Phyto Diversity in Buxawaha Tehsil, District Chhatarpur, M.P., India. Part-I: Tree Diversity

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Abstract

The study area is a protected forest in Buxwaha tehsil in Chhatarpur district in the state of Madhya Pradesh. The study was carried out to determine the diversity at tree layer. The study area was sampled with 50 square quadrats of 30 x 30 m size. In total 57 species of trees were recorded. Basal area was found to be maximum for mahua (*Madhuca longifolia*) while frequency, density and IVI were found to be maximum for teak (*Tectona grandis*). Different diversity indices produced different values. Whittaker plot indicated almost log normal model while the K-dominance plot indicated poor evenness in the tree layer. The rarefaction plot indicated a little more effort required for sampling.

Keywords: Chhatarpur, Tree diversity, IVI, Whittaker plot, K-dominance plot.

Introduction

The study area, forms a part of the Bundelkhand region which comes under Deccan Peninsula Biogeographic Region of India (WII, 2000). The area has highly undulating topography, varies from 408 m to 466 m above sea level. First description of the area as the Highlands of Central India, was given by Forsyth (1872). At the time teak was scattered all over the region. Even at that time settlements in the forests, for the common requirements in timber and fuel have hacked down the forests into mere scrub. Buch (1991) has described the area under the southern part of the Yamuna catchment. Presently the forest of the study area are maintained as protected forests means where the rights of the people are protected to use the forest as resource for nistar purposes.

According to the Revised Survey of Forest Types of India (Champion and Seth, 1968), forests in the area are of two types, dry tropical and dry teak forests:

1. II 5ACIb and
2. II 5AC$_3$.

The area receives an average rainfall of more than 1,000 mm. With so much rainfall still the area is included under dry zone probably because the rainfall is highly seasonal. More than 80 per cent of the rain falls within a short interval of about 3 months from about mid-June to mid-September. Most spectacular is the

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summer aspect of the forests when the temperature rises from the lowest of about 8°C in the winter to to about 45°C in the summer. The entire forest gives a deserted, denuded look with *Lannea coromendelica* and *Bowsellia serrata* trees with their whitish stem, standing out almost as flagship species.

Study area has relatively good variety and density of vulnerable to least concern mammals. Some of them are: Chinkara (*Gazella gazelle*), four horned antelope (Chausingha, *Tetraceros quadricornis*), Sloth bear (*Melursus ursinus*), leopard (*Panthera pardus*), hanuman langur (*Presbytes entellus*), Rhesus macaque (*Macaca mulatta*), Indian mongoose (*Herpestes edwardsii*), small mongoose (*H. javanicus*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), Indian civet (*Paradoxurus hermaphrodites*), common fox (*Vulpes bengalensis*), hyena (*Hyaena hyaena*), nilgai (*Boselaphus tragocamelus*), wild boar (*Sus scrofa*), sambar (*Rusa unicolor*), spotted dear (*Axis axis*), porcupine (*Hystrix brachyura*), tree shrew (*Ananthana ellioti*), wild dog (*Cuon alpinus*) and honey badger (rattle, *Mellivora capensis*). Still of importance is that the vulture species *Gyps bengalensis* has also been spotted in the area.

Several indices have been proposed to quantify the biodiversity, but so far no single index has been found adequate to summarize the concept of biodiversity (Hulbert, 1971; Purvis & Hecter, 2000). Magurran (2004) considers that richness(s) as proposed by Whittaker (1972) is the simplest and still most commonly applied index to represent biodiversity, however, accepts that species or trait abundance is also important for diversity. Simplest of indices incorporating the abundance was proposed by Berger and Parker (1970). The index reports the proportion of most abundant species and has analytical relationship with the geometric series of the species abundance model (May, 1975; Caruso *et al.*, 2007). Shannon and Simpson have combined richness and abundance to propose compound indices (Magurran, 2004), Simpson's evenness index, being the inverse of Simpson's diversity index is closely related to the later. One controversy is about the Shannon index, Shannon Weaver index or the Shannon Wiener index. Original paper was published by Shannon (1948) and was again published with Shannon and Weaver (1949). The source of Shannon Wiener is not known. Thus for Shannon index Shannon (1948) should be quoted.

