ALTITUDINAL VARIATION IN STRUCTURAL COMPOSITION OF VEGETATION IN SATPURA NATIONAL PARK

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Introduction

Forests of Madhya Pradesh hold a unique status in terms of diversity of forest types (Champion and Seth, 1968) ranging from tropical dry deciduous to semi-evergreen forest, which occur on hills particularly on the Satpuras. The hills of Satpura range are a treasure trove of biodiversity and hence are usually known as "Queen of Satpuras" a Botanist's paradise. Satpura National Park is one of the important national parks of Madhya Pradesh and is situated on Pachmarhi hills of Satpura range. It is constituted by hill forest, having the highest peak of 1,352 m amsl. The area is covered with tropical moist and tropical deciduous forests with some portion of Central India sub-tropical hill forest. Though flora of Pachmarhi hills on Satpura ranges was extensively studied at various levels by a number of field workers (Pandey and Srivastava, 1952; Rao and Narayanaswami, 1960; Joseph, 1963; Jain and Kaul, 1986; Omachan and Masih, 1992), they have not been adequately analysed and assessed for the forest community. For management of the forest ecosystem, it is essential to evaluate it at regular intervals to get information about structure and function, which is basic to the understanding of a particular ecosystem. Moreover, quantitative information on these forests is lacking in proportion to the size of this region. Hence the objectives of the present study were to study the structural composition and diversity of vegetation of Satpura National Park at different altitudes.

Material and Methods

Site : Satpura National Park, Pachmarhi, District Hoshangabad (Madhya Pradesh) was established in 1981, with a view to conserve the nature and ecology of the region. It is located between 22° 23' to 22° 36' North latitude and 77° 55' to 78° 27' East longitude at the elevation ranges 400-1,352 m amsl. The topography is hilly undulating with few plain lands. It extends over an area of 524 km^2, belonging to northern dry deciduous forests. The geology consists of the Gondwana sandstone in the North and the Deccan trap in the East.

Climate : The climate of park is typically monsoonic with three defined seasons i.e. summer (March to June), rainy (July to October) and winter (November to February). Satpura National Park receives 2120.91 mm of rain. In general the temperature ranges from 11° to 42°C all over the area.

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Methods : The whole area was divided into three elevations <900m, 900-1,100m and 1,100-1,350 m. The phytosociological analysis was done on 20m x 20m quadrats for each site (Sharma *et al*, 1986). Each site consisted of 10 running quadrats and care was taken to sample most representative site. Girth at breast height (GBH at 1.35 m above ground level) was taken for all woody species. All the individuals with GBH>20 cm were taken as a tree in each quadrat (Manilal *et al.*, 1989).

The vegetation data was quantitatively analysed for frequency, density, abundance and basal area as per Curtis and McIntosh (1950). The relative values of frequency, density and dominance were determined following Phillips (1959), Mishra (1968). These quantities were summed up for getting Important Value index (IVI) of individual species (Curtis 1959). On the basis of IVI, dominant, co-dominant and main associated species were recognized in different sites (Mueller-Dombois and Ellenberg, 1974). To get distribution pattern of species, abundance to frequency ratio (A/F ratio) of different species was determined. This ratio indicates regular (0.025), random 0.025-0.05) and contagious (>0.05) distribution (Curtis and Cottom, 1956). Similarity index between different communities was calculated following Sorenson (1948) formula. Species diversity was calculated by using Shannon and Weiner (1963) information species diversity index which is the ratio of importance value of species and importance value of all the species. This diversity index was calculated by the formula :

$$\overline{H} = \sum_{i=1}^{S} (Ni/N)\log_n (Ni/N)$$

Where :
$\overline{H}$ = Shannon index of Diversity
Ni = IVI for species i
N = Total IVI of all species in a stand

Concentrations of Dominance (CD) was measured by Simpsons index (1949) as :

$$CD = \sum_{i=1}^{S} (Ni/N)^2$$

where again, Ni and N are the same as in above species diversity index.

Results and Discussions

Vegetation analysis : The importance value index of tree species of all sites was arranged in decreasing order. Plant community was arrived after the name of first two tree dominant species (Muller-Dombois and Ellenberg, 1974). Plant community in each elevation was recognized accordingly.

At elevation range <900m, *Chloroxylon swietenia* had maximum IVI (42.1) followed by *Terminalia tomentosa* (33.5) and hence, the plant community on this elevation was recognized as *Chloroxylon-Terminalia* community. At 900-1100m elevations *Shorea robusta* (88.25) had maximum IVI followed by *Terminalia tomentosa* (39.63) and therefore, community was identified as *Shorea-Terminalia*. At 1100-1350m elevation *Syzygium cumini* had maximum IVI value (29.24) followed by *Terminalia tomentosa* (25.88) and therefore, community was identified as *Syzygium-Terminala* (Table 1).

In the present study density of trees at 900 m elevation (lower hills) is the highest of 944.5 trees/ha. However with

Table 1

Forest types and vegetation communities at different elevation ranges.

