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Den-site Selection of Indian Porcupine and its Physical Characteristics in Central India Landscape

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ABSTRACT

Indian Crested Porcupine (*Hystrix indica*) dens were monitored in Pench Tiger Reserve, M.P., between December 2013 and June 2014 to determine the physical characteristics and factors/variables that help to select the den site. Fine-scale denning habitat selection was studied by comparing field measured characteristics/parameters of den sites with its random sites. The analysis of these parameters of den was done by Principal Component Analysis & logistic regression models. Very little published information on denning ecology of porcupine is available. Two types of den were identified in the study area, rock cavity den (n= 22) and excavated den (n= 5); however there was no significant difference in the dimensions of these two types of den. Overall the average height and width of entrances were 71.11cm (± 5.63) and 60.22 cm (± 4.9) respectively, with 2.5 cm (± .33) entrance openings. The depth of den is like a tunnel and entrance was covered with quills, faecal matters, antlers or bones of other mammals. Mostly dens were made on mid-steep slopes facing the northeast direction. PCA result shows that the selection of den site of porcupine is more likely to be a high rocky area with medium dense ground cover such as grass, herbs with high seedling species and lower tree density. Also porcupines prefer the den site near the water bodies. Further, logistic regression models using these as candidate variables identified proximity to rocks and herb density.

Key Words: *Hystrix indica*; Principal Component Analysis; Den Ecology; Porcupine Habitat.

INTRODUCTION

Dens are the essential components of the life history of most rodents. Within the order Rodentia, selection of den sites is determined by availability of dens, availability of food near dens, protection from predation, escape from biting insects, potential interaction with other individuals, and protection from cold temperatures over winter months (Morin et al. 2005, Hwang et al. 2007). Indian Porcupines is the one of the largest member of class Rodentia of order Hystricomorpha and den sites are extremely important for it because they are nocturnal and shy animal as they need hiding place for day time, according to Svendsen (1976) initial social and physical development of the young occurs there, and den sites provide protection from the physical environment and from predators. Studies examining pattern of habitat use and survivorship of mammals often use den sites as an important ecological factor. It seems obvious that the availability of suitable denning sites plays an important role in the reproductive performance of the species because dens are necessary for reproduction and other activities (Smits et al. 1988). Although porcupine has a wide geographical distribution but little is known about its denning ecology however many studies have been conducted on different aspects such as feeding, foraging etc. There are only few papers involving selection of den sites and its use, of relatively similar species such as North American Porcupine and Crested porcupine in North America and Africa respectively (Monetti et al. 2005, Morin et al. 2005, Somers and Thiel 2007, Mally 2008, Locke 2009) but no study was carried out on Indian Porcupine, in India or anywhere. This study is the first to examine the porcupine den site selection in Pench Tiger Reserve, India. This study addressed that which types of habitat used by porcupine to make their dens or

describe the characteristics of den site that is what physical and vegetation parameters within these preferred habitats are associated with porcupine's dens.

STUDY AREA

The study was conducted in Karmajhiri range of Pench Tiger Reserve, Madhya Pradesh (Figure 1). The Reserve is located in the southern lower reaches of the Satpura hill range on the southern border of Madhya Pradesh, in the Seoni and Chhindwara districts (78º 55'E - 79º 35'E and 21º 35'N -22º 00'N). It has a total area of 757.85 sq. km, which includes the Sanctuary (183 sq. km), the National Park (245.85 sq. km) and Reserved Forest (229 sq. km). The Tiger Reserve has three ranges, the National Park consisting of Karmajhiri and Gumtara range in Seoni and Chindwara districts respectively; and Kurai range that makes up the Sanctuary to the east of the National Park. Karmajhiri range was selected as extensive study area for the reason that is present at the centre of reserve. Data were collected during the period December 2013 to Jun 2014.

