaspur, CG, India

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Abstract

Increasing population and changing lifestyle lead extensive commercial exploitation of the natural resources and loss of biodiversity. Therefore, documentation of biodiversity is mandatory to develop the strategies of conservation and management. A tropical deciduous forest area of Guru Ghasidas Vishwavidyalaya (GGV) campus was divided into eleven grids and studied by quadrat method. A total of 26 tree species were observed inside GGV campus. Of the 26 tree species, 21 were identified as Butea monosperma, Acacia nilotica, Eucalyptus, Ziziphus mauritiana, Millettia pinnata, Delonix regia, Azadirachta indica, Tectona grandis, Alkana tinctoria, Saraca asoca, Diospyros melanoxylon, Dalbergia sisso, Mangifera indica, Madhuca indica, Syzygium cumini, Cascabela thevetia, Dendrocalamus strictus, Ficus religiosa, Phyllanthus emblica, Cassia fistula, and Alangium salvifolium. These plant species belong to 14 different families. Among them Fabaceae was the most dominant family followed by Myrtaceae. Acacia nilotica, Butea monosperma, Eucalyptus, Delonix regia and Diospyros melanoxylon displayed higher frequency, density and abundance in the study site. On the basis of IVI values Butea monosperma, Acacia nilotica, Delonix regia, Eucalyptus, Diospyros melanoxylon and Cassia fistula were documented as predominant plant communities.

Keywords: Frequency, Density, Abundance, Importance value index, Shannon-Weiner diversity.

Introduction

Biodiversity is defined as the total number of genes, species and ecosystems of a region. In simplest words it includes genetic diversity, species diversity and ecosystem diversity. India has rich biodiversity because of its equatorial location and considered one of the 12 "mega-diverse" countries in the world. Of the world's twelve biodiversity hotspots, two were situated in India and these are known as North-Eastern region and the Western Ghats. India's contribution in the world's biodiversity is approximately 8% while it occupies only 2.42% of the world's land area[1]. The highest contribution is made by plant species and 12% of the world's flora are found in Indian forests.

Structural analyses of natural plant communities provide a valuable source of information for understanding the relationship between plant form and environment[2]. The species diversity studies help us to understand community composition, structure, changes and development[3]. Further, species diversity and ecosystem fluctuations are affected by human activities, deforestation and multi-environmental factors[3-6]. Forest structure and composition are strongly correlated with the environmental factors, such as climate and topography[7,8]. Local climate of the area leads to the presence of specific plant species followed by several environmental parameters, namely, temperature, pH, moisture, soil and biological pressure[9,10]. Thus, plant species respond very well to their surrounding environment and understanding of forest structure is a pre-requisite to describe various ecological processes and ecosystem diversity[11,12].

Plants are useful to the social communities and also play an important role in the maintenance of natural ecosystem[13]. Many plant products are essential for human survival in the form of food, medicine and timber for home construction, and have been used from ancient time by tribal and rural peoples. Around 80% population over the world uses medicinal plants to cure different health related problems[14]. High demand rate of plant products for various purposes promote either overexploitation or cultivation of specific plant species[13,15], and thus economic valuation of ecosystem services neglects the value of biodiversity conservation[16]. Additionally, continuously increasing population has a great pressure of employment generation and creation of economic opportunities which result in the industrialization/ urbanization and destruction of aesthetic quality[17]. These activities encourage loss of habitat, fragmentation, pollution and disturbance in the forests. The above said issues culminate into the gradual decrease or disappearance of specific native plant species and invasion by the opportunistic species. Thus, loss of biodiversity (specifically extinction of rare species) and gene pool occurs which would be much more useful in the future[13]. Therefore, documentation is necessary for sustained utilization and conservation of biodiversity[12]. Guru Ghasidas Vishwavidyalaya, Bilaspur

(GGV) is a central university located in central part of India, which covers an area of around 700 acres. The university is established in the diversity rich tropical deciduous forest area and the tree species may be facing the pressure of anthropogenic activities. Hence, the present study is an attempt to determine the structure, composition and diversity of tree species in GGV campus, Bilaspur.