Elevation ranges	Forest types*	Vegetation community					
		Trees	IVI	Shrubs	IVI	Herbs	IVI
< 900m (Lower hills)	$5A/C_3$ Dry Mixed Deciduous Forest (Mixed Forest)	*Chloroxylon swietenia - Terminalia tomentosa*	42.1 33.50	*Helicteres isora* *Capparis zeylanica*	18.96 18.47	*Apluda nutica* *Eragrostis nutanns*	20.48 17.64
900-1100m (Mid. hills)	$5B/C_1c$ (IV) Northern Tropical Dry Peninssular Low Leval Sal (Sal Forest)	*Shorea robusta - Terminalia tomentosa*	88.25 39.63	*Vernonia divergence* *Strobilanthes asparimum*	22.34 21.28	*Amaranthus spinosum* *Apluda mutica*	12.27 11.47
1100-1350m (Upper hills)	$8A/C_3$ Central Indian Sub-Tropical Hill Forest (Hill Forest)	*Syzygium cumini - Terminalia tomentosa*	29.24 25.88	*Zizyphus oenoplea* *Flamingia bractiata*	27.25 24.67	*Eragrostis nutans* *Ageratum conyzoides*	28.64 14.26

* As per Champion and Seth (1968)

increase in elevation there is a decrease in the density. At elevation 900-1100m, the density is 750 trees/ha with further increase in elevation to 1100-1300 the density drops to 555 trees/ha. Thus, there is decrease in the tree density with increasing altitude (Table 2). Decreasing density and also reduction in total species with increasing altitude seem to be a function of hostile edaphic factors occurring at high elevation. Agarwal (1980) observed maximum value of density at foothills of Baldia forests. As per Saxena (1979) density of plants in tropical forests varies from 550 to 1100 plants/ha and 350 to 2080 plants/ha in temperate forests. The area of present study belongs to tropical forests and thus density figure seems to be in reasonable limits.

The density of shrubs varied from 6,660 plants/ha at 1,100-1,350 m elevation, 6,993 plants/ha at 900-1,100m to 8,991 plants/ha at <900m elevation. In the present study in Satpura National Park, higher density of shrubs is associated with lower elevation, which is in accordance with the study done in Navegaon National Park by Ilorkar (1999). Depositions of finer particle at lower elevation create better moisture conditions for survival of shrub growth (Ilorkar, 1999).

Table 2

Total density, number of trees, shrubs and herbs at different elevation ranges.

Elevation/ Community	Total number of species			Total density		
	Trees	Shrubs	Herbs	Trees	Shrubs	Herbs
<900m *Chloroxylon-Terminalia*	45	29	43	944.5 ($26.28m^2/ha$)	8991/ha ($29.02m^2/ha$)	$33.3/m^2$ ($9.70cm^2/m^2$)
900-1100m *Shorea- Terminalia*	29	27	40	750.0 ($17.37m^2/h$)	6993/ha ($13.55m^2/ha$)	$32.7/m^2$ ($6.7cm^2/m^2$)
1100-1350m *Syzygium-Terminalia*	31	19	37	555.0 ($16.96m^2/ha$)	6660/ha ($8.95m^2/ha$)	$26.6/m^2$ ($9.28cm^2/m^2$)

Density of herbaceous flora is more (33.3 plants/m^2) at lower elevation <900m and it is low (26.6 plant/m^2) at higher elevation of 1100-1350m and thus follows pattern similar to shrub. It is attributed to better edaphic conditions (Table 2).

In the present study total basal cover occupied by trees at different altitudes follows almost similar pattern like that of density. Total basal cover at <900m (lower hills), 900-1100m (middle hills) and 1100-1350m (upper hills) elevations is 26.28 m^2/ha, 17.37 m^2/ha and 16.96 m^2/ha respectively and is a function of number of tree (Table 2).

Highest basal cover (26.28 m^2/ha) is due to more mature trees as appeared at elevation range <900m belonging to *Chloroxylon-Terminalia* plant community where there were 450 mature trees/ha. Lower basal cover (17.37m^2/ha and 16.96 m^2/ha) is because of less number of mature trees. There were 350 mature trees/ha on 900-1100m elevation and only 300 mature trees/ha on 1100-1350m elevation. This is in accordance with Singhal and Soni (1989). The difference between the basal area of tree at 900-1100m and 1100-1350m elevation is not significant (17.37 m^2/ha as against 16.96 m^2/ha), even though total tree density is of the order of 750 trees/ha and 555 tree/ha respectively, owing to the fact that plant communities are dominated more by saplings and seedlings (37% at 900-1100m and only 34% at 1100-1350m elevation). This is in tune with Rikhari *et al.*, (1991) and Ralhan *et al.* (1982). A basal area is an important criterion for evaluating the timber production in forest ecosystem (Agarwal, 1992).