METHODOLOGY

Data Collection on Den Site Selection

The entire area was surveyed randomly in all representative habitats to locate porcupine den. Local residents or

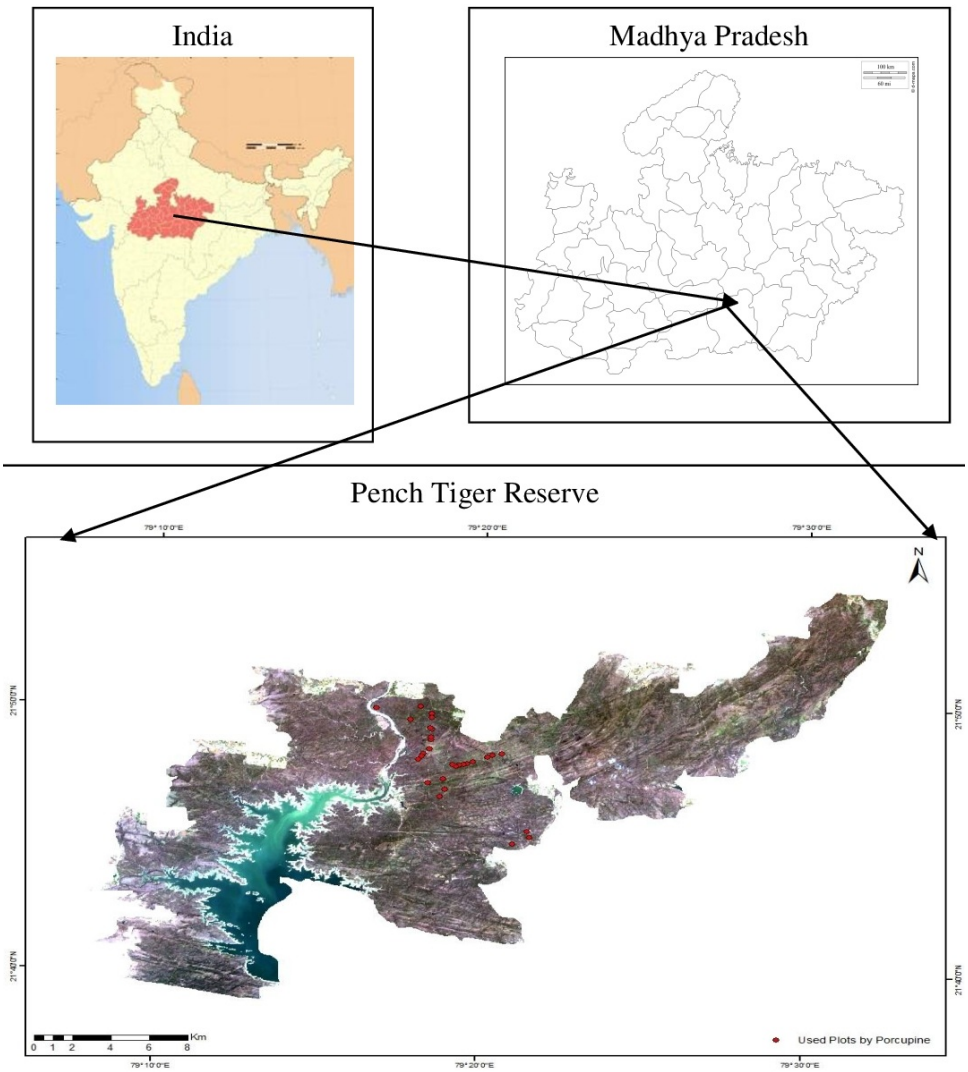

Figure 1: Map of the study area

forest workers were contacted to collect information on porcupine occurrence and den site. Porcupine dens were identified from direct sightings of porcupine as well as the presence of sign (quills, pellets, digging, and foot marks). At each den site, random plots were laid at 50m distance from the den site and den types, characteristics, site characteristics and its habitat were recorded.

Each den site served as the center of a 10 m radius circular sampling plot to study the vegetation structure for density, diversity and richness. The grass and herb composition was quantified by laying 0.5×0.5 m quadrats in the plot. Tree cover, shrub cover, herb cover and grass cover was estimated by ocular estimated method and ground cover was estimated by point intercept method (Canfield 1941). All these variables were also measured for the random sites of dens.

