CHAPTER 4

HABITAT STUDIES

4.1 Introduction

Habitat use by a species is affected by its density, densities of and interactions with other species, availability and abundance of resources and various other biotic and abiotic factors (Block and Brennan 1993). Role of habitat selection in speciation and adaptive radiation was developed by Lack (1940, 1944). He emphasised the importance of habitat segregation in closely related species and of habitat diversity in the multiplication of congeneric species. In closely related species like the Tragopan pheasants with continuous distribution perhaps habitat plays an important role in segregating sympatric populations.

There have been some habitat studies of the Ring-necked Pheasant in England and America (Hill and Robertson 1988a). Among the Tragopan pheasants, habitat studies on the Western Tragopan, Cabot's Tragopan and the Temminck's Tragopan have recieved fair amount of attention (Islam and Crawford 1987, Young *et al.* 1991, Bland and Han Xian1992, Ding Chang Qing and Zheng Guang-mei 1992, Shi Hai Tao *et al.* 1996). In India a detailed single species work has been performed on the Cheer Pheasant (Kaul 1989), Himalayan Monal Pheasant (Sharma 1990, Kumar 1997), and the White-crested Kaleej Pheasant (Iqbal 1992, Ahmed 1994).

Perusal of literature on the habitat of Satyr Tragopan served no more than to establish the fact that it was a forest bird. No quantitative information on habitat use so critical for the conservation of this rare and threatened species was available.

Satyr Tragopan is essentially a forest inhabiting species rarely wandering up towards the snow or into the open. Though the species is known to remain in the outskirts rather than the deeper recesses of the woods it seldom voluntarily leaves the cover of its habitat (Hume and Marshall 1879). Beebe (1918-22) considered the species to be a thorough forest bird, which kept to thick cover and was found in ringal hillsides. The ruggedness of its habitat can be judged by the description of Beebe (1918-22) - "the narrow side gorges etched out of the slopes by tiny unchartered streams" while Lelliot and Yonzon (1980) observed them on ridge tops rather than the steep bamboo covered slopes. Inglis (1930) observed the bird in impenetrable cover of ringal bamboo and Gaston (1980) described the habitat as dense cover with well developed understorey.

4.2 Methodology

Sites where Satyr Tragopan were encountered were marked and considered a bird site. Various parameters of the habitat were measured at this site.

I sampled the tree density according to 10 trees sampling method. I used only 5 trees because the distribution of trees was homogenous and counting 10 trees took a much longer time. In this method of sampling habitat variables, the size of the sampling plot is governed by the density of trees. Thus in areas where the trees are widely spread, 10 trees may occupy an area or plot which may not represent the true microhabitat of the Satyr Tragopan. At each sampling point, the species and ther distance of the 5th and 6th trees from the sampling point were measured to obtain the size of the sampling plot. Tree cover variables were measured inside this plot of 5 trees. Within this a 3m x 3m quadrat was laid for measuring the understorey characteristics while two 1m x 1m quadrats were laid inside each 3 m x 3 m sampling quadrat to measure the ground cover characteristics. The habitat variables measured by this method in each sampling point are given in Table 4.1

The vegetation characteristics were defined before being measured . These were:
Trees: Were defined as those plants with woody stems greater than 5 m in height and greater than 30 cm in g.b.h.

Shrubs: Were defined as those woody stemmed plants with 1- 5 m height and less than 30 cm g.b.h.

Ground cover: Were defined as those annual or perennial plants less than 1m height.

Around each bird site four random plots or non-bird plots were laid for comparison with the bird plot. The locations of these plots was determined by four compass bearings (north,south,east and west) and their distance (paces) from the animal site by generating random numbers from 1 to 100.

Table 4.1: Showing the various habitat parameters measured in habitat studies

Variable	Definition	Measurements
Altitude (alt)	Height of sample site above m.s.l.	Altimeter (m)
Slope (sl)	Steepness of slope	In degrees by Abney's compass
Aspect (asp)	Direction faced by the slope	Directional compass
Topography (topo)	General features of sampling site	Descriptive
Snow cover (snc)	% of snow cover within the sampling plot	Occular estimation
Snow cover depth (snd)	Depth of snow covering the plot area	Measuring scale in cm
Canopy cover (cc)	% tree cover within the sampling site	Occular measurement using a pipe of 1.5cm diameter and 18cm length. 5 occular measurements in four directions
Canopy height (ch)	Height from the ground to inner canopy cover	Occular estimation in metres
Shrub cover (sc)	% shrub cover within the sampling site	Occular estimation
Shrub cover height (sh)	Height from ground cover of understorey	Measuring tape in metres
Ground cover (gc)	% ground cover	Occular estimation
Ground cover height (gh)	Height of ground cover	Measuring scale in cm.

Analysis: To determine the area of the sampling plot for obtaining density measurements of trees, the mean of the distance between the 5th and the 6th tree was considered as the radius of the sampling plot ($r = d_1 + d_2/2$, where r = radius and d_1 = distance to 5th and d_2 = 6th trees in metres). Density of trees (td) was calculated in the following way:

Area occupied by 5 trees = πr^2

Area occupied by 1 tree = $\pi r^2/5 = x$

Therefore the density (trees/hectare) = 10,000/x

As shrub and ground cover were measured in quadrats of fixed dimensions shrub density (sd) and ground density (gd) were calculated by number of plants/m^2. The identity of the trees, shrubs and ground cover vegetation and their number were used to calculate the species diversity and species richness. Tree species diversity (tsd), shrub species diversity (ssd) and ground cover species diversity (gsd) were measured by the Shannon-Wiener's diversity index ($H' = -\Sigma$ pi log pi, where pi is the proportion of the ith species in the sample). Tree species richness (tsr), shrub species richness (ssr) and ground cover species richness (gsr) were measured by the Margalef's Species Richness Index (RI = s-l/(ln N) where s is the number of species in a sample and N is the total number of individuals in a sample. Both the indices were calculated by using the software package "Ecopack".

Habitat and community studies are multidimensional in nature and it is desirable to use multivariate statistical procedures to identify variables that may be useful in assessing habitat (Rextad *et al.* 1988). For analysis of Satyr Tragopan habitat variables, I used Principal Component Analysis (PCA). This method of analysis identifies variables that account for maximum variation in a data set and produces a smaller number of uncorrelated variables that are the linear functions of original variables (Bhattacharyya 1981, Seber 1984:176-203). To identify discriminating variables between the animal plots and random plots I used Discriminant Function Analysis (DFA). This procedure is used to develop linear models of variance that maximise the separation of groups and classify additional observations (Williams 1981). DFA generates a discriminant function(s) based on linear combinations of predictor variables, which provide the best discrimination between the groups. To calculate the avoidance and preference of broad habitat types of the study area I generated Bonferroni confidence intervals (Neu *et al.* 1974 and Byers *et al.* 1984). The computer programme PREFER (Prasad and Gupta 1992) was used to calculate these confidence intervals. Parametric one way ANOVA and Mann Whitney U tests were used for other comparisons while Pearson Correlation Coefficient was used for calculating the relationship between different variables. All proportional data were arcsine transformed while the others were log transformed to obtain normal by distributed data sets amenable to multivariate analysis.