Total basal area covered by shrubs at <900m (lower hills), 900-1,100m (middle hills) and 1,100-1,350m (upper hills) elevations is 29.02m^2/ha, 13.55m^2/ha and 8.95m^2/ha respectively. At the elevation of <900 m, shrubs had highest total basal area (29.02m^2/ha) as well as higher density (8991 plants/ha) while at elevation 900-1,100m and 1,100-1,350m, shrubs recorded low basal area as well as low density (6993 plants/ha, 6660 plants/ha respectively). Shrubs are more sensitive to subtle environment as well as edaphic difference than the trees (Table 2).

Shorea robusta is not found in upper hills at 1100-1350m elevations. *Shorea robusta* thus prefers the mid slope position/ mid hills of Satpura National Park. At elevation range <900m, *Chloroxylon swietenia* showed the highest density (175 trees/ha) as well as basal area (4.20m^2/ha). It showed low density (2.5 tree/ha) and low total basal area (0.52m^2/ha) on middle hills and was almost absent at 1,100-1,350m. It looks, therefore, that in nature *Chloroxylon swietenia* prefers lower hills. *Syzygium cumini* showed better performance at upper hills at elevation range 1,100-1,350m in term of higher density (80 trees/ha) and basal area (3.32m^2/ha) as against the performance of *Syzygium cumini* at elevation<900 m and 900-1,100 m elevation. Thus *Syzygium cumini* prefers upper hills but it is also scattered/rare in other elevations. (Table 3).

Distribution pattern : The trend of distribution pattern depends both on physio-chemical nature of environment as well as on the biological peculiarities of organisms themselves. In the study area, all the species belonging to tree, shrub and herb layers in general, had shown contiguous distribution. In all three community 55 to 82% trees showed contiguous distribution while 18 to 42% species had random distribution; regular type distribution was observed only in 3 to 4% species. About 58 to 78% of shrubs had contiguous distribution and 38 to 42% had random distribution on three elevation ranges. About 78 to 90% herb species showed contiguous distribution and regular distribution was almost absent or negligible in the study area (Table 4). Thus no serious competition exists among the species on all the sites since regular type of distribution is almost negligible. Occurrence of regular distribution indicates competition between individuals. According to Odum (1971) contiguous distribution is common in nature and random distribution is found in very uniform environment. Contiguous distribution in natural forest has also been reported by Singhal *et al.* (1986). Variation in the distribution pattern across the slope and vegetation strata seems to be associated with multitude of factors specially microenvironment and biotic nature (Joshi and Tiwari, 1990).

Table 3

Density and basal area of dominant tree species in communities at different elevations

Community	Dominant species	<900m		900-1,100m		1,100-1,350m	
		Density trees/ha	Basal area m^2/ha	Density tree/ ha	Basal area m^2/ha	Density trees/ha	Basal area m^2/ha
Chloroxylon-Terminalia	*Chloroxylon swietenia*	175	4.20	2.5	0.52	-	-
Shorea-Terminalia	*Shorea robusta*	27.5	1.19	305	6.21	-	-
Syzygium-Terminalia	*Syzygium cumini*	32.5	1.83	22.5	0.75	80	3.32

Table 4

Distribution pattern (%) of trees, shrubs and herbs in three plant communities corresponding to different elevation ranges

Community	Elevation/ Range	Trees			Shrubs			Herbs		
		R	r	C	R	r	C	R	r	C
I	>900m (Lower hills)	-	18	82	3	38	59	3	16	81
II	900-1100m (Middle hills)	4	27	69	-	22	78	-	10	90
III	1100-1350m (Upper hills)	3	42	55	-	42	58	-	22	78

R - Regular I - *Chloroxylon - Terminalia* community
r - Random II - *Shorea - Terminalia* community
C - Contiguous III - *Syzygium - Terminalia* community

Table 5

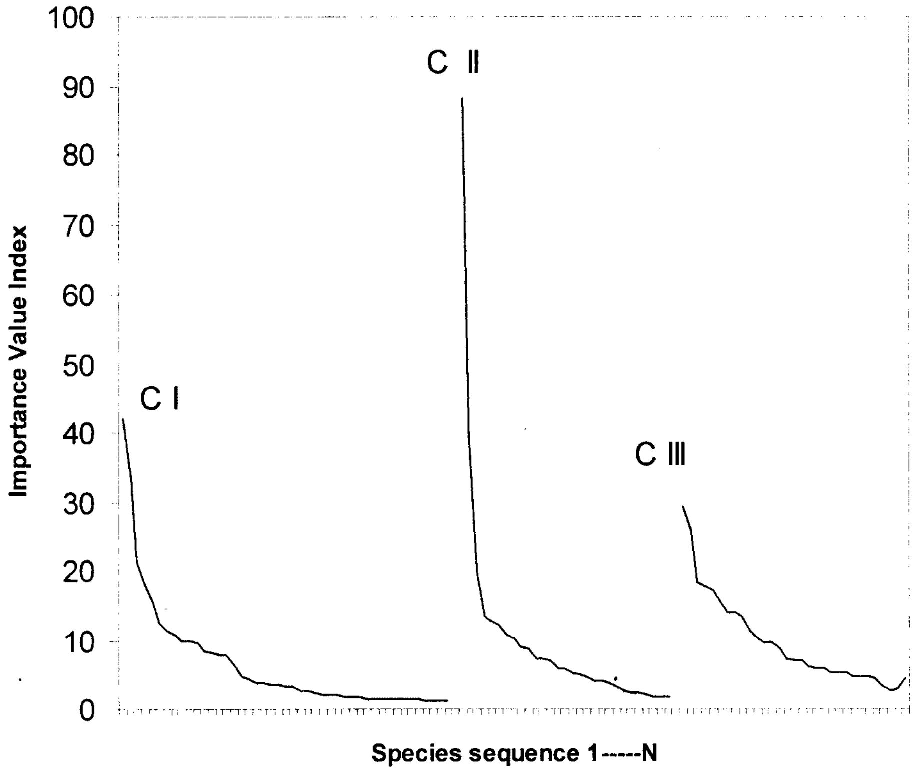
Diversity Index (H) and Concentration of dominance (CD) of trees shrubs and herbs in three plant communities in Satpura National Park.