Variety of methods used to display species abundance data has made it difficult to make a comparative studies of diversity. Out of several species abundance distribution methods one of the best known and most informatics methods is the rank/abundance plot or dominance/diversity curve (Magurran, 2004), to which Krebs (1999) prefers to term Whittaker plots in celebration of their inventor (Whittaker, 1965). In this plotting proportional or percentage abundances are used. k-dominance plot is the another way of presenting species abundance data in a ranked format (Lambshead *et al.*, 1983; Platt *et al.*, 1984). Y-axis in the plot is percentage cumulative abundance while the X-axis is the species rank or log species rank. Under this plotting method more elevated curves represent the less diverse assemblages and *vice versa*. The shape of the plot indicates the type of species abundance, viz., geometric series log normal or broken stick.

Several possibilities exist for describing tree size and accordingly also tree size diversity. Examples are diameter, basal area, height, crown height and crown width. Circumference at breast height (CBH) can easily be converted to Diameter at breast height (DBH) or basal area and is most simple method to measure, hence, is a preferred method to sample tree size. The diameter is also highly correlated to other tree size parameters (Lexerod & Eid., 2006). Diversity indices, dominance abundance plots and importance value index (IVI) (Brashears *et al.*, 2004) have become common methods of phytosociological analysis, for comparison between sites and to determine the percentage of similarity between two sites. The purpose of determining diversity by a numerical index is to provide a means of comparison between different sites (Hill, 1973). However, some objections have been raised against biodiversity values. Morris *et al.* (2014) consider that biodiversity is a multidimensional property.

So far no any systematic study has been carried out in the region either for its vegetation nor for phytodiversity. Present study was made, therefore, to analyze phytosociology, calculate some diversity indices and draw some plots to draw inference about the tree diversity of the forests of the area.

Material and Methods

The tree layer was studied with the help of square shaped 50 quadrats of 30 x 30 m. The size of plant to be taken as tree has some variation according to different workers. Brashears *et al.* (2004) have taken plants with >12.7 cm diameter at breast height (Circumference >39.91 cm), Forest Survey of India, in its report has taken >10 cm diameter at breast height (Circumference >31.43 cm). On the other hand, Mishra (1989) and Chaubey *et al.* (2015) have taken plants with >6.36 cm diameter at breast height (Circumference >20 cm) as trees; and this has been adopted for the present study. Number and girth of trees were recorded species wise in each sampling plot.

1. Importance Value Index (IVI)

Basal area, frequency and density, their relative values and Importance value index (IVI) of individual specie were calculated using the following formulae:

$$\text{Basal area} = \frac{(\text{Circumference at breast height})^2}{12.56}$$

$$\text{Frequency (\%)} = \frac{\text{No. of sampling plots in which the species is present}}{\text{Total No. of plots sampled}} \times 100$$

$$\text{Density (Ha}^{-1}) = \frac{\text{No. of individuals of the species}}{\text{Total area sampled (ha)}}$$

$$\text{Relative basal area} = \frac{\text{Basal area of the species}}{\text{Basal area of all the species}} \times 100$$

Frequency of the species

$$\text{Relative frequency} = \frac{}{\text{Frequency of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Density of all the species}} \times 100$$

IVI (of trees) = Relative basal area + Relative frequency + Relative density.

2. Diversity Indices

Most of the workers and formulae suggest the use of number of individuals for the calculation of diversity indices. However, during present investigation, in the formulae for the calculation of diversity indices number of individuals has been replaced either by basal area or by IVI. This has been done because taking the number of individuals for the calculation of diversity indices may overestimate the contribution by a species, having larger number of individuals but the individuals have smaller basal areas; similarly the contribution of species with fewer number of individuals but with larger basal area will be underestimated. Similarly IVI is the value obtained by combining the relative values of basal area, frequency and density. The combined value cancels out the effect of large value in any one parameter of a species and small value in another parameter of the same species. Thus, IVI is a better parameter to be taken for the calculation of diversity indices. Therefore, presently diversity indices have been calculated both by taking basal area or the IVI values instead of number of individuals.