4.3 Results

4.3.1: Macrohabitat: Broadly, five habitat types were available to the Satyr Tragopan in the Singhalila National Park. The type and their proportions (in parenthesis) were wet temperate or mixed oak forests (0.481), pure conifer or subalpine forests (0.126), mixed conifer forests (0.119), pure bamboo patches (0.231) and plantation forests (0.04). Generally in this method utilisation of a certain habitat type is quantified by the number of separate sightings in that habitat. In my studies on the Satyr Tragopan direct sightings of the bird ~~was low,~~ were scarce therefore I also took into consideration the number of faecal droppings collected from different habitats along with direct sightings to quantify availability-utilisation.

4.3.1.1 Pre-monsoon season: During this season 50 evidences (direct and indirect) were obtained for vegetation sampling of the Satyr Tragopan habitat. The species seemed to significantly prefer mixed oak forests while it significantly avoided pure conifer or subalpine forests indicating their dispersal in lower altitudes of the study area (Table 4.2).

Table 4.2: Availability-utilisation of different vegetation types by Satyr Tragopan during pre-monsoon season

Habitat type	Relative Area (ha)	Expected usage	Observed usage	Confidence intervals
Oak forests	0.481	24.05	39	0.629-0.931**
Pure conifer forest	0.126	6.3	0	0.000-0.000
Mixed conifer forests	0.119	5.95	4	0.000-0.179*
Pure bamboo patches	0.231	11.55	6	0.001-0.239
Plantation forests	0.040	2.00	1	0.000-0.071

** = used more than available, * = used less than available, rest not significant at p = 0 .05

4.31.2 Monsoon season: During this season 26 animal plots were located based on direct and indirect evidences of Satyr Tragopan. The species used pure bamboo patches more significantly in proportion to their availability while mixed conifer and plantation forests were used significantly less in proportion to their availability (Table 4.3).

Table 4.3: Availability and utilisation of different habitat types by Satyr Tragopan during the monsoon season.

Habitat type	Relative area (ha)	Expected usage	Observed usage	Confidence intervals
Oak forests	0.481	12.51	17	0.467-0.840
Pure conifer forest	0.126	3.28	1	0.000-0.114
Mixed conifer forest	0.119	3.09	0	0.000-0.000*
Pure bamboo patches	0.231	6.01	8	0.127-0.489**
Plantation forest	0.040	1.04	0	0.000-0.000*

** = used more than available, * = used less than available, rest not significant at p = 0.05.

4.3.1.3 Post-monsoon season: 30 plots were located for habitat sampling studies during this season. From the dispersion of these animal plots in the different habitat types of the study area it seemed that the Satyr Tragopan used oak forests significantly more in proportion to their availability while plantation and mixed conifer forests were used significantly less in proportion to their availability (Table 4.4).

Table 4.4: Availability and utilisation of different habitat types by Satyr Tragopan during the post-monsoon season.

Habitat type	Relative Area (ha)	Expected usage	Observed usage	Confidence intervals
Oak forests	0.481	14.43	20	0.495-0.889**
Pure conifer forest	0.126	3.78	4	0.009-0.257
Mixed conifer forest	0.119	3.57	1	0.000-0.099
Pure bamboo patches	0.231	6.93	5	0.031-0.303*
Plantation forest	0.040	1.20	0	0.000-0.000*

** = used more than available, * = used less than available, rest not significant at p = 0.05.

4.3.2. Microhabitat

4.3.2.1 Premonsoon season

4.3.2.1.1 General microhabitat: From the pre-monsoon season general habitat data PCA extracted 4 factors which cumulatively accounted for 64.523% of variance in the habitat variables. Factor 1 and Factor 2 explained 37.9% variance (19.28% and 18.62%) while Factor 3 explained 15.89% and Factor 4 explained 11.23%.

In Factor 1 there were high positive loadings for ground cover variables (henceforth ground cover factor) and this Factor apparently represented open areas with abundant herb cover as ground cover was negatively correlated with canopy cover ($r = -.208$, $n = 197$, $p = .001$) and shrub cover ($r = -.200$, $n=197$, $p = .001$). Factor 2 showed high loadings for shrub cover (henceforth shrub factor) and this probably reflected areas with tall and dense shrub cover which is most likely to be ringal (*Arundinaria maling*), with sparse ground cover. Factor 3 represented steeply sloping areas (slope factor) with good tree cover (henceforth tree factor) ($r = .160$, $n= 197$, $p= .05$) (Table 4.5).

Table 4.5: Showing four extracted factors and factor loadings (>.50) of random plots in pre-monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover			.761	
Canopy height				.529
Tree density			.744	
Shrub cover		.923		
Shrub height		.921		
Shrub density				
Shrub diversity				.701
Ground cover	.819			
Ground cover height	.603			
Ground cover density	.841			
Ground cover diversity	.673			
Steepness of slope			.572	
Variance explained	**19.28%**	**18.62%**	**15.39%**	**11.23%**

Thus it seems that during the pre-monsoon season the general habitat available to the Satyr Tragopan were equally represented by areas with good ground or scrub cover as well as with dense and tall vegetation at the understorey level while wooded areas with tree cover were poorly represented (Figure 4.1).

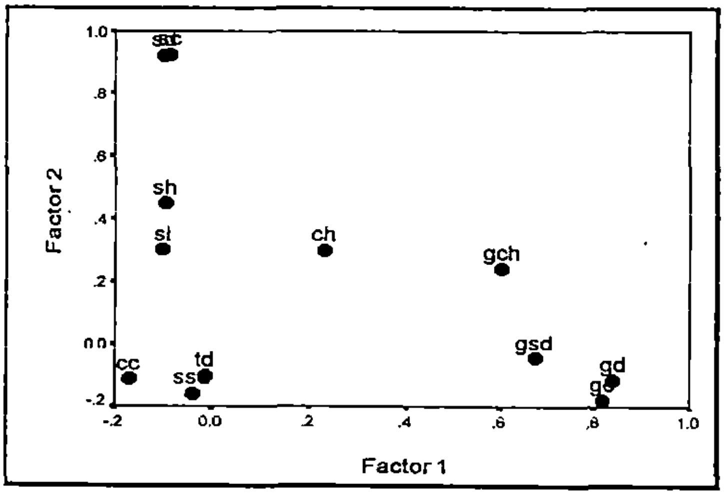


Fig 4.1. Factor Plot in rotated space of habitat variables of random plots. (pre-monsoon season)

4.3.2.1.2 Utilised habitat : PCA extracted four factors from the original animal centered habitat data set for the pre-monsoon season. These together accounted for 73.7 % of variance. Heavy positive loadings (>.5) were obtained for shrub factor and ground cover height in Factor 1. Ground cover factor was heavily loaded in Factor 2 and tree factor was had high loadings in Factor 3. (Table 4.6).

Table 4.6: Showing the four extracted factors and the factor loadings (>.5) of habitat variables for animal plots of Pre-monsoon season

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover			.794	
Canopy height			.815	
Tree density			.712	
Shrub cover	.916			
Shrub height	.852			
Shrub density	.888			
Shrub diversity				.923
Ground cover		.770		
Ground cover height	.525	.559		
Ground cover density		.749		
Ground cover diversity				
Steepness of slope				
Variance explained	**26.46%**	**19.13%**	**18.58%**	**9.53%**

Here Factor 1 seemed to reflect areas with abundant shrub or bamboo cover with sparse ($r= -.399$, $n= 50$, $p = .001$) but tall herb cover ($r = .346$, $n = 50$, $p = .05$) at the ground level. Factor 2 apparently represented areas having dense ground vegetation, a characteristic of open areas ($r = .299$, $n =50$, $p = .05$), while Factor 3 apparently represented wooded areas ($r = .514$, $n = 50$, $p = .001$). The Satyr Tragopan during this season seemed to be associated with vegetation prevalent at the understorey and ground level rather than wooded areas (Fig 4.2).