Elevation	Communities	Trees		Shrubs		Herbs	
		H	CD	H	CD	H	CD
<900m (Lower Hills)	*Chloroxylo-Terminalia* (I)	3.62 (45)	0.057	3.85 (29)	0.036	3.53 (43)	0.038
900-1100m (Middle Hills)	*Shorea-Terminalia* (II)	2.71 (29)	0.1209	3.16 (27)	0.041	3.44 (40)	0.042
1100-1350m (Upper Hills)	*Syzygium-Terminalia* (III)	3.02 (31)	0.048	2.57 (19)	0.059	3.26 (37)	0.059

Figures in brackets denote the number of species

Species diversity is the fundamental character of plant community. It denotes the number of species in a given area. Index of tree species diversity in the three tree communities i.e. *Chloroxylon-Terminalia, Shorea-Terminalia* and *Syzygium-Terminalia* is 3.62, 2.71 and 3.02 respectively (Table 5). These values lie within the ranges reported for other tropical forest. Knight (1975) reported tree species diversity of 3.6 to 5.40 for tropical forests. High species diversity is an indication of maturity in the ecosystem (Marglef, 1963, Odum, 1969) and low species richness is

Fig. 1



Dominance-Diversity curve of tree species

I - *Chloroxylon - Terminalia* community
II - *Shorea - Terminalia* community
III - *Syzygium - Terminalia* community

result of incorporation of some species through competition. Accordingly, forest belonging to *Chloroxylon-Terminalia* community on lower hills with 3.62 tree species diversity index shows more tree species with total 45 species of trees and at the same time maturity of ecosystem. On the other hand species diveristy index is low of the order of 2.71 in *Shorea-Terminalia* community on mid hills where total 29 tree species are spread (Table 5). Dominant tree species in the community is on climatic climax stage. At the upper hill elevation range where *Syzygium-Terminalia* community has been identified, the diversity index of the tree species is 3.02 with occurrence of 31 tree species. Risser and Rice (1971) reported maximum value of diveristy index varying between 2 and 3. For mixed deciduous forests values of diversity index were higher than that in Sal forests (Singhal and Sharma, 1989).

Value of concentration of dominance in respect of tree species varies from 0.048 on upper hills to 0.1209 on middle hills and 0.057 on lower hills (Table 5). Maximum value of concentration of dominance is obtained on mid hills because *Shorea robusta* is the one single species dominating in the community of mid hills. In other two communities on upper and lower hills, the values of concentration of dominance are low which indicate that the value is shared by several species. These values are comparable to the average value of Tropical Forest presented by Knight (1975) who calculated concentration of dominance as 0.6.

Dominance-diversity curve (d-d Curve) : Dominance diversity curve was developed for species under each community separately. As illustrated in Fig. 1 under plant community *Chloroxylon-Terminalia* (<900m), *Chloroxylon swietenia* and *Terminalia tomentosa* occupied top position on dominance-diversity (d-d) curve because of their high values of IVI (42.1 and 33.3 respectively). Under plant community *Shorea-Terminalia* (900-1100m), species *Shorea robusta, Terminalia tomentosa* and *Buchanania lanzan* occupied top position because of high IVI 88.25, 39.63 and 19.77 respectively. Under plant community *Syzygium-Terminalia* at (1100-1350m), species like, *Syzygium cumini, Terminalia tomentosa, Terminalia chebula* had higher IVI like 29.24, 25.88 and 18.38 respectively and hence these species were placed much higher on d-d curve as compared to other species in this community. The lowest position on the d-d curve has been occupied by *Ougeinia oojeinensis* (1.13) and also *Kydia calycina* (1.13), *Bridelia retusa* (1.69), *Bombax ceiba* (2.68) under the communities *Chloroxylon –Terminalia, Shorea–Terminalia* and *Syzygium–Terminalis* respectively (Fig. 1, Tables 6, 7, 8)

Table 6

Density, Frequency, Total Basal Area, Abundance and Importance Value Index of trees in Chloroxylon-Terminalia community corresponding to<900 m elevation (Lower hills).