Material and methods

Study site: Bilaspur district is one of the major cities of Chhattisgarh state and situated in the North- Western part of the state (Figure-1). The district's geographical location is between 21° 47′ - 23° 8′ N latitude and 81° 14′ - 83° 15′ E longitude. The temperature of the site varies between 13 - 45°C. The climate is warm, humid and sub-humid with an annual rainfall of approximately 1400 mm. A major proportion of precipitation (90-95%) is received in the months of June-October. During monsoon season the atmospheric humidity of the region is increased up to 90%. Humidity starts decreasing from October onward and reaches as low as 15-20% during peak summer months. The general vegetation of the area has been classified as tropical deciduous forest.

Methods: The present work was carried to document the diversity of tree species at GGV campus by quadrat method as has been suggested by Mishra[18], Cintron and Novelli[19], Shukla and Singh[20]. GGV campus was divided into eleven grids (Figure-2). The different numbers of the quadrats were sampled in each grid depending on the area. The size of the quadrat was 27 x 27 meter square. The specimens were identified with the aid of standard local floras, available literature and monographs.

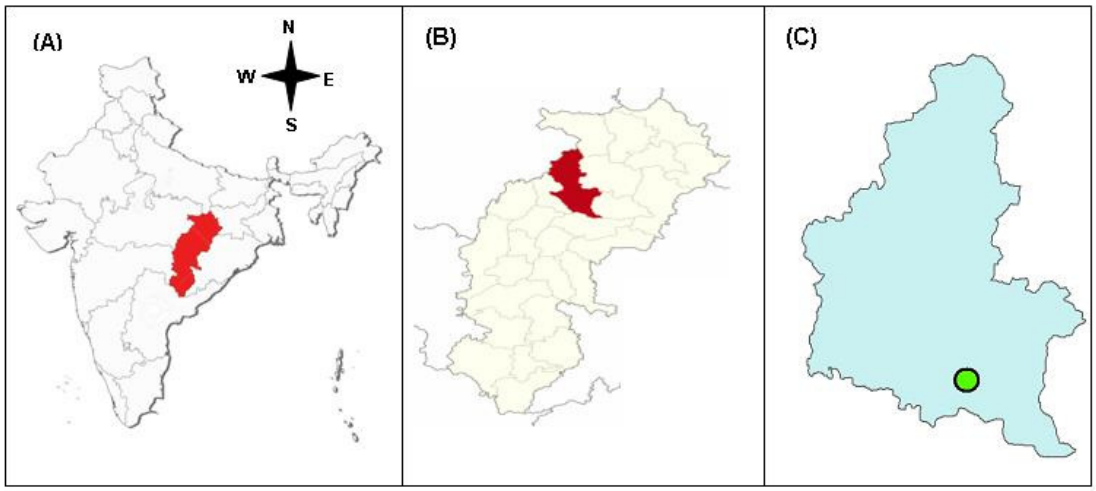

Figure-1: Location of study site. (A) Map of India shows the location of Chhattisgarh state, (B) Map of Chhattisgarh shows the location of Bilaspur district, (C) Map of Bilaspur district shows the point location of GGV campus.