Apart from above parameters some variables only measured for den sites to know the physical description and characteristics of porcupine's den. These parameters are type of den, its dimension (height, width and number of openings), aspect or direction of den opening, slope of den (low, medium, high and very high).

Data Analysis

Densities of all these variables were calculated manually. Species diversity and richness were calculated by using modified version of "SPECDIVER BAS" (Ludwing and Reynolds 1988), a module of software STASTICAL ECOLOGY written in BASIC.

To understand the den characteristic of porcupine, Principal Component Analysis (PCA) was used to confounding of highly correlated variables. All the quantitative data in the data matrix were transformed using Log and Arcsine transformation to improve the normalcy in the data and then transformed data were standardized by calculating the mean and standard deviation of each column of data matrix (Zar 1984).

$$S = (a\text{-mean}) / \text{standard deviation}$$

where S is the standardized value, and a is the transformed value of each cell of data matrix.

Factor analysis was used to reduce the dimensionality of den site and random sites variables. The first three factors were used for interpretation as these explained maximum variations in the data set. Before using PCA most of the auto-correlated variables were dropped. As den site analysis concentrated on 30 variables around the den and random sites, were recorded out of which only 14 variables were used for PCA, and factor scores were saved. Den and random sites were plotted in three dimension space defined by PCI, PCII and PC III. All the extracted factors with eigen values of more than one were saved and used for logistic regression analysis. In logistic regression, the principal component was then used as candidate variables in logistic regression model with forward stepwise entry.

RESULTS

Physical Characteristics of Den and its Types

27 dens were examined 27 and completed a detailed ecological assessment of the area around each den. Of these, there were 5 excavated and 22 rock cavity dens. Excavated dens were located almost exclusively in areas of deep, fine textured soils while Rock cavity dens were located exclusively in rocky outcrops.

The dimension of excavated and rock cavity den, the mean width of den was found to be almost similar of rock 60.5cm (± 5.80) and excavated 59.0 cm (±8.27) den. However the result of t- test was not found to be significant ($t = 0.11$, $p > 0.05$). The mean height of rock cavity den 73.2 cm (±6.13) was found to be higher than excavated den 62.0cm (±14.8). However the result of t test was not found to be significant ($t = 0.76$, $p > 0.05$). And the mean number of entrances of rock cavity den 2.6 (±0.39) was found to be more than excavated den 1.8 (±0.37) (Table 1). However the result of t-test was not found to be significant ($t = 1.02$, $p > 0.05$). The mean elevation of den was found to be maximum in rock cavity den 565.85m (±7.33) and minimum in excavated den 552m (± 22.6) (Table 1). However the result of t test was not found to be significant ($t = 0.67$, $p > 0.05$)

Over all the average height and width of entrances were (71.11± 5.63) cm and (60.22 ± 4.9) cm respectively with (2.5 ± .33) entrance openings (Table 1). The depth of den is like a tunnel and entrance were covered with quills, pellets, antlers or bones of other mammals.

About one third (upto 29.63%) of entrances of dens faced NE direction followed by SE direction (18.52%). Fewer dens were on eastern and western direction (3.70%) (Figure 2). The location of den on slopes that mostly excavated dens was found to be in lower steep slope. The frequency of these den types decreased as steepness increased where as rock cavity dens were found to be maximum in medium steep slope (Figure 3).