(i) Shannon index

Shannon index was calculated using the formula (Shannon, 1948):

$H' = - \Sigma pi \; ln \; pi$

Where,

Pi = the proportion of basal area or IVI of the species relative to the total basal area or IVI of all the species,

ln = the natural logarithm,

The final product is multiplied by -1.

(ii) Margalef's index of species richness (M): (Kent and Coker, 1992).

$M = \frac{(S-1)}{\ln N}$

Where, S = No. of species

N = No. of individuals ha^{-1} or Total of IVI values.

(iii) Simpson's index (Simpson, 1949)

The calculation of the Simpson index (Simpson, 1949) is based on the squared proportions of basal area in each diameter class.

$D = \Sigma Pi^2$

Pi = the proportion of basal area or IVI of the species relative to the total basal area or IVI of all the species,

The value of D has inverse relationship with the diversity, 0 represents infinite diversity and, 1 represents no diversity.

(iv) Simpson index of diversity = 1-D

(v) Simpson's index of dominance = 1/D

(vi) Simpson evenness = 1/D x S

S = No. of species

(vii) Berger Parker index of diversity = 1/d. Berger Parker (1970).

d = (Total basal area or IVI of trees in the grid / Max. basal area or IVI of individual species in grid).

(viii) Pielou's species Evenness index (EH) (Magurran, 2004)

= (H'/*ln*(s))

Where H' = Shannon index

S = No. of species

Basal area, number of individuals, importance value index (IVI) or any other parameter may be taken as the parameter for plotting K-dominance, rank abundance and rarefaction. However, as the IVI is derived after combining three parameters, this was considered to be better and was used also for drawing the plots. Plotting for K-dominance, rank abundance and rarefaction was done using Biodiversity Pro software (http://www.sams.ac.uk).

3. *Diversity Plots*

The plots were drawn with the help of Biodiversity Pro software. To accommodate several orders of magnitude on the same graph, species are plotted in a $\log_{10}$ format in sequence from most to least abundant along the x-axis and their abundances on the y-axis. High dominance indicated with a steep plots signifying a geometric or log series distribution while shallower slopes imply higher evenness consistent with a log normal or even a broken stick model. Rank abundance plots have the advantage that they highlight the differences in evenness and with the help of the plots inference could be drawn about the model best describing the data (Nee *et al.*, 1992; Tokeshi, 1993; Smith and Wilson, 1996; Maguran, 2004).

Result and Discussion

IVI values for trees is given in Table 1. Among the 57 species of trees, a wide range of basal area, was recorded ranging from 0.0026 m^2/ha for ber (*Zyziphus mauritiana*) to 2.1334 m^2/ha for mahua (*Madhuca longifolia*). This is because the area of study is a protected forest area where the people's right for *nistar* purposes are protected, i.e., people can collect fuel wood and other nistar requirement from the forest. Although rules are there not to cut living trees but the people have all the methods to first kill a living tree through ringing or some other methods. The tree dies over a time and people are now free to cut and collect such tree. Charcoal is also prepared extensively within the study area, which is another major cause for cutting the trees. However, during all these illegal cutting Mahua trees are spared. The process going on since nineteenth century (Forsyth, 1889) large sized mahua trees are standing in the area as flagship species along with *Lannea coramandelica*. This is the reason for the maximum basal area of mahua.