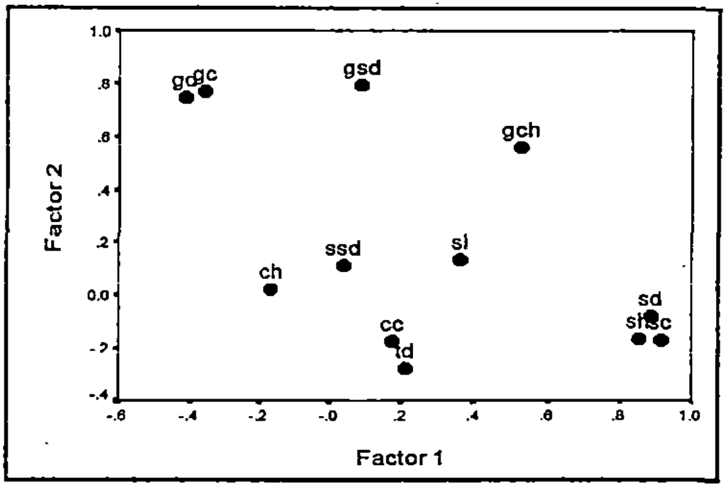


Fig.4.2 Factor Plot in rotated space showing habitat variables of animal plots. (pre-monsoon season)

4.3.2.1.3 Available and Utilised habitat: To assess the difference between animal and random plots 12 of the 17 habitat variables which were measured were included in the stepwise DFA. In discriminant function 1 shrub cover and slope were the variables which differed significantly between the animal and random plots (λ = .944, d.f. = 2, p = .001) and this function correctly classified 80.6% of the cases in the pre-monsoon data set (Table 4.7).

Table 4.7 Habitat variables discriminated by DFA showing standardised discriminant function coefficients (DFC) between animal plots (n= 50) and random plots (n= 197) of pre-monsoon season

Variables	DFC	Correlation coefficient	Animal Plots $\bar{x}$ (s.e.)	Random Plots $\bar{x}$ (s.e.)	F	p
Shrub cover	.695	.828	20.86 (±2.73)	31.62 (±1.69)	10.037	.002
Steepness of slope	.577	.737	31.54 (±1.78)	34.67 (±.667)	7.988	.005

According to this analysis the animal plots were characterised by low shrub cover and less steep ground as compared to the random plots.

PCA of all the habitat plots (animal and random plots combined) of the pre-monsoon season extracted 4 factors which together explained 64.78% of the variance (Factor 1 = 19.83%, Factor 2 = 19.32, Factor 3 = 16.44% and Factor 4 = 9.18%). In Factor 1 high positive loadings were obtained for shrub cover variables, in Factor 2 ground cover variables had high loadings while tree cover variables and slope were highly loaded on Factor 3. Factor Plot of animal and random plots were plotted against the scores of Factor 1 and 2 and this showed that both the types of plots were clumped together and there were no distinct separation between the animal and random plots (Fig 4.3).

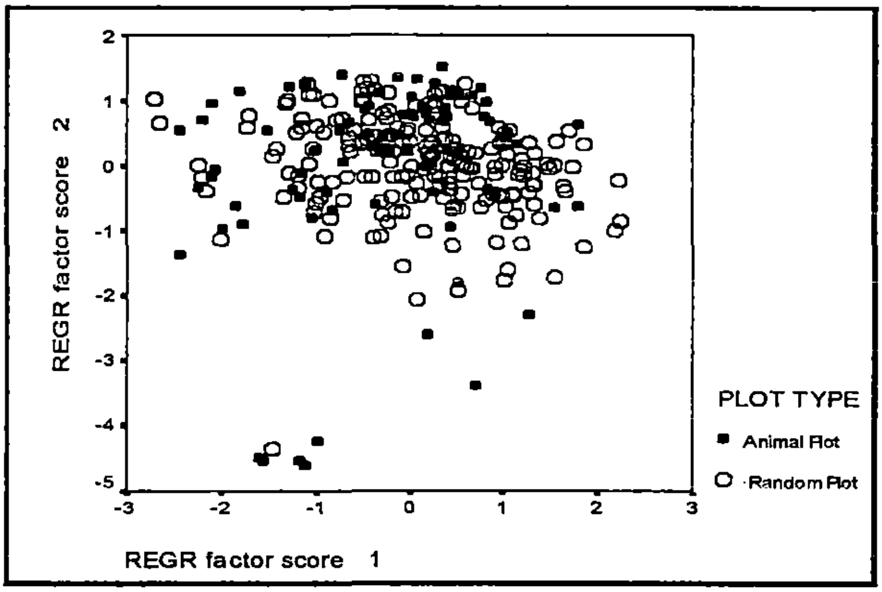


Fig. 4.3 Regression Factor Score Plot of animal and random plots of pre-monsoon season

4.3.2.2 Monsoon season

4.3.2.2.1 Available habitat: PCA extracted four factors from the general habitat of the monsoon season which explained 73% of the total variation with 25.6%, 20%,17.76% and 10.2% explained by Factors 1,2,3 and 4 respectively. Tree factor had high positive loadings in Factor 1 while ground cover factor had negative loadings. Factor 2 had high loadings for shrub factor while ground cover factor and slope were heavily loaded in Factor 3 (Table 4.8).

Table 4.8: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover	.882			
Canopy height	.835			
Tree density	.875			
Shrub cover		.914		
Shrub density		.885		
Shrub height		.676		
Shrub diversity			.824	
Ground cover	-.588		.566	
Ground cover height			.558	
Ground cover density	-.579			
Ground cover diversity			.727	
Steepness of slope				.918
Variance explained	**25.6%**	**20%**	**17.76%**	**10.2%**

Factor 1 apparently represented densely wooded areas with bare ground ($r = -.313$, $n = 99$, $p = .001$) while Factor 2 represented areas with dense shrub vegetation and sparse ground cover ($-.171$, $n = 97$, $p = .05$) (Fig 4.4).

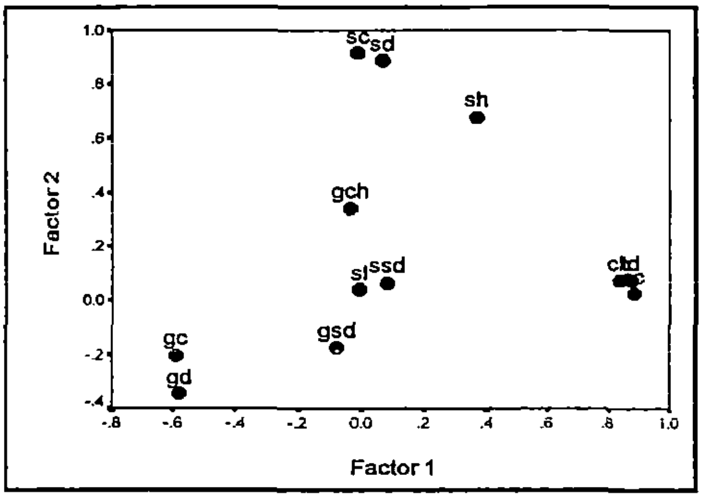


Fig. 4.4 Factor plot in rotated space of habitat variables of random plots (monsoon season)

4.3.2.2.2 Utilised Habitat: PCA extracted 4 factors which together explained 73.4 % of variance in the monsoon habitat of the Satyr Tragopan. High factor loadings were obtained for the tree factor in Factor 1 while in Factor 2 the shrub factor obtained high loadings. ($r = -.142$, $n = 26$, n.s.) (Table 4.9).