Sl. No.	Species	Density/ha	Frequency (%)	Total basal area (m^2/ha)	Abundance	A/F	Relative density (%)	Relative frequency (%)	Relative dominance (%)	IVI
1	2	3	4	5	6	7	8	9	10	11
1.	*Chloroxylon swietenia*	175.0	90	4.20	7.70	0.08	18.5	7.62	15.98	42.10
2.	*Terminalia tomentosa*	125.0	80	3.50	6.20	0.07	13.2	6.77	13.31	33.30
3.	*Buchanania lanzan*	52.5	60	2.50	3.50	0.05	5.55	5.08	9.57	20.23
4.	*Terminalia chebula*	55.0	70	0.95	3.14	0.04	5.82	5.93	3.72	15.47
5.	*Syzygium cumini*	32.5	40	1.83	3.25	0.08	3.43	3.38	6.96	13.77
6.	*Madhuca indica*	45.0	60	3.01	3.00	0.05	4..76	5.08	11.45	21.29
7.	*Lagerstroemia parviflora*	30.0	50	1.08	2.40	0.04	3.17	4.23	4.10	11.43
8.	*Shorea robusta*	27.5	40	1.19	2.75	0.06	3.00	3.38	4.52	10.80
9.	*Diospyros melanoxylon*	42.5	50	0.32	3.40	0.06	4.50	4.23	1.20	9.95
10.	*Mimusops hexandra*	32.0	40	0.78	3.20	0.08	3.43	3.38	2.96	9.77

Contd...

1	2	3	4	5	6	7	8	9	10	11
11.	*Terminalia bellirica*	30.0	40	0.79	3.00	0.07	3.17	3.38	3.00	9.55
12.	*Saccopetalum tomentosum*	22.5	40	0.66	2.25	0.05	2.38	3.38	2.51	8.27
13.	*Anogeissus latifloia*	27.5	30	0.73	3.60	0.12	3.00	2.54	2.70	8.24
14.	*Phyllanthus emblica*	30.0	40	0.33	3.00	0.07	3.17	3.38	1.25	7.80
15.	*Cassia fistula*	30.0	40	0.32	3.00	0.07	3.17	3.38	1.21	7.76
16.	*Anogeissus pendula*	20.0	30	0.44	2.30	0.07	2.11	2.54	1.67	6.32
17.	*Bauhinia retusa*	12.5	30	0.21	1.60	0.05	1.32	2.54	0.79	4.65
18.	*Miliusa tomentosa*	7.5	10	0.16	3.00	0.30	0.80	0.84	0.60	4.44
19.	*Ziziphus mauritiana*	7.5	20	0.29	1.50	0.07	0.80	1.69	1.10	3.59
20.	*Casearia tomentosa*	15.0	20	0.14	3.00	0.15	1.58	1.69	0.53	3.80
21.	*Mangifera indica*	7.5	10	0.27	3.00	0.30	0.79	0.84	1.02	2.65
22.	*Dalbergia paniculata*	10.0	20	0.22	2.00	0.05	1.05	1.60	0.83	3.50
23.	*Lannea coromandelica*	10.0	20	0.26	2.00	0.10	1.05	1.69	0.98	3.72
24.	*Butea monosperma*	10.0	20	0.12	2.00	0.10	1.05	1.69	0.45	3.19
25.	*Gardenia latifolia*	10.0	10	0.17	4.00	0.40	1.05	0.84	0.64	2.53
26.	*Aegle marmelos*	5.0	10	0.02	2.00	0.20	0.52	1.69	0.07	2.28
27.	*Cariya arboria*	7.5	20	0.20	1.50	0.07	0.20	1.69	0.76	3.25
28.	*Murraya koenigii*	7.5	10	0.11	3.00	0.30	0.80	0.84	0.41	2.05
29.	*Flacourtia indica*	5.0	10	0.17	2.00	0.20	0.52	0.84	0.64	2.00
30.	*Schleichera oleosa*	5.0	10	0.14	2.00	0.20	0.52	0.84	0.53	1.89
31.	*Haldina cardifolia*	5.0	10	0.19	2.00	0.20	0.52	0.84	0.34	1.70
32.	*Pterocarpus marsupium*	2.5	10	0.15	1.00	0.10	0.26	0.84	0.57	1.67
33.	*Mitragyna parviflora*	2.5	10	0.15	3.00	0.10	0.26	0.84	0.57	1.67
34.	*Semecarpus anacardium*	5.0	10	0.06	2.00	0.20	0.52	0.84	0.22	1.58
35.	*Acacia catechu*	5.0	20	0.06	1.00	0.10	0.52	0.84	0.22	1.58
36.	*Cochlospermum religiosum*	5.0	10	0.05	2.00	0.20	0.52	0.84	0.19	1.55
37.	*Albizia lebbek*	2.5	10	0.08	1.00	0.10	0.26	0.84	0.30	1.40
38.	*Hardwickia binata*	2.5	10	0.09	1.00	0.10	0.26	0.84	0.34	1.44
39.	*Soymida febrifuga*	2.5	10	0.09	1.00	0.10	0.26	0.84	0.34	1.44
40.	*Carisa pinnata*	2.5	10	0.07	1.00	0.10	0.26	0.84	0.26	1.36
41.	*Wrightia tinctoria*	2.5	10	0.03	1.00	0.10	0.26	0.84	0.11	1.21
42.	*Elaeodendron glaucum*	2.5	10	0.03	1.00	0.10	0.26	0.84	0.11	1.21
43.	*Ougeinia oojeinensis*	2.5	10	0.01	1.00	0.10	0.26	0.84	0.03	1.13
44.	*Kydia calycina*	2.5	10	0.01	1.00	0.10	0.26	0.84	0.03	1.13
45.	*Caseasia graviolense*	2.5	10	0.07	1.00	0.10	0.26	0.84	0.26	1.36
		944.5		26.28						