Table 1. Physical Characteristics of Porcupine Den

Types of Den	No of Entrances	Width (cm)	Height (cm)	Elevation (m)
Rock Cavity Den	2.6 ±0.39	60.5 ± 5.80	73.2 ±6.13	565.8 ±7.33
Excavated Den	1.8 ±0.37	59.0 ± 8.27	62.0 ±14.8	552,0 ±22.6
Over all	2.5 ±0.33	60.2 ±4.9	71.1 ± 5.63	563.8 ±6.13

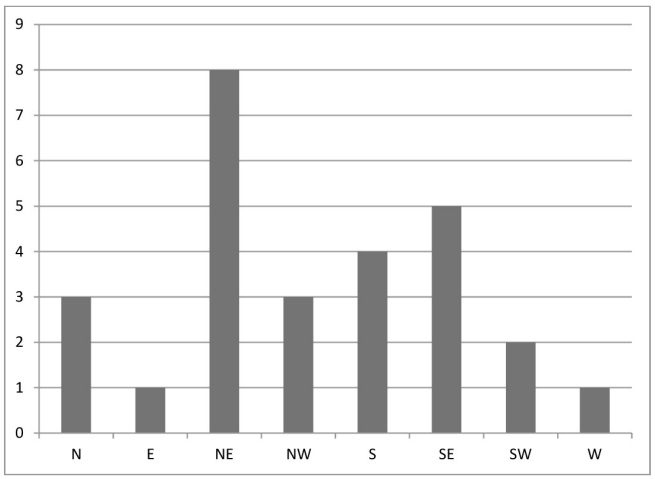

Figure 2. Different Aspects of porcupine den

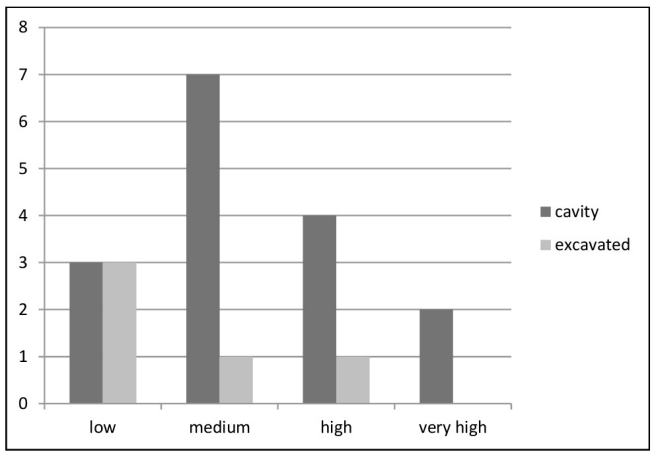

Figure 3. Comparison in slope of excavated and rock cavity den of porcupine

Variables/Factors Affecting the Den Site

PCA performed on den sites and random sites of porcupine. It provides the component loading of 14 variables from 57 sampling plots of 30 variables (Table 2). The first three principal components accounted for 56% of the variation on data set. The first factor was highly positively correlated with sapling density (r = 0.790), sapling diversity (r = 0.739), litter (r = 0.627), tree density (r = 0.525) and negatively correlated with rock (r =-0.717). The second factor was highly positively correlated with herb density (r = 866), grass density (r = 0.822), herb diversity (r = 0.778) and negatively correlated with distance from nearest water body (r = -595). The third factor was positively correlated with seedling richness (r =0.818) and seedling density (r= 0.813).

Table 2. Loading of 14 variables on the first three components

Variables	PC I	PC II	PC III
Distance from nearest water	0.205369	-0.59491	-0.11358
Grass density	0.464767	0.821764	0.110979
Grass cover	0.476357	0.318816	-0.38255
Herb density	0.316762	0.866372	0.102618
Herb diversity	0.23114	0.778094	-0.12459
Litter	0.627189	0.104657	0.162765
Rock	-0.71711	-0.33609	-0.1096
Sapling density	0.790031	0.256247	0.222981
Seedling density	0.189223	0.152035	0.812679
Seedling richness	0.265401	-0.01848	0.817695
Tree density	0.525069	0.139804	0.435934
Sapling diversity	0.739352	-0.09732	0.100292
Shrub density	-0.04553	0.21744	0.203254
Shrub cover	0.205047	-0.02846	-0.25384
% Variance	22.45%	19.83%	13.72%
Cumulative Variance	22.45%	42.28%	56.01%

The logistic regression model had an efficiency of 81.48% correct classification of den sites and contrast sites of porcupine (Table 3). In this model, these three components were accurately classified for 77.78 % of the

Table 3. Logistic Regression Model for the correct classification

Variables	B	S.E.	Wald	Df	Sig	R	Exp(B)
Herb density	3.316	2.6194	1.603	1	0.2055	0.000	27.550
Rock	-1.253	0.5119	5.992	1	0.0144	-0.2309	0.2856
Constant	-1.211	1.1334	1.142	1	0.2852		

contrast site and 85.19 % of the den site. According to this model rock and herb are most important component for the selection of den. And then scored were saved to correlate these three PCs to find out the relation of habitat parameters with the den site.