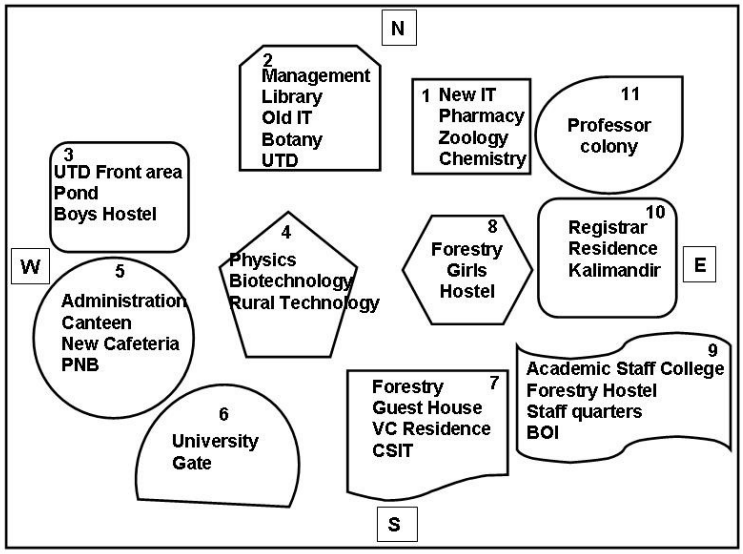

Figure-2: Grid distribution pattern of the study site.

Data analysis: The minimum number of quadrat requirement for tree species diversity assessment of GGV campus were determined by cataloging the different species found in the sampled quadrats. This information was compiled in another table for successive quadrats till now occurrence of any new plant species was observed.

Important community parameters such as frequency (F), density (D) and abundance (A) of all plant species were calculated following the standard methods[17,18]. Their relative values (%) such as relative frequency (RF), relative density (RD), relative abundance (RD) and importance value index (IVI) were also analyzed as per the methods given in Mandal and Joshi[17]. The formulas used for the above mentioned calculations are as follows:

$$Frequency\ (F) = \frac{Number\ of\ samples\ in\ which\ species\ present}{Total\ number\ of\ samples\ studied}$$

$$Density\ (D) = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ samples\ studied}$$

$$Abundance\ (A) = \frac{Total\ number\ of\ individuals\ of\ a\ species}{Total\ number\ of\ samples\ in\ which\ species\ present}$$

$$\text{Re}lative\ Frequency\ (RF) = \frac{Frequency\ of\ individual\ species}{Sum\ of\ frequency} x100$$

$$\text{Re}lative\ Density\ (RD) = \frac{Density\ of\ individual\ species}{Sum\ of\ density} x100$$

$$\text{Re}lative\ Abundance\ (RA) = \frac{Abundance\ of\ individual\ species}{Sum\ of\ abundance} x100$$

Imp or tan ce value index (IVI) = Re lative Frequency + Re lative Density + Re lative Abundance

The species diversity index was calculated (H') by the method of Shannon and Weiner with the help of following formula;

$H = -\sum Pi \ln Pi$

Where: H' = Shannon -Weiner diversity index, Pi is the proportion of individuals in the ith species i.e (ni/N); ni = importance value index of the species; and N = importance value index of all the species.

The dominance index was calculated by Simpson's index as follows;

$$D = \sum_{i=1}^{s} P_i^2$$

Where, Pi is same as for the Shannon-Weiner diversity.

Evenness (E) was calculated using the formula;

$$E = \frac{H'}{\ln R}$$

Where: R = richness i.e. total number different species observed in the study site.

Results and discussion

A total of 94 quadrats were sampled from all the grids and the new tree species were observed up to sampling of 77 quadrats, thereafter, increased sampling did not result in the observation of any new species. In this study a total of 26 tree species were observed from GGV campus. Of the 26 species, 21 tree species were identified up to species level with the help of standard local floras and monographs, and five tree species remained unidentified (Table-1). Identified tree species were named as *Butea monosperma, Acacia nilotica, Eucalyptus, Ziziphus mauritiana, Millettia pinnata, Delonix regia, Azadirachta indica, Tectona grandis, Alkana tinctoria, Saraca asoca, Diospyros melanoxylon, Dalbergia sisso, Mangifera indica, Madhuca indica, Syzygium cumini, Cascabela thevetia, Dendrocalamus strictus, Ficus religiosa, Phyllanthus emblica, Cassia fistula,* and *Alangium salvifolium.* These tree species belong to 14 families and Fabaceae contributed the highest proportion of tree species followed by Myrtaceae (Table-1). The remaining families contributed only single tree species.