Table 7

Density, Frequency, Total Basal Area, Abundance and Importance Value Index of trees in Shorea-Terminalia community corresponding to 900-1100m elevation (Middle hills)

Sl. No.	Species	Density/ha	Frequency (%)	Total basal area (m^2/ha)	Abundance	A/F	Relative density (%)	Relative frequency (%)	Relative dominance (%)	IVI
1.	*Shorea robusta*	305.0	100	6.21	12.20	0.12	40.60	12.50	35.75	88.25
2.	*Terminalia tomentosa*	82.5	90	3.02	3.60	0.04	11.00	11.25	17.38	39.63
3.	*Buchanania lanzan*	52.5	70	0.70	3.00	0.04	7.00	8.75	4.02	19.77
4.	*Diospyros melanoxylon*	32.5	50	0.50	2.60	0.05	4.33	6.25	2.87	13.45
5.	*Madhuca indica*	17.5	30	1.14	2.30	0.70	2.33	3.75	6.57	12.65
6.	*Syzygium cumini*	22.5	40	0.75	2.25	0.05	3.00	5.00	4.31	12.13
7.	*Lagerstroemia parviflora*	20.0	40	0.51	2.00	0.05	2.66	5.00	2.93	10.59
8.	*Chloroxylon swietenia*	25.0	30	0.52	3.30	0.10	3.33	3.75	2.49	10.07
9.	*Anogeissus latifolia*	22.5	30	0.37	3.00	0.10	3.00	3.75	2.13	8.88
10.	*Casearia graveolens*	25.0	30	0.27	3.30	0.10	3.33	3.75	1.55	8.63
11.	*Bauhinia variagata*	20.0	30	0.15	2.60	0.08	2.66	3.75	0.86	7.27
12.	*Phyllanthus emblica*	17.5	30	0.19	2.30	0.07	2.30	3.75	1.09	7.19
13.	*Schleichera oleosa*	10.0	20	0.55	2.00	0.10	1.33	2.50	3.16	6.99
14.	*Cariya arboria*	10.0	20	0.34	2.00	0.10	1.33	2.50	1.95	5.78
15.	*Lannea coromandelica*	7.5	20	0.39	1.50	0.07	1.00	2.50	2.24	5.74
16.	*Cassia fistula*	15.0	20	0.13	3.00	0.20	2.00	2.50	0.74	5.24
17.	*Bombax ceiba*	5.0	20	0.33	1.00	0.10	0.66	2.50	1.89	5.05
18.	*Gardenia latifolia*	5.0	10	0.09	2.00	0.20	0.66	1.25	0.51	4.61
19.	*Pterocarpus marsupium*	5.0	20	0.18	1.00	0.05	0.66	2.50	1.03	4.19
20.	*Terminalia chebula*	12.5	10	0.18	5.00	0.50	1.66	1.25	1.03	3.94
21.	*Terminalia bellirica*	5.0	10	0.32	2.00	0.20	0.66	1.25	1.84	3.75
22.	*Casearia tomentosa*	10.0	10	0.09	4.00	0.40	1.33	1.25	0.51	3.09
23.	*Hardwickia binata*	5.0	10	0.01	2.00	0.20	0.66	1.25	0.57	2.48
24.	*Aegle marmelos*	2.5	10	0.14	1.00	0.10	0.33	1.25	0.80	2.38
25.	*Albizia odoratissima*	5.0	10	0.05	2.00	0.20	0.66	1.25	0.28	2.19
26.	*Anogeissus pendula*	2.5	10	0.06	1.00	0.10	0.33	1.25	0.34	1.92
27.	*Miliusa tomentosa*	2.5	10	0.04	1.00	0.10	0.33	1.25	0.23	1.81
28.	*Elaeodendron glaucum*	2.5	10	0.03	1.00	0.10	0.33	1.25	0.17	1.75
29.	*Bridelia retusa*	2.5	10	0.02	1.00	0.10	0.33	1.25	0.11	1.69
		750.0		17.37						