The distribution of den sites and contrast sites in relation to first and second component (Figure 4). The graph shows that porcupine preferred the area to den site selection that have high rocky cover with medium sapling density, sapling diversity, litter cover, tree density and with the presence of low to medium herb density, grass density, herb diversity and water body.

The distribution of den sites and contrast sites in relation to first and third component (Figure 5). The graph shows that porcupine preferred area to den selection that have high rock cover with lower to medium sapling and tree densities with medium to high seedling densities.

The distribution of den sites and contrast sites in relation to second and third component (Figure 6). The graph suggests that the porcupine preferred den sites that have low to medium herb and grass densities with medium to high seedling density and richness.

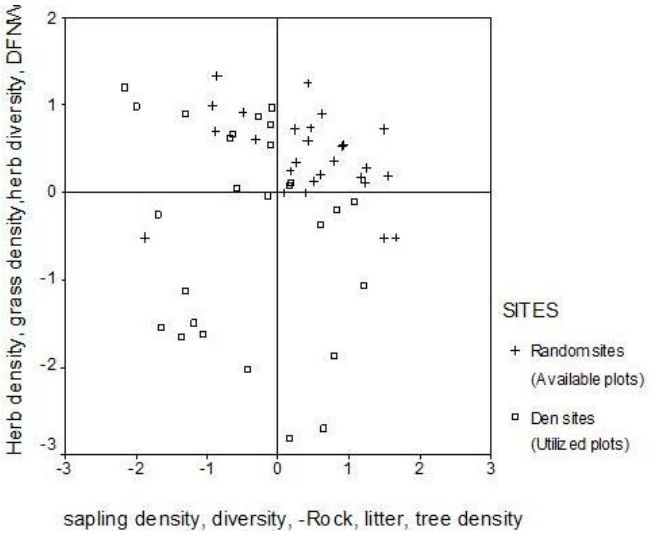

Figure 4. Ordination of den sites and random sites of porcupine in PTR

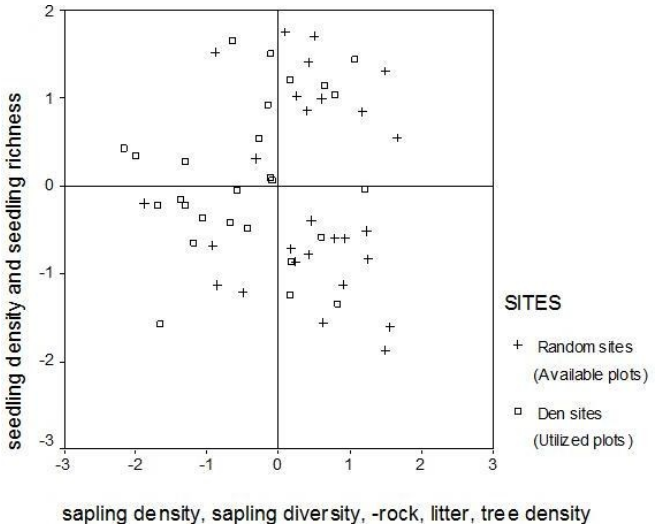

Figure 5. Ordination of den sites and random sites of porcupine in PTR

Overall conclusion from the PCA (Figure 7) is that the selection of den site of porcupine is more likely to be a high rocky area with medium dense ground cover such as grass, herbs with high seedling species and lower tree density. And also porcupines prefer the den site near the water bodies.