Compositional analysis revealed higher frequency, density and abundance values for *Acacia nilotica, Butea monosperma, Eucalyptus, Delonix regia* and *Diospyros melanoxylon* (Table-2). A similar pattern was observed for relative frequency, relative density and relative abundance. The IVI values of tree species ranged from 116.526 to 0.907. On the basis of IVI values *Butea monosperma, Acacia nilotica, Delonix regia, Eucalyptus, Diospyros melanoxylon* and *Cassia fistula* were recognized as predominant trees. Diversity analysis results show Shannon-Weiner index of 2.397, Simpson dominance index 0.156 and evenness 0.736 for tree plants inside GGV campus (Table-3).

Discussion: The observations of new species up to sampling of 77 quadrats indicate that a minimum of 77 samples are required to the study the structure, composition and diversity of trees inside GGV campus. Thus, studied 94 samples are adequate for the present study. A total of 26 tree species were observed from GGV campus. The major focus of the study was to document the tree species which contribute a lower proportion of total plant diversity not only in the GGV campus but also in other forests of India[21]. Therefore, observation of only 26 different tree species appears justified and gets support from an earlier study in which lower proportion of tree species was also revealed during the vegetation structure and composition analysis of GGV campus[9]. The observed tree species were also reported in the literature from deciduous forests of Madhya Pradesh and Chhattisgarh with the exception of quite few species[9,22,23]. The dominance of Fabaceae and Myrtaceae find

support from the study of Patel who concluded that Fabaceae and Myrtaceae families are major contributors of plant diversity in GGV campus[9]. Thus, the present study corroborates from earlier studies, however, it indicates that few tree species inhabited due to the dispersal of seeds through birds and animals or changes in the climatic conditions which support their survival and propagation[24]. These are *Diospyros melanoxylon, Saraca asoca,* and *Alkana tinctoria.*

Table-1: Documentation of the tree species in the study area and their medicinal uses.

Common name	Botanical name	Family	Parts used	Uses
Palas	*Butea monosperma*	Fabaceae	Bark, leaf, seed	Skin disease, diabetes
Babul	*Acacia nilotica*	Fabaceae	Leaf, stem, bark	Antiseptic for wounds
Nilgiri	*Eucalyptus*	Myrtaceae	Stem	Timber
Ber	*Ziziphus mauritiana*	Rhamnaceae	Fruit	Vitamin C
Karanj	*Millettia pinnata*	Fabaceae	Plant Juice and seed's oil	Antiseptic
Gulmohar	*Delonix regia*	Fabaceae	Flowers, leaf, stem, bark	Antimicrobial and antidiabetic
Neem	*Azadirachta indica*	Meliaceae	Leaf, stem, bark, seeds	Antimicrobial, antidiabetic, antihelmenthic, skin disease
Sagaun	*Tectona grandis*	Verbenaceae	Root	Ringworm control
Ratanjot	*Alkana tinctoria*	Boraginaceae	Fruit	Wound healing and antimicrobial
Ashoka	*Saraca asoca*	Fabaceae	Bark	Tonic
Tendu	*Diospyros melanoxylon*	Ebenaceae	Fruit, flower	Skin disease
Shisham	*Dalbergia sisso*	Fabaceae	Leaf, stem	Skin disease, Itching
Aam	*Mangifera indica*	Anacardiaceae	Fruit	Vitamin A, tonic
Mahua	*Madhuca indica*	Sapotaceae	Leaf, flower, bark	Cough, ulcer, skin disease
Jamun	*Syzygium cumini*	Myrtaceae	Seed	Antidiabetic
Kaner	*Cascabela thevetia*	Apocynaceae	Seed	Antifungal
Bans	*Dendrocalamus strictus*	Poaceae	Stem, root	Astringent
Peeple	*Ficus religiosa*	Moraceae	Seed	Asthma
Amla	*Phyllanthus emblica*	Euphorbiacae	Fruit	Anticancer
Amaltas	*Cassia fistula*	Fabaceae	Seed, bark	Antiviral tonic
Akol	*Alangium salviifolium*	Alangiaceae	Root, bark	Sikn disease
Acc1	Acc 1	----------	---------	----------
Acc2	Acc 2	----------	---------	----------
Acc3	Acc 3	----------	--------	----------
Acc4	Acc 4	----------	--------	----------
Acc5	Acc 5	----------	--------	----------

Acc1, Acc2, Acc3, Acc4 and Acc5 are unidentified tree species

Table-2: Frequency, density, abundance, relative frequency, relative density and relative abundance of tree species inside GGV campus.