Table 8

Density, Frequency, Total Basal Area, Abundance and Importance Value Index of trees in Syzygium-Terminalia community corresponding to 1100-1350m elevation (Upper hills)

Sl. No.	Species	Density/ ha	Frequency (%)	Total basal area (m^2/ha)	Abundance	A/F	Relative density (%)	Relative frequency (%)	Relative dominance (%)	IVI
1.	*Syzygium cumini*	80.0	90	3.32	3.6	0.03	14.4	9.78	5.06	29.24
2.	*Terminalia tomentosa*	70.0	90	2.62	3.1	0.03	12.6	9.78	3.50	25.88
3.	*Terminalia chebula*	42.5	50	2.11	3.4	0.06	7.65	5.43	5.30	18.38
4.	*Mangifera indica*	27.5	50	1.87	2.2	0.04	4.95	5.43	7.27	17.65
5.	*Buchanania lanzan*	47.5	60	0.94	3.3	0.05	8.55	6.52	2.12	17.19
6.	*Anogeissus latifolia*	37.5	70	0.46	2.1	0.03	6.75	7.60	1.33	15.68
7.	*Madhuca indica*	42.5	20	1.66	3.4	0.10	7.65	2.17	4.19	14.01
8.	*Cassia fistula*	27.5	60	0.06	1.8	0.03	4.95	6.52	2.46	13.93
9.	*Albizia odoratissima*	5.0	20	0.48	1.0	0.10	0.90	2.17	10.38	13.45
10.	*Anogeissus pendula*	15.0	30	0.73	2.0	0.06	2.70	3.26	5.26	11.22
11.	*Mimusops hexendra*	27.5	30	0.51	3.6	0.12	4.95	3.26	1.99	10.20
12.	*Saccopetalum tomentosum*	15.0	50	0.50	1.2	0.02	2.70	5.43	1.42	9.55
13.	*Cariya arboria*	5.0	20	0.29	1.0	0.10	0.90	2.17	6.38	9.45
14.	*Bauhinia retusa*	25.0	30	0.20	3.3	0.11	4.50	3.26	0.85	8.61
15.	*Semecarpus anacardium*	15.0	10	0.01	6.0	0.60	2.70	1.08	3.46	7.24
16.	*Kydia calycina*	7.5	30	0.01	1.0	0.03	1.35	3.26	2.36	6.97
17.	*Sterculia urens*	2.5	10	0.08	1.0	0.10	0.45	1.08	5.39	6.92
18.	*Elaeodendron glaucam*	10.0	30	0.10	1.3	0.04	1.80	3.26	1.09	6.15
19.	*Lagerstroemia parviflora*	10.0	20	0.17	2.0	0.10	1.80	2.17	1.83	5.80
20.	*Phyllanthus emblica*	10.0	20	0.01	2.0	0.10	1.80	2.17	1.70	5.67
21.	*Dalbergia paniculata*	2.5	10	0.20	1.0	0.10	0.45	1.08	3.56	5.09
22.	*Ougeinia oojeinensis*	2.5	10	0.08	1.0	0.10	0.45	1.08	3.56	5.09
23.	*Haldina cardifolia*	2.5	10	0.08	1.0	0.10	0.45	1.08	3.56	5.09
24.	*Casearia graveolens*	2.5	10	0.07	1.0	0.10	0.45	1.08	3.24	4.77
25.	*Diospyros melanoxylon*	2.5	10	0.07	1.0	0.10	0.45	1.08	3.03	4.56
26.	*Ficus hispida*	2.5	10	0.07	1.0	0.10	0.45	1.08	3.03	4.56
27.	*Schleichera oleosa*	5.0	20	0.06	1.0	0.10	0.90	2.17	1.31	4.38
28.	*Ceriscoides latifolia*	2.5	10	0.03	1.0	0.10	0.45	2.08	1.55	3.08
29.	*Bombax ceiba*	2.5	10	0.02	1.0	0.10	0.45	1.08	1.15	2.68
30.	*Casearia tomentosa*	2.5	10	0.03	1.0	0.10	0.45	1.08	1.34	2.87
31.	*Litsea glutinosa*	5.0	20	0.05	1.0	0.10	0.90	2.17	1.18	4.25
		555.0		16.96						

Conclusion

In view of the above observations it may concluded that three major communities were identified at three elevations along with shrubs and herbs communities. There was decrease in density with increasing altitude. On the basis of basal area and density *Shorea robusta* prefers the mid hills at 900-1100 m, *Chloroxylon swietenia* performs better at lower hills (<900 m) and *Syzygium cumini* preferred to grow in the upper hills (1100-1350m elevation). Distribution pattern of species were contiguous and diversity index was higher in lower elevation. Based on the finding of the present study the management of this National Park should be aimed at elimination of all forms of human exploitation and biotic disturbance by developing the core and buffer zone concept. Improvement should be made in physical and biological parameters of habitats in the park, to increase the availability of resources to wildlife. Existing grasslands are a few in number and small in size to accommodate variety of wildlife. Therefore, it is necessary to improve the productivity of grasslands with reseeding and management. Deferred or rotational grazing system should be practiced.