It suggests that porcupine mostly used open rocky areas or densely ground area with high grass and herb density, sapling diversity and richness, they also prefer the area with high tree density, diversity and richness however avoid the area that have high litter cover and shrub dense area.

DISCUSSION

Porcupines are the shy as well as nocturnal animals, therefore the direct sighting of the species is very difficult, and hence the indirect evidences were used to

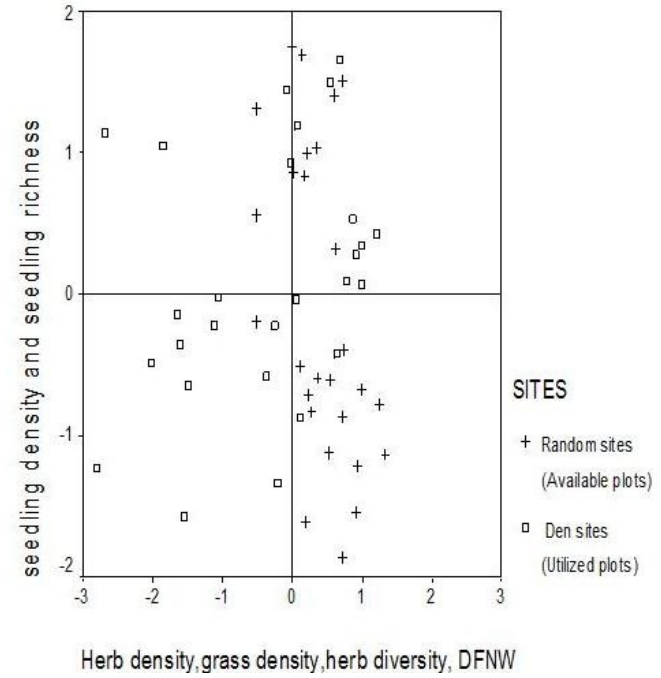

Figure 6: Ordination of den sites and random sites of porcupine in PTR

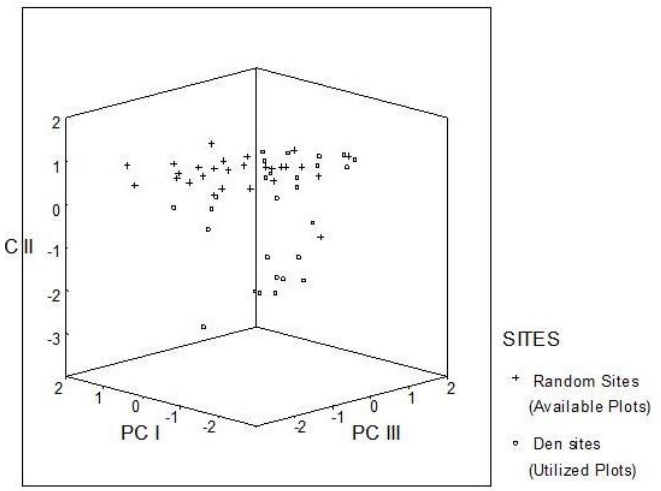

Figure 7: Ordination of den and random sites of porcupine in PTR in 3-dimensional space.

study the den selection by porcupine in PTR Therefore method was based on the indirect evidences such as presence of faecal matter, dig signs, quills and bones. A multivariate test that is PCA produced a characterization of dens that was not clearly related to the measured habitat variables because of the large number of variables. Hence auto-correlated variables were excluded and important habitat factors which responsible for the selection of den sites were evaluated.

Habitat selection, home range size, and den selection in porcupines is largely determined by characteristics of the environment and the animal, including weather, climate, food preference, population density, body size, and sex. Habitat selection and activity patterns of the Porcupine are made to maximize foraging opportunities, mating success, and survival during harsh seasonal change (Locke 2009).

There is only little published work of Indian porcupine's den ecology. Most studies were conducted on the denning habit of porcupine of ecologically similar species *Erithizon dorsatum* (North American Porcupine) and *Hystix cristata* (crested porcupine) in North America and Africa.