Name of tree species	Number of individuals	Number of quadrats in which tree was present	Frequency % (F)	Density (D)	Abundance (A)	Relative frequency (RF)	Relative density (RD)	Relative abundance (RA)
Butea monosperma	1591	80	85.106	16.925	19.887	85.314	22.516	8.696
Acacia nilotica	2796	88	93.617	29.744	31.772	19.512	39.570	13.893
Eucalyptus	470	38	40.425	5	12.368	8.425	6.651	5.408
Ziziphus mauritiana	60	16	17.021	0.638	3.75	3.547	0.848	1.639
Millettia pinnata	73	07	7.446	0.776	10.428	1.551	1.032	4.559
Delonix regia	585	33	35.106	6.223	17.727	7.317	8.278	7.751
Azadirachta indica	25	11	11.702	0.265	2.272	2.439	0.352	0.993
Tectona grandis	53	07	7.446	0..563	7.571	1.551	0.749	3.310
Alkana tinctoria	64	04	4.255	0.680	16.000	0.886	0.904	6.996
Saraca asoca	47	10	10.638	0.5	4.700	2.217	0.665	2.055
Diospyros melanoxylon	377	31	32.978	4.010	12.161	6.873	5.334	5.317
Dalbergia sisso	43	08	8.510	0.457	5.375	1.773	0.607	2.350
Mangifera indica	13	05	5.319	0.138	2.600	1.108	0.183	1.136
Madhuca indica	06	04	4.255	0.063	1.500	0.886	0.083	0.655
Syzygium cumini	15	09	2.127	0.021	1.000	0.443	0.027	0.437
Cascabela thevetia	12	03	3.191	0.127	4.000	0.665	0.168	1.749
Dendrocalamus strictus	52	06	6.382	0.553	8.666	1.330	0.735	3.789
Ficus religiosa	07	06	6.382	0.074	1.116	1.330	0.098	0.509
Phyllanthus emblica	12	02	2.127	0.127	6.000	0.443	0.168	2.623
Cassia fistula	260	10	10.638	2.765	26.000	2.217	3.678	11.369
Alangium salviifolium	106	20	21.276	1.127	5.300	4.434	1.499	2.317
Acce.1	284	37	39.361	3.021	7.675	8.204	4.019	3.356
Acce. 2	88	13	13.829	0.936	6.769	2.882	1.245	2.959
Acce. 3	15	02	2.127	0.159	7.500	0.443	0.211	3.279
Acce. 4	17	04	4.255	0.180	4.500	0.880	0.239	1.858
Acce. 5	09	04	4.255	0.095	2.250	1.858	0.126	0.983
Total			479.774	75.167	228.687			

Table 3: Diversity and dominance of tree species inside GGV campus.