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SUMMARY

Three major tree communities were identified in the Satpura National Park, Madhya Pradesh i.e. *Chloroxylon-Terminalia* community at elevation range <900m (Lower hills). *Shorea - Terminalia* community at 900-1100m elevation (Middle hills). *Syzygium- Terminalia* community at 1100-1350m elevation (Upper hills). There was decrease in density with increasing altitude. On the basis of basal area and density *Shorea robusta* preferred the mid hills, *Chloroxylon swietenia* performed better at lower hills and *Syzygium cumini* preferred to grow in upper hills. The distribution pattern of species is contiguous. Diversity index of tree species in three plant communities i.e. *Chloroxylon-Terminalia, Shorea-Terminalia* and *Syzygium-Terminalia* was 3.62, 2.71 and 3.02 respectively. High species diversity is an indication of maturity in the ecosystem. The tree species richness was 45, 29 and 31 at <900m, 900-1100 m and 1100-1350 m elevation respectively. Forest belonging to *Chloroxylon-Terminalia* is biodiversity rich area because of more number of species. There are 29 shrub species under *Chloroxylon-Terminalia,* community followed by 27 shrub species under *Shorea-Terminalia* community and only 19 shrub species under *Syzygium-Terminalia* community. In corresponds to species diversity index of 3.85, 3.16 and 2.57 respectively. Diversity index of herbs in these communities was 3.53, 3.44 and 3.26 respectively, which corresponds to herb species richness in term of individual members of 43, 40 and 37.

सतपुड़ा राष्ट्रीय उपवन की वनस्पतियों के संरचनात्मक गठन में ऊंचाईयों के अनुसार विभिन्नता

पी०के० खत्री, एन०जी० तोते व आर०के० पाण्डेय

सारांश

सतपुड़ा राष्ट्रीय उपवन मध्य प्रदेश में तीन मुख्य वृक्ष समुदायों अर्थात्, *क्लोरोक्सीलन - टर्मिनेलिया* समुदाय < 900 मी० ऊंचाईयों वाले क्षेत्र (निम्न पहाड़ियों) में, *शोरिया - टर्मिनेलिया* समुदाय 900 - 1100 मी0 की ऊंचाईयो पर (मध्यम

पहाडियों में), *सायजीगियम-टर्मिनेलिया* समुदाय 1100-1350 मी॰ की ऊंचाईयों पर (ऊपर की पहाड़ियों में), को मिलते पहचाना गया। ऊंचाई बढ़ने के साथ वृक्ष धनत्व कम होता गया। आधारिक क्षेत्रफल और घनत्व की दृष्टि से *शोरिया रोबस्टा* को मध्यम पहाड़ियों, *क्लोरोक्सीलन स्वीटेनिया* को निम्न पहाड़ियों और *सायजीगियम क्यूमिनाई* को ऊपर की ऊंची पहाड़ियों पर ज्यादा अच्छी सक्रियता से बढ़ते हुए पाया गया। इन जातियों के वितरण की रूपसज्जा सांसर्गिक है। इस तीन वृक्ष समुदायों अर्थात् *क्लोरोक्सीलन-टर्मिनेलिया, शोरिया टर्मिनिलिया* और *सायजीगियम-टर्मिनेलिया* में वृक्ष जातियों का विविधता निर्देशांक क्रमश: 3.62, 2.71 और 3.02 है। जातिगत उच्च विविधता परिस्थिति संहति की पौढता की सूचक है। वृक्ष जाति सम्पन्नता < 900 मी॰, 900-1100 मी॰ और 1100-1350 मी॰ की ऊंचाईयों में क्रमश: 45, 29 और 31 रहती पाई गई। *क्लोरोक्सीलन-टर्मिनेलिया* वाला वन जैवविविधता की दृष्टि से सम्पन्न क्षेत्र है, क्योंकि इसमें ज्यादा जातियां पाई जाती हैं। *क्लोरोक्सीलन-टर्मिनेलिया* समुदाय में 29 क्षुप जातियां मिलती है जिसके पश्चात् क्रम में *शोरिया-टर्मिनेलिया* समुदाय आता है जिसमें 27 क्षुप जातियां मिलती हैं तथा *सायजीगियम-टर्मिनेलिया* समुदाय में केवल 19 क्षुप जातियां ही मिलती हैं जो इसकी जाति विविधता के निर्देशांकों 3.85, 3.16 और 2.57 से भी क्रमश: मेल खाता है। इन समुदायों में शाकों की विविधता क्रमश: 3.53, 3.44 और 3.26 है जो व्यष्टिगत सदस्यों की संख्या 43, 40 और 37 की दृष्टि से शाक जातियों की सम्पन्नता से मेल खाती है।

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