Table 4.9: Showing the extracted factors and the factor loadings (>.5) of habitat variables for animal plots of monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover	.858			
Canopy height	.785			
Tree density	.767			
Shrub cover		.942		
Shrub density		.857		
Shrub height		.798		
Shrub diversity	.507			
Ground cover	-.664			
Ground cover height				.773
Ground cover density			.825	
Ground cover diversity			.933	
Steepness of slope				.764
Variance explained	**25.2%**	**20%**	**14.18%**	**12.14%**

The ground cover factor had negative component loading in Factor 1 which probably indicated that during the monsoon season the Satyr Tragopan habitat consisted of areas with dense woodland (Factor 1) with bare ground ($r = -.577$, $n= 26$, $p = .001$) or dense shrubland (Factor 2) (Fig. 4.5)

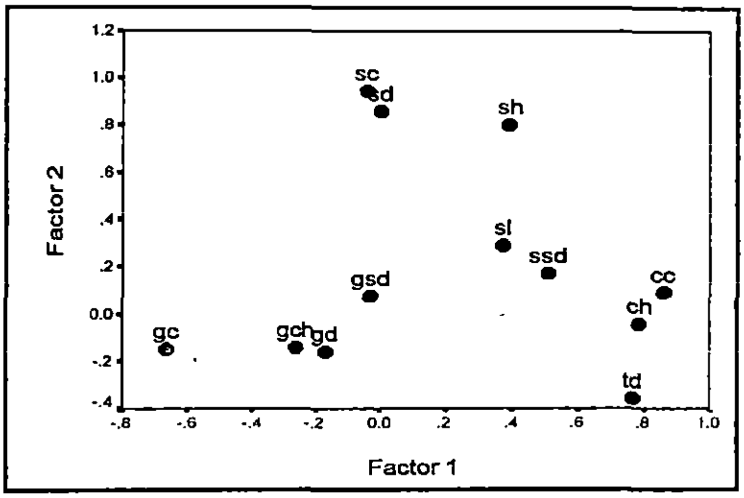


Fig. 4.5. Factor Plot in rotated space of habitat variables of animal plots (Monsoon season)

4.3.2.2.3 Available and utilised habitat: From the monsoon habitat data DFA extracted canopy cover, ground cover density, shrub cover density and shrub species diversity as the variables that discriminated significantly between animal and random plots ($\lambda = .562$, d.f = 4, $p = .000$). DFA had an efficiency of 88 % in correctly classifying the animal and random plots during the monsoon season (Fig. 4.6). Cover at the tree level and density of vegetation at the understorey and ground level were the main variables that separated the animal and random plots (Table 4.10). The Satyr Tragopan seemed to be associated more with lower canopy cover, lower ground cover density and lower shrub cover density in its monsoon habitat than compared to its surrounding habitat.

Table 4.10: Habitat variables discriminated by stepwise DFA showing the Discriminant Function Coefficient (DFC) on discriminant function 1 between animal plots (n= 26) and random plots (n= 99) with F values of extracted variables (Monsoon season).

Variables	DFC	Correlation coefficient	Animal Plots $\bar{x}$ (s.e.)	Random Plots $\bar{x}$(s.e)	$F_{1,124}$	p
Canopy cover	.785	.289	20.85(±4.2)	33.27(±2.10)	7.99	.005
Ground cover density	1.063	.366	46.63(±11.70)	125.87(±25.20)	12.82	.000
Shrub cover density	.769	.478	.6333(±.2370)	1.91(±.1722)	21.91	.000
Shrub cover diversity	-.285	-.057	.292(±.176)	.161(±.017)	.32	.569

PCA extracted 4 factors from the animal and random plots of the monsoon season which cumulatively explained 69.6% of variance (Factor 1 22.6%, Factor 2 20%, Factor 3 16.87% and Factor 4 10%). In Factor 1 high positive loadings were obtained for tree factor and negative loading for ground cover. In Factor 2 shrub factor obtained high loadings while in Factor 3 high loadings were obtained for ground cover factor. Regression Factor score plot were constructed by plotting the animal and random against Factor 1 and 2 scores. This showed separation between animal and random plots during monsoon season. The animal plots were negatively associated with Factor 2 i.e. with shrub factor whereas the random plots were scattered all over the rotated factor space (Fig 4.6).

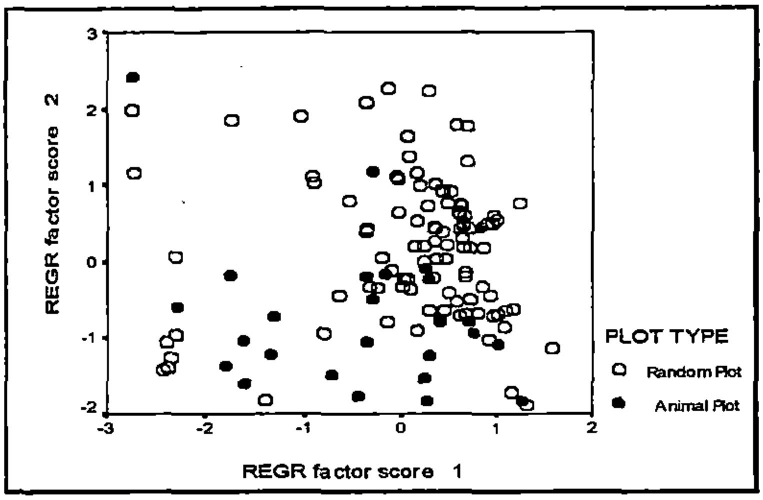


Fig 4.6. Regression Factor Score Plot of animal and random plots of the monsoon season

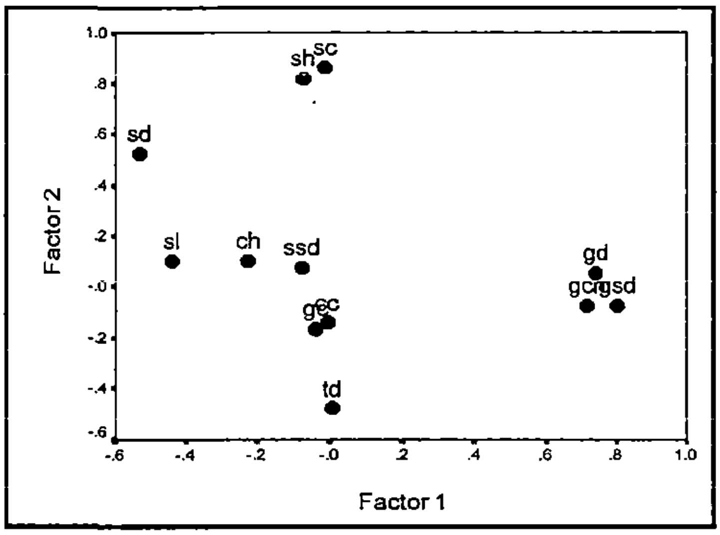
4.3.2.3 Post-monsoon season

4.3.2.3.1 Available habitat: PCA extracted 5 factors which together explained approximately 70% of the variance in the available habitat during the post-monsoon season. High loadings were obtained for ground cover factor in Factor 1 and shrub factor in Factor 2 (Table 4.11).