Table 1: IVI of Trees

SN	Species	BA m^2 ha^{-1}	Fre	Den ha^{-1}	RBA	RF	RD	IVI
1.	*Acacia catechu*	0.2633	48	21.33	2.33	4.72	6.03	13.08
2.	*Acacia leucophloea*	0.3897	8	2.22	3.45	0.79	0.63	4.86
3.	*Adina cordifolia*	0.0110	2	0.22	0.10	0.20	0.06	0.36
4.	*Aegle marmelos*	0.6717	70	27.56	5.94	6.89	7.79	20.63
5.	*Albizzia lebbek*	0.1273	8	1.34	1.13	0.79	0.38	2.29
6.	*Albizzia odoratissima*	0.0996	6	0.67	0.88	0.59	0.19	1.66
7.	*Anogeissus latifolia*	0.1644	26	13.11	1.45	2.56	3.71	7.72
8.	*Anogeissus pendula*	0.6960	32	28.22	6.16	3.15	7.98	17.29
9.	Bauhinia malabaica	0.0170	4	0.44	0.15	0.39	0.12	0.67
10.	Bauhinia racemosa	0.0483	8	0.89	0.43	0.79	0.25	1.47
11.	Bombax ceiba	0.0935	6	0.67	0.83	0.59	0.19	1.61
12.	Boswellia serrata	0.9410	24	6.22	8.33	2.36	1.76	12.45
13.	Bridelia retusa	0.0405	14	3.33	0.36	1.38	0.94	2.68
14.	Buchanania lanzan	0.3715	58	18.22	3.29	5.71	5.15	14.15
15.	Butea monosperma	0.0510	2	0.22	0.45	0.20	0.06	0.71
16.	Casearia tomentosa	0.1886	12	5.56	1.67	1.18	1.57	4.42
17.	Cassia fistula	0.0245	28	4.67	0.22	2.76	1.32	4.29
18.	Catunaregan uliginosa	0.0113	2	0.22	0.10	0.20	0.06	0.36
19.	Chloroxylon swietenia	0.1356	6	1.78	1.20	0.59	0.50	2.29
20.	Choclospermum religiosum	0.0319	2	0.22	0.28	0.20	0.06	0.54
21.	Cordia myxa	0.0483	2	0.22	0.43	0.20	0.06	0.69
22.	Dalbergia latifolia	0.0594	4	0.44	0.53	0.39	0.12	1.04
23.	Dalbergia paniculata	0.0754	2	0.22	0.67	0.20	0.06	0.93
24.	Diospyros melanoxylon	0.5905	82	37.56	5.23	8.07	10.62	23.91
25.	Ehretia laevis	0.0663	2	0.22	0.59	0.20	0.06	0.85
26.	Elaeodendron glaucum	0.0099	8	0.89	0.09	0.79	0.25	1.13
27.	Emblica officinalis	0.1518	22	5.56	1.34	2.17	1.57	5.08
28.	Feronia limosa	0.0453	2	0.22	0.40	0.20	0.06	0.66
29.	Ficus infectoria	0.1299	2	0.22	1.15	0.20	0.06	1.41
30.	Ficus racemosa	0.0637	2	0.22	0.56	0.20	0.06	0.82
31.	Flacourtia ramontchii	0.2110	66	10.00	1.87	6.50	2.83	11.19
32.	Garuga pinnata	0.0111	16	6.89	0.10	1.57	1.95	3.62
33.	Gmelina arborea	0.0851	4	0.67	0.75	0.39	0.19	1.34
34.	Grewia tiliaefolia	0.0483	4	0.44	0.43	0.39	0.12	0.95
35.	Holarrhaena antidysenterica	0.0085	16	4.44	0.08	1.57	1.26	2.91
36.	Holoptelia integrifolia	0.0204	2	0.22	0.18	0.20	0.06	0.44
37.	Hymenodictyon excelsum	0.0681	4	0.44	0.60	0.39	0.12	1.12
38.	Lagerstroemia parviflora	0.5408	74	24.44	4.79	7.28	6.91	18.98
39.	Kydia calycina	0.0410	6	0.67	0.36	0.59	0.19	1.14