In our study area, 27 dens were selected, out of which 22 dens were rock cavity and 5 excavated types. According to Roze (1989) there are other types of dens such as hollow trees/logs, buildings, dirt burrows, banks, washouts, culverts, and thickets. But rock cavity dens are mostly used by porcupine because they provide a sheltered and dry microhabitat (Griesemer et al. 1998). Rock cavity dens have the most stable temperatures and large thermal mass to keep the inside temperature higher than ambient temperature (Neil 2008) where as excavated dens in shallow soils would be more prone to flooding during winter rainstorms or winter thaws, compared with rock caves (Schwartz et al. 1987). In present study porcupine avoid bare areas due to the hypothesis of Monetti et al. (2005) that soil compactness, hence den stability, is important for den site selection.
The dimension of den was compared with the observation of Kayani et al. (2006) that was carried out in Pakistan, in which width, height, number of opening and elevation was 47.5 cm (±21.45), 43.0cm (±8.32) cm, 4.44cm (±1.59) and 89.0 cm (±24.41) respectively, these observations were different with our findings may be due to the topography of land such as terrain.

The mean size of entrance holes was similar to the size of the porcupines. It suggests that appropriately sized entrances may be easily defended by a single porcupine, in case of a predator attack. And number of entrances is used as index of den complexity (Kayani et al. 1990). In our findings rock cavity den has more complexity than excavated den due to the more number of entrance in rock cavity den.

Other factor such as slope, aspects may also influence on den site selection. According to Monetti et al. (2005) Porcupines showed a clear avoidance of a northern aspect. Felicoli and Santini (1994) suggested

that porcupines might select south exposures to synchronize with sunset but in present findings porcupines mostly used Northeast direction followed by south east. According to other authors who conducted studies on other mammals denning habits suggest that mammals apparently did not select any one aspect for den sites. Unger (1999) found similar results, but Matteson (1992) found a moderate preference for south and east facing slopes. Solar radiation at dens does not appear to be a factor in selection. While, other factors like terrain or slope, may influence den site selection. In present study, porcupines used medium steep slopes for denning, possibly for a better rain drainage, but according to Monetti et al. (2005) suggest that we cannot exclude that steep slope selection was a consequence of soil or vegetation preference.

The variables such as grass density, herb density, diversity, rock cover, tree regenerations species, distance from the nearest water body, determined the distribution of den sites which shows that these are the most important preferred variables to select the den. On comparing the role of vegetation to choose the den site with Kayani *et al* (1990), he suggested that plantation with denser under story vegetation were favored by porcupine to select den site. According to other studies such as Switzer and Berger (1992), Morin et al. (2005), and Locke (2009) etc., porcupine used mostly rock cavity dens and our observations also confirm this statement as the rock cover plays significant role in selection of den because of its sheltered and dry microhabitat. According to Neils (2008), rock dens have the most stable temperatures and large thermal mass to keep the inside temperature higher than ambient temperature. Instead of this, some researchers such as Shapiro (1949) suggest that porcupine dens are not critical, though, in providing warmth, they keep away from their dens in night but as our view, since porcupine is nocturnal species due to which they foraging in night. Apart from the types of den, feeding preference is also important factor to den selection. As this study shows that Indian porcupine of PTR mostly feed upon seeds, grasses, fallen leaves and herbs that's why dense ground cover plays important role in selection of den. And we also suggest the reason to select dense ground cover near the den site, may provide horizontal protection or little structural defense from ground predators.

The Porcupine dens have also been shown to provide shelter not only for the builders but also for many other co-habiting species (Kinlaw 1999). In Nieuwoudtville, Africa Bragg et al. (2005) observed that some other species of rodents occupying a multi-entrance porcupine den. Ant-eating chats (*Myrmecocichla formicivora*), spiders, bat-eared foxes (*Otocyon megalotis*), striped pole-cats (*Ictonyx striatus* Perry), and colonies of bees also inhabit new and collapsed Cape porcupine dens. Porcupine dens therefore alter the landscape and provide a source of refuge for other species.

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