Table 4.11: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of post-monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Canopy cover			.861		
Canopy height			.797		
Tree density					
Shrub cover		.862			
Shrub density		.525			
Shrub height		.818			
Shrub diversity					.916
Ground cover					
Ground cover height	.716			-.838	
Ground cover density	.742				
Ground cover diversity	.806				
Steepness of slope				.606	
Variance explained	**18.7%**	**16.72%**	**13.78**	**11.5**	**9.2**

Factor 1 apparently represented open areas with abundant ground cover which was expected in this very moist and wet season prevalent in the study area. The ground cover variables though negatively correlated to the canopy variables were statistically insignificant due to their low values and therefore inconclusive. However Factor 1 seemed to represent sparse vegetation at the understorey level (-.239, n = 96, p = .001). Factor 2 represented areas with dense vegetation at the understorey level and sparse vegetation at the canopy and ground cover level (r= -.235, n= 96, p = .001) (Fig 4.7)



4.7

Fig. 4.7 Factor plot in rotated space of habitat variables of random plots (Post-monsoon season)

4.3.2.3.2 Utilised Habitat: Four factors were extracted out of the animal plots which cumulatively explained 72.42% variance. Factor loadings were high for canopy cover, shrub factor and negatively high for ground cover height and diversity in Factor 1. Factor 2 had high loadings for canopy cover, ground cover, shrub height and slope (Table 4.12).

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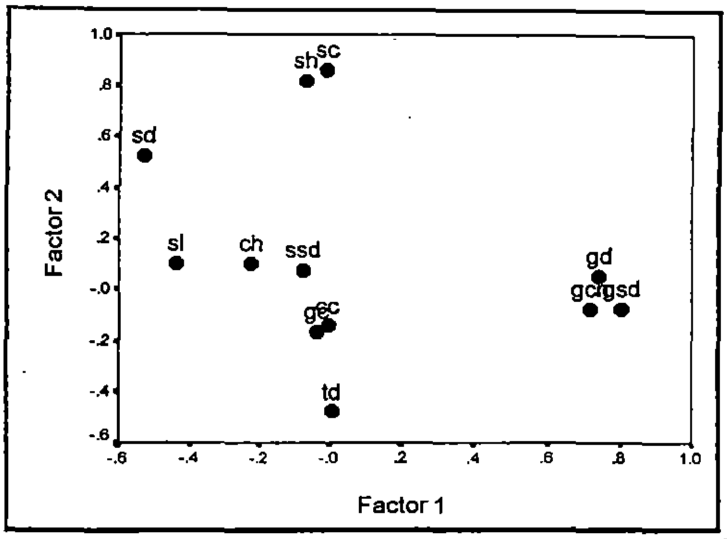

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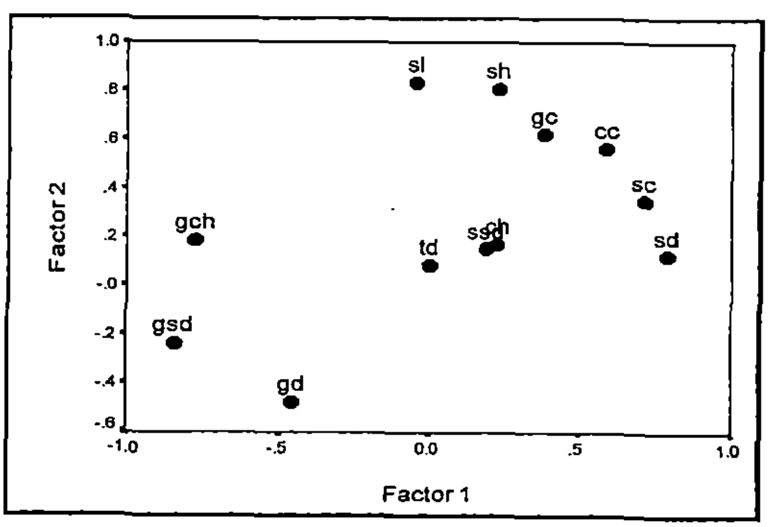
Table 4.12: Showing the extracted factors and the factor loadings (>.5) of habitat variables for animal plots of post-monsoon season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover	.590	.568		
Canopy height				.786
Tree density			-.918	
Shrub cover	.716			
Shrub density	.792	.809		
Shrub height				
Shrub diversity				-.785
Ground cover				
Ground cover height	-.778	.624		
Ground cover density				
Ground cover diversity	-.839			
Steepness of slope		.832		
Variance explained	**27.5%**	**21.48%**	**11.97%**	**11.43%**

Factor 1 seemed to reflect wooded areas with dense understorey vegetation and therefore sparse ground level vegetation ($r = -.373$, $n = 30$, $p = .05$). Factor 2 represented well wooded steep areas with tall understorey and dense ground cover (Fig 4.8).



4.8

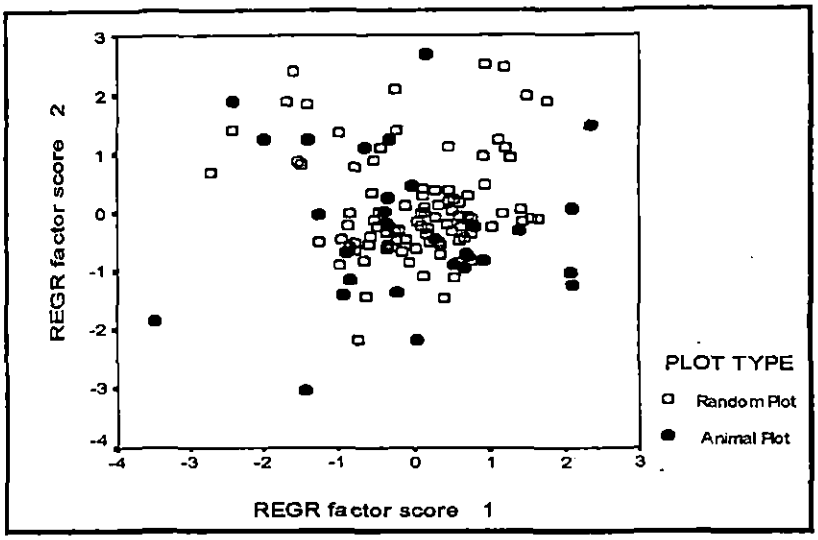
Fig 4.8 Factor Plot in rotated space of habitat variables of animal plots Post-monsoon season

4.3.2.3.3 Available and Utilised habitat: In Stepwise DFA the discriminant function 1 separated out canopy cover, ground cover height, shrub cover, shrub density and slope as discriminating variables from the post-monsoon habitat of Satyr Tragopan (λ= .735, d.f. = 5, p = .000). DFA had an efficiency of 83.3% in correctly classifying the animal and random plots of the post-monsoon season. Canopy cover, shrub cover and steepness of slope were the most important discriminating variables between the two plots. Moreover Satyr Tragopan was associated with low canopy cover, gentler slopes and more shrub cover during this season (Table 4.13).