40.	Lannea coromandelica	0.4030	44	17.56	3.57	4.33	4.96	12.86
41.	Madhuca longifolia	2.1334	70	15.78	18.88	6.89	4.46	30.23
42.	Maytenus emarginata	0.0127	2	0.22	0.11	0.20	0.06	0.37
43.	Miliusa tomentosa	0.0310	22	4.00	0.27	2.17	1.13	3.57
44.	Mitragyna parviflora	0.0203	4	0.44	0.18	0.39	0.12	0.70
45.	Ougeinia oojeinensis	0.0292	10	1.56	0.26	0.98	0.44	1.68
46.	Schleichera oleosa	0.0046	2	0.22	0.04	0.20	0.06	0.30
47.	Schrebera swietenoides	0.0249	2	0.22	0.22	0.20	0.06	0.48
48.	Soymida febrifuga	0.0082	10	4.00	0.07	0.98	1.13	2.19
49.	Sterculia urens	0.0170	2	0.22	0.15	0.20	0.06	0.41
50.	Syzigium cuminii	0.0398	4	0.44	0.35	0.39	0.12	0.87
51.	Tectona grandis	1.0449	84	61.78	9.25	8.27	17.46	34.98
52.	Terminalia arjuna	0.0717	2	0.22	0.63	0.20	0.06	0.89
53.	Terminalia bellirica	0.1657	6	0.67	1.47	0.59	0.19	2.25
54.	Terminalia chebula	0.0645	4	0.44	0.57	0.39	0.12	1.09
55.	Terminalia tomentosa	0.5390	54	13.78	4.77	5.31	3.90	13.98
56.	Wrightia tinctoria	0.0342	4	0.67	0.30	0.39	0.19	0.89
57.	Zyziphus mauritiana	0.0026	4	0.44	0.02	0.39	0.12	0.54
	TOTAL	11.2992	1016	351.29	100	100	100	300

Abbreviations:

BA = Basal area m^2/ha
Fre = Frequency
Den = Density/ha
RBA = Relative basal area
RF = Relative frequency
RD = Relative density
IVI = Importance value index

The study area is basically a teak forest area, but teak is the first species attempted to cut illegally. Hence not a single large tree of teak is visible in the area but a large number of them are surviving in smaller sizes. Due to this, although the teak with basal area of 1.0449m^2/ha is second in order with respect to basal area but frequency, density and IVI values were recorded highest for the teak with values of 84, 61.78 and 34.98 respectively. Some of the other species, in decreasing order of IVI, were *Madhuca longifolia* (30.23), *Diospyros melanoxylon* (23.91), and *Aegle marmelos* (20.63). Some other tree species with higher values of IVI were *Lagerstroemia parviflora* (18.98), *Anogeissus pendula* (17.29), *Terminalia tomentosa* (13.98), *Acacia catechu* (13.08) and *Lannea coramandelica* (12.86). During leafless period of the trees in the months of March to May trees like *Lannea coramandelica* and *Boswellia serrata* give a special look with their whitish, tall trees. The forest area had a poor basal cover of only 0.113 per cent, however, such lower, per cent basal cover is not unexpected of a protected forest.

Different diversity indices, calculated for presently recorded data are given in Table 2. The indices were calculated both by taking basal area as well as IVI as the base for calculation. The values for different indices exhibited wide range of variation, however, almost similar values for different indices were obtained either by taking basal area or the IVI for calculating the indices. Thus with the present data any one of the parameter: basal area or the IVI may be taken for the calculation of biodiversity indices. Different indices giving different values indicate that while comparing two stands through biodiversity indices, comparision should be made with the same index.

Table 2: Different Diversity Indices

SN	Index	Based on Basal Area	Based on IVI
1.	Shanon index (H')	3.13	3.25
2.	Maragalef index of species richness (M)	9.55	9.82
3.	Simpson index (D)	0.072	0.056
4.	Simpson index of diversity (1-D)	0.928	0.944
5.	Simpson index of dominance (1/D)	13.87	17.86
6.	Simpson index of evenness (1/D x S)	0.243	0.313
7.	Berger parker index of dominance (1/d)	0.189	0.116
8.	Pielou's index of species evenness (EH)	0.775	0.804

Rank abundance curve or the Whittaker plot (Fig. 1) shows almost a log normal model as has been observed by Whittaker (1960) and redrawn by Magurran (2004) and plot drawn by Magurran (1968). The log normal models indicate that the species in the study area have random niche distribution.