Name of tree species	IVI	*pi*	(-) *ln pi*	(-) *pi ln pi*	pi^2
Butea monosperma	116.526	0.316	1.152	0.364	0.1000
Acacia nilotica	72.975	0.1980	1.620	0.321	0.0390
Eucalyptus	20.484	0.0550	2.900	0.160	0.0030
Ziziphus mauritiana	6.034	0.0160	4.135	0.066	0.0003
Millettia pinnata	7.142	0.0193	3.950	0.076	0.0004
Delonix regia	23.346	0.0630	2.770	0.175	0.0040
Azadirachta indica	3.784	0.0100	4.610	0.046	0.0001
Tectona grandis	5.610	0.0150	4.200	0.063	0.0002
Alkana tinctoria	8.786	0.0230	3.770	0.087	0.0005
Saraca asoca	4.937	0.0130	4.340	0.056	0.0002
Diospyros melanoxylon	17.524	0.0470	3.058	0.144	0.0022
Dalbergia sisso	4.730	0.0120	4.430	0.053	0.0001
Mangifera indica	2.427	0.0060	5.120	0.031	0.0000
Madhuca indica	1.624	0.0040	5.520	0.022	0.0000
Syzygium cumini	0.907	0.0020	6.220	0.012	0.0000
Cascabela thevetia	2.582	0.0070	4.960	0.035	0.0001
Dendrocalamus strictus	5.854	0.0150	4.120	0.062	0.0002
Ficus religiosa	1.937	0.0050	5.300	0.027	0.0000
Phyllanthus emblica	3.234	0.0080	4.830	0.039	0.0001
Cassia fistula	17.264	0.0460	3.080	0.142	0.0021
Alangium salviifolium	8.25	0.0220	3.820	0.084	0.0005
Acc.1	15.579	0.0420	3.170	0.133	0.0018
Acc. 2	7.086	0.0190	3.960	0.075	0.0004
Acc. 3	3.933	0.0100	4.610	0.046	0.0001
Acc. 4	2.977	0.0081	4.820	0.039	0.0001
Acc. 5	2.967	0.0080	4.830	0.039	0.0001
				H'= 2.397	D = 0.1555

Evenness (E) = 0.736.

The results of frequency, density, abundance, relative frequency, relative density and relative abundance are in agreement with the study of Shukla and Singh from deciduous forest of Sarguja district, Chhattisgarh, India[20]. On the basis of IVI values *Butea monosperma, Acacia nilotica, Delonix regia, Eucalyptus, Diospyros melanoxylon* and *Cassia fistula* were recognized as predominant tree communities. Structural and compositional analysis observations find support from the studies of Bijlwan and Patel, who have reported the predominance of *Diospyros melanoxylon*, *Butea monosperma* and *Acacia nilotica* in the forests of Chhattisgarh and GGV campus respectively[9,22]. It is worth mentioning that attention should be paid by the conservationists for the less dominant *Syzygium cumini*, *Madhuca indica*, *Ficus religiosa*, *Cascabela thevetia* and *Azadirachta indica* which are important source of medicines and antimicrobial compounds.

The observed diversity results are congruent with previous reports of Chhattisgarh and Madhya Pradesh forest areas. Prasad and Pandey observed the species diversity ranging from 0.32 to 3.76 in Bilaspur, Mandla, Balaghat and Jabalpur districts of Chattissgarh and Madhya Pradesh[25]. Simpson dominance index of our study is also harmonious with various studies from forests of Chhattisgarh and Madhya Pradesh.

The observed diversity values indicate that precipitation, warm and moist climate support the growth and survival of the various tree species in GGV campus. However, the low diversity values in comparison to standard literature may be linked to the utilization of large proportion of resources by only few species as well destruction of vegetation during the construction of university buildings. Therefore, the selected tree species proliferate and dominate in the GGV campus, Bilaspur.

Conclusion

This study revealed the presence of 26 tree species inside GGV campus, and of these 21 were identified as *Butea monosperma, Acacia nilotica, Eucalyptus, Ziziphus mauritiana, Millettia pinnata, Delonix regia, Azadirachta indica, Tectona grandis, Alkana tinctoria, Saraca asoca, Diospyros melanoxylon, Dalbergia sisso, Mangifera indica, Madhuca indica, Syzygium cumini, Cascabela thevetia, Dendrocalamus strictus, Ficus religiosa, Phyllanthus emblica, Cassia fistula,* and *Alangium salvifolium.*

The most dominant families were Fabaceae and Myrtaceae. IVI values indicate that *Butea monosperma, Acacia nilotica, Delonix regia, Eucalyptus, Diospyros melanoxylon,* and *Cassia fistula* are predominant tree communities.

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