Table 4.13 Habitat variables discriminated by DFA showing standardised discriminant function coefficients(DFC) between animal plots(n=30) and random plots(n=96) of post-monsoon season.

Variables	DFC	Correlation coefficient	Animal Plots $\bar{x}$ (s.e.)	Random Plots $\bar{x}$ (s.e)	$F_{1,125}$	p
Canopy cover	.509	.467	18.23(± 2.15)	21.11(± .97)	9.74	.002
Ground cover height	.563	.318	10.15(± 1.15)	11.41(± .49)	1.34	.248
Shrub cover	-.708	-.263	32.6(±5.08)	19.67(±1.37)	11.97	.001
Shrub density	.696	.271	2.99(±.582)	3.64(±.317)	1.01	.316
Steepness of slope	.473	.441	31.97(±1.90)	36.53(±.823)	6.32	.013

PCA extracted 5 factors from the animal-random plot matrix which cumulatively explained 67.87% of variance in habitat variables. Factor 1 and 2 accounted for an almost equal percentage of variance (16.77% and 16.72% respectively). The other factors explained less than 15% of variance individually (Factor 3 = 14.39%, Factor 4 = 10% and Factor 5 = 9.2%). In Factor 1 high loadings were obtained for shrub factor and slope while in Factor 2 high loadings were obtained for ground cover factor.



4.9

Fig ~~4.8~~: Factor Plot in rotated space of animal and random plots Post-monsoon season.

Regression factor score obtained by plotting the animal and random against scores of Factor 1 and 2 showed that the random plots were more or less clumped at the centre of the factor space with most positively associated with Factor 2 or ground cover factor. The animal plots were scattered all over the factor space. The plot thus showed that there was no clear separation of the animal and random plots during this season (Fig. 4.9).

4.3.2.4.1. Winter season:

Available habitat: PCA of the random plots extracted 4 factors which together explained 71.7% of the variance. In Factor 1 positive high loadings were obtained for ground cover factor and negative loadings for tree density and shrub cover height. In Factor 2 high loadings were obtained for shrub factor and in Factor 3 high loadings were obtained for canopy height, ground cover height and slope (Table 4.14).

Table 4.14: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of winter season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover				
Canopy height			.814	
Tree density	-.727			
Shrub cover		.866		
Shrub density		.914		
Shrub height	-.734			
Shrub diversity		-.501		
Ground cover	.863			
Ground cover height			.529	.579
Ground cover density	.866			
Ground cover diversity				.886
Steepness of slope			.878	
Variance explained	**23.5**	**19%**	**15.2%**	**13.9%**

Factor 1 apparently represented open areas with abundant ground cover while Factor 2 represented areas with dense shrub cover (Fig 4.~~9~~10).

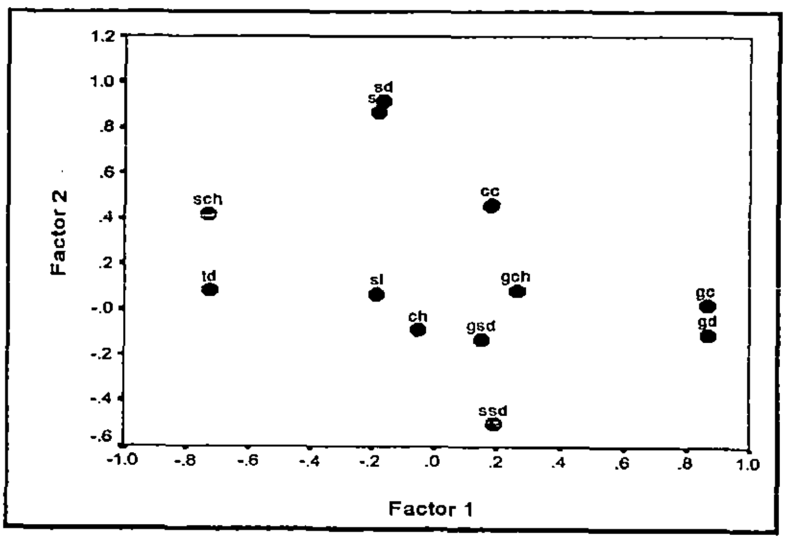


Fig. 4.~~9~~10 Factor Plot in rotated space of habitat variables of random plots winter season

4.3.2.4.2 Utilised habitat: In the utilised habitat or animal plots PCA extracted 3 factors which cumulatively explained 78 % of variance (Factor 1= 31.6%, Factor 2=25.8% and Factor 3= 20.6%). In Factor 1 high factor loadings were obtained for

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Table 4.14: Showing the extracted factors and the factor loadings (>.5) of habitat variables for random plots of winter season.

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Canopy cover				
Canopy height			.814	
Tree density	-.727			
Shrub cover		.866		
Shrub density		.914		
Shrub height	-.734			
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Ground cover	.863			
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Ground cover density	.866			
Ground cover diversity				.886
Steepness of slope			.878	
Variance explained	**23.5**	**19%**	**15.2%**	**13.9%**

Factor 1 apparently represented open areas with abundant ground cover while Factor 2 represented areas with dense shrub cover (Fig 4.10).

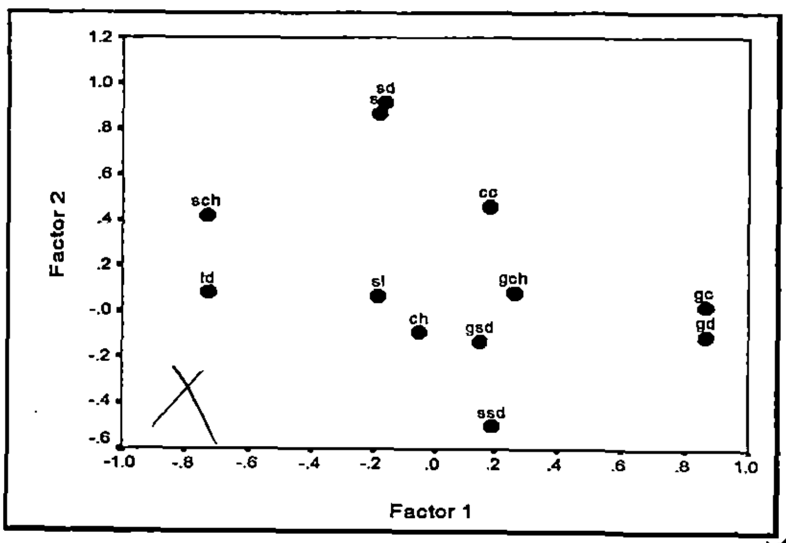

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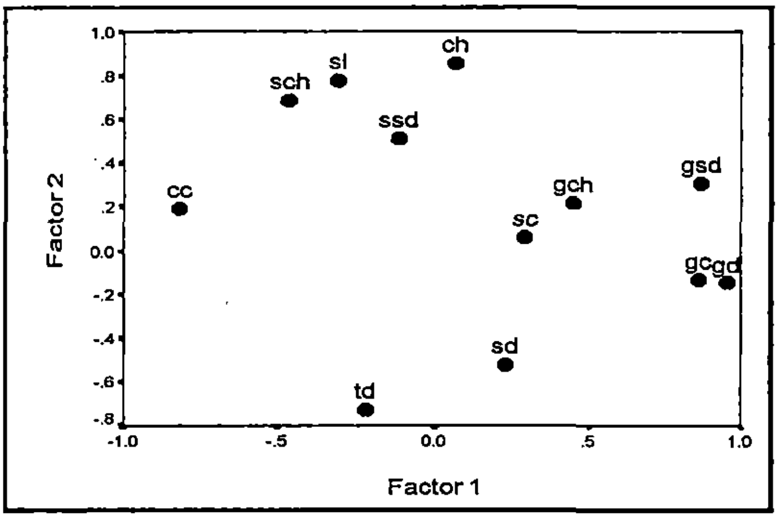
Fig. 4.10 Factor Plot in rotated space of habitat variables of random plots winter season