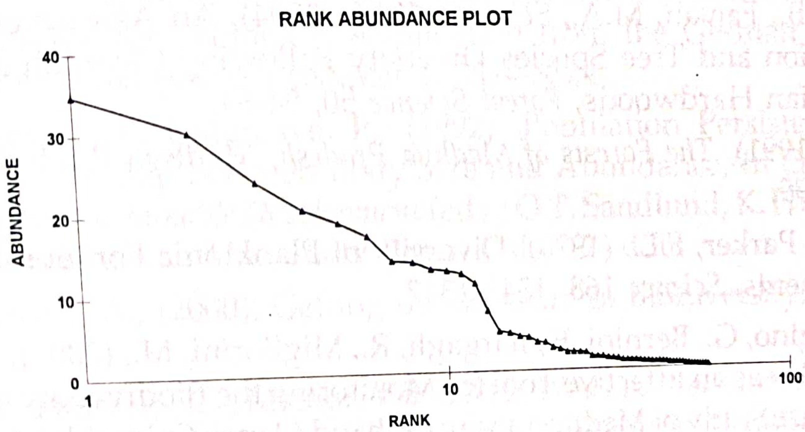

Fig. 1: Rank Abundance Curve or the Whittaker Plot for the Tree Layer in Study Area

K-Dominance abundance plot (Fig. 2) indicates that evenness is poor in the tree layer of the study area as the more elevated curves represent less diverse assemblage (Mogurran 2004).

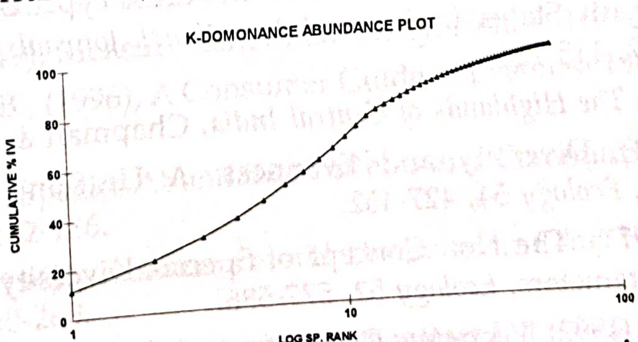

Fig. 2. K-Dominance Abundance Plot for the Tree Layer in Study Area

The rarefaction plot (Fig. 3) shows an ascending trend indicating that sampling of the area was not satisfactory and requires more intensive sampling.

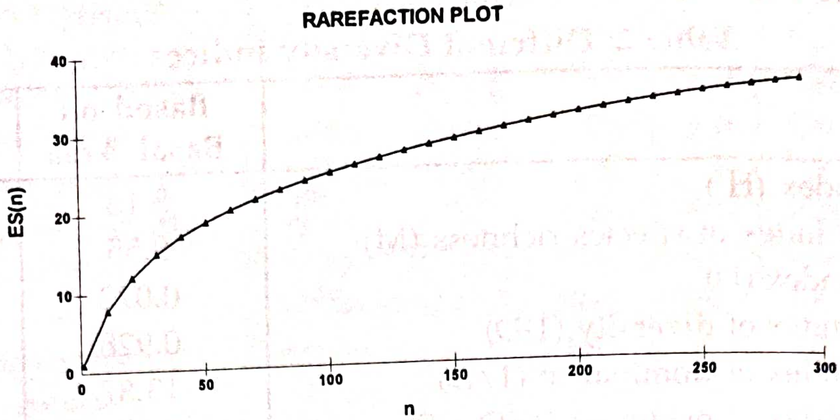

Fig. 3: Rarefaction Plot for the Tree Layer of the Study Area

The study area being a protected forest area is in degraded condition. Tree species, less useful to the local people or the species more useful when surviving (*Madhuca longifolia*) are domination the tree layer. However, the area still supports a good variety and density of wildlife.

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