4.3.2.4.2 Utilised habitat: In the utilised habitat or animal plots PCA extracted 3 factors which cumulatively explained 78 % of variance (Factor 1= 31.6%, Factor 2=25.8% and Factor 3= 20.6%). In Factor 1 high factor loadings were obtained for ground cover factor. Factor 2 had high positive loadings for canopy height, shrub height, shrub diversity and slope with negative loadings for shrub density and tree density. In Factor 3 high positive loadings were obtained for shrub factor and negative loading was obtained for ground cover height (Table 4.15).

Factor 1 apparently represented open areas with abundant ground cover ($r = .742$, $n = 38$, $p = .001$) while Factor 2 represented steep areas with tall but sparse shrub and tree cover and Factor 3 represented areas with dense vegetation at the understorey level (Fig 4.11)

Table 4.15: Showing the extracted factors and the factor loadings (>.5) of habitat variables for animal plots of winter season.

Variables	Factor 1	Factor 2	Factor 3
Canopy cover	-.817		
Canopy height		.854	
Tree density		-.726	
Shrub cover			.863
Shrub density		-.524	.692
Shrub height		.689	
Shrub diversity		.511	.732
Ground cover	.865		
Ground cover height			-.680
Ground cover density	.958		
Ground cover diversity	.872		
Steepness of slope		.779	
Variance explained	**31.6%**	**25.8%**	**20.6%**



4•11

Fig. 4.~~10~~ Factor Plot in rotated space of habitat variables of animal plots winter season

The habitat variables of the winter when subjected to DFA showed no discriminating variables between the animal and the random plots indicating a random use of habitat during this season. PCA of the animal and random plots extracted 5 factors which explained 78% of variance (Factor1= 22.3%, Factor 2 17.1%, Factor 3 15.1%, Factor 4 14.1% and Factor 5 9.3%). High factor loadings were obtained for ground cover factor and negative loading was obtained for shrub height and tree density in Factor 1. High loading were obtained for shrub factor in Factor 2 while in factor 3 there were high loading for canopy height and slope.

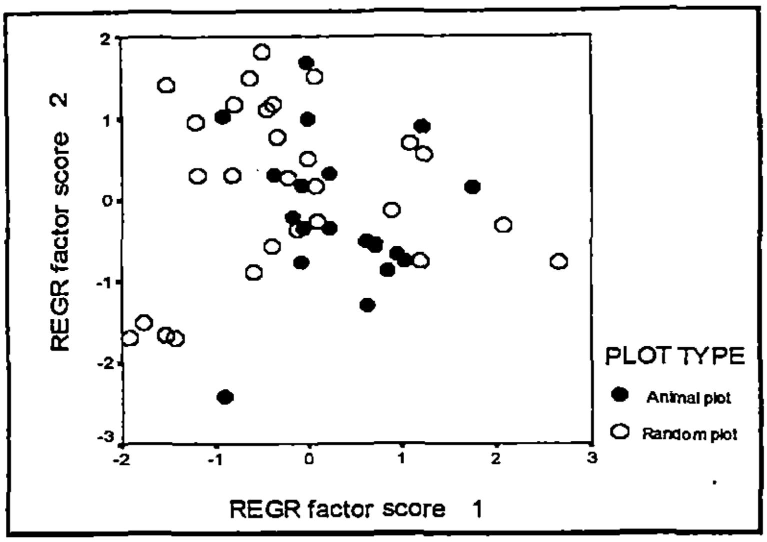


Fig. 4.12 Regression factor score plot of animal and random plots of winter season

Scatter constructed by plotting the Factor scores of Factor 1 and 2 showed that there was no separation between the available and utilised plots of the Satyr Tragopan. This indicated a random use of the habitat variables during the winter season (Fig. 4.12).

4.4. Discussion

Several authors (Lack 1933,1949, Svardson 1949, Hilden 1965) have theorised that birds select habitats on the basis of 'sign stimuli' that convey information about ultimate factors like food production and nest site availability. Root (1967) documented cases in which given bird species appear to be directly associated with ultimate factors. Other studies have described the structural and functional components of vegetation usually involving some form of symbolism denoting items considered important to the avifauna present (Weins 1969). MacArthur and MacArthur (1961) developed a technique to describe the layering of vegetation and found that by computing a foliage height diversity, based upon the distribution of vegetation layers one could predict the bird species diversity of a given community. Sturman (1968) found that the canopy volume and upper storey vegetation were significantly correlated with Chikadee abundance.

During the pre-monsoon season both the available and utilised micro habitats of the Satyr Tragopan were mainly associated with areas outside the primary forest in edges or secondary vegetation characterised by sparse canopy cover but dense vegetation at the understorey and groundstorey level. The habitat in the available and the utilised plots of Satyr Tragopan, generally, did not show much difference. However the two types of microhabitat differed in shrub cover and steepness of slope. It seemed that the Satyr Tragopan used areas that had lower shrub cover and gentler ~~less steep~~ slopes ~~than were available~~. Their habitat during this season was associated with open areas having good understorey and ground cover vegetation. Thus in spring, the Satyr Tragopan apparently occurred in oak forests preferring the forest edges with the shrub and ground cover forming important components of its habitat. Temminck's Tragopan was also observed to occur in forest edges which were rich in grasses and bushes in spring. During their studies on Temminck's Tragopan Shi Hai Tao and Zheng Guang-mei (*1997*) found that the species showed preference for areas of good cover and abundant bushes during the summer season.

Pre-monsoon season coincides with the breeding season of the Satyr Tragopan when the birds generally advertise their presence through calls and display (Islam and Crawford 1996). Such activities appear to be more advantageous in open areas. Being a ground dwelling species the herb layer probably forms a potential source of food for this species. Pre-monsoon may also be the season for the commencement of nesting activities (Baker 1921, Johnsgard 1986). Many studies on pheasants and grouse have shown that nest predation was an important reason for losses in productivity (Reynolds 1988). Deficiency in nesting habitat have been described as limiting factors to pheasant population (Trautman 1960, Leite 1971, Guthery *et al.* 1980). Predators were found to be the proximate factors in influencing nest loss in sage grouse (Gregg *et al.* 1994) and Cabot's Tragopan (Zhang Zheng Wang and Zheng Guang-mei 1989), but the ultimate cause in sage grouse and Cabot nest predation was related to the available vegetation. Tall dense vegetation may provide visual scent and physical barriers between predators and nests of ground nesting birds (Bowman and Harris 1980, Redmond *et al.* 1982, Sugden and Beyersbergen 1986,87, Crabtree *et al.* 1989) . The study of Delong *et al.*(1995) suggested that greater amounts of tall grass cover and medium shrub height were collectively associated with lower probability of nest predation. Wallstead and Pyrah (1974) and Gregg *et al.* (1994) demonstrated that the greater amount of shrub cover at nest sites was associated with non predated sage grouse nests. These studies suggest that cover and height of the shrubs in a relatively small area (i.e. nest site) influences nest fate. Snyder (1984) observed that that the number of early spring nests of Ring-necked Pheasant placed at different nesting cover was directly related to height-density quality of the vegetation. Pheasant breeding density was also related to the availability of woodland edges with high levels of shrub cover 200-300 cm in height and arable land (Robertson *et al.* 1993b). Thus cover at the shrub and ground levels seemed to be an essential feature of the nesting site and fate of ground nesting birds like the Satyr Tragopan. The shrub cover composed predominantly of ringal probably provided the species with vital cover for the nest and also a barrier against predation and nest loss. The relatively open areas with ground cover probably provided the food for this ground feeding species and also areas for communication and advertisement.

In the monsoon season also the general microhabitat characteristics of the bird and the non-bird sites were similar. Birds seemed to be associated with primary forests characterised by dense canopy cover and understorey vegetation and sparse ground cover. However while comparing the habitat of the animal and random plots four habitat variables were found to be different between the two types of plots in this season.

In the post-monsoon season the available habitat was represented by open canopy areas with dense shrub and ground cover while the birds were found to use close canopied steep areas with dense shrub and tall but sparse ground cover. Among the habitat variables significant differences were obtained for canopy cover, ground cover height and steepness of slope between the bird and the non-bird plots, therefore there seemed to be more or less an equal use of shrub variable in both the plots which formed a very important component of the Satyr Tragopan habitat in this season.

In both the monsoon and post-monsoon seasons the Satyr Tragopan was associated with breeding activities like incubation, hatching and rearing of broods which were expected to occur in areas of good cover. Studies (Meyers *et al.* 1988) have revealed that survival of Ring-necked Pheasants depended in part on the habitat they used because survival of broods was related to availability of thicker cover types and in some cover types survival was a function of the age of the brood. Warner (1984) has also suggested that mortality of young may contribute equally as a limiting factor to the survival of adult Ring-necked pheasants.

In SNP there is a very dense growth of *Arundinaria maling, A. racemosa and Thamnocalamus aristata* over a large extent known as temperate bamboo brakes. These are found in large fire swept areas of the Park as a seral type vegetation (Champion and Seth 1968) from where other tree species have been exterminated. *Daphne cannabina, Berberis aristata*, and *Pipthanthus nepalensis* are the other species known to occur with the ringal species. Perhaps ringal which formed the most common shrub cover in the Singhalila forests provided the secure hatching and early brooding cover. The dense overhead cover probably provided efficient lanes for travel and escape. It appears that in the monsoon and post-monsoon seasons the vital breeding activities necessitated the Satyr Tragopan to remain in well-wooded areas or primary forests with adequate cover for protection and shelter. Meanwhile abundant ground cover prevalent during these seasons apparently provided an abundant source of food to the adults as well as their broods.

In the winter the available sites were associated with steep edge areas possessing dense ground and shrub vegetation. Similar to the observations on the Ring-necked Pheasant (Collias and Taber 1951, Goransson 1980 and Ridley 1983) the Satyr Tragopan in this season were also associated with edge areas but with steep slopes having dense ground cover and sparse but tall canopy and shrub cover.

Similarly Cabot's Tragopan used areas with thick undergrowth , a greater percentage of bare ground, proximity to water sources and a gentle slope while areas with abundance of fallen nuts were preferred for roosting (Young *et al.* 1992). There was no difference in the habitat variables of the bird site and the non-bird site which indicated the rather random use of the area by the species. It is very important to understand the winter habitat use of Satyr Tragopan because work on the related Common pheasant has shown that winter habitat choice was a key factor in determining over winter survival (Gatti *et al.* 1989, Hill and Robertson 1988, Robertson *et al.* 1989). Winter habitat cover in Ring-necked pheasants is suspected to be the major limiting factor on pheasant population in southern Idaho. Declines have been attributed to loss of cover (Owen 1987). Winter habitat use by hen Ring-necked Pheasants (Leptich 1992) showed heavy use of wetlands because of the presence of adequate cover in this habitat type which was essential for moving around and escape during the day and roosting and thermal cover at night. In winter the Temmick's Tragopan expanded its range size occurring in a variety of broad-leaf bamboo mixed forest (Shi Hai Tao and Zheng Guang-mei 1997). Winter and spring habitat use by Gray Partridge (Perdix perdix) (Church and Porter 1990) showed that in winter coveys selected grain stubble as the waste or left over grain was an important source of food for the species. Thus all these studies have confirmed the importance of cover to survive the constraints of winter season. In Singhalila National Park snowfall began by November or December but did not remain for long. Snowfall in January was more severe and remained sometimes upto March April. The Satyr Tragopan therefore appear to range over larger areas because during winter due to scarcity of resources, the birds try and cover large areas to obtain scarce resources. The association of the bird with ground cover probably meant that the vegetation provided cover for roosting, warmth and food. At the canopy level all the deciduous species in the mixed oak forests were without cover, while most of the plants in the shrub and ground were either dead or in defoliated phase to survive the winter. Thus the cover at the ground cover level was a very important winter habitat variable of the Satyr Tragopan. The importance of ground cover in the winter habitat of the Satyr Tragopan agreed with the observations of Robertson (1985) who suggested that primary ground dwelling species like the Common Pheasant would be expected to be affected by the quality of habitat at the ground level.

4.5 Conclusions

Like all other species of Tragopan pheasants the Satyr Tragopan is a true forest bird and in Singhlila National Park it was found to be associated more with the shorter vegetation attributes of its habitat like shrub and ground cover than the tree cover variables. Corroborating the observations of others (Beebe 1918-1922, Ali and Ripley 1978, Lelliott and Yonzon 1980, Young and Kaul 1987) the habitat of the species included gentle to steep and rugged forested areas with shrubby undergrowth or dense ringal cover.

In SNP the Satyr Tragopan were found predominantly in mixed oak forests with marked seasonal shift in microhabitat use though there was marked difference between the available and utilised habitat only in the monsoon season. The habitat of the species showed association with habitat variables like shrub cover, height and density and ground cover, height and density. Canopy cover was important in reflecting the primary forest or edge areas within the forest while attributes like canopy height and tree density did not form any important component of the satyr Tragopan habitat. Similar to the studies of Islam and Crawford (1987) on the habitat use of the Western Tragopan, it seemed that in a Satyr habitat the structural components of the vegetation at the shrub and ground cover level were more important than the components at the canopy or tree level. Tall shrub cover, height and density probably were important for females that were nesting for cover and protection. On the other hand shorter shrubs and ground cover would be important for the brood while the brightly coloured males would also need dense cover as protection from potential predators. Being primarily ground dwelling and herbivorous the ground cover vegetation probably provided the species with abundant and easily procurable food. As suggested by Robertson (1985) it may be appropriate to conclude that because pheasants like Satyr Tragopan are primarily ground living birds, their habitat selection is expected to be on the quality of shrub and ground cover rather than on higher life forms like tree cover variables.