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Conservation Status and Habitat Use of Musk Deer in Govind Pashu Vihar Wildlife Sanctuary and National Park, Uttarkashi, India

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ABSTRACT

Among the four species of musk deer, *Moschus chrysogator* is the only species present in the Indian Himalayan region. Data on abundance and habitat use of musk deer were collected using direct and indirect methods. Monitoring of the existing forest trails passing through different forest was done at dawn and dusk. Abundance estimation of musk deer was also done by pellet group counts. About 63 plots, each of 10m radius, were established along transect. Pellet group density (pellet group/ha) was also calculated for different season on different transects. Mean and standard error was calculated and Kruskal-Wallis one way ANOVA was used to test the significant difference between the pellet group density and different habitat parameters. Principal component axis was used on available and utilised plots. There were significant differences in mean values of habitat attributes between available and utilized plots and musk deer preferred area with high shrub density, diversity and shrub cover with the high tree cover area but low grass cover. The conservation implications of the results are discussed.

Key Words: Musk Deer (*Moschus chrysogastor*), Govind Pashu Vihar Wildlife Sanctuary and National Park, Pellet Group Density, Alpine Meadows Forest.

INTRODUCTION

The family Moschidae is represented by four species (Grubb 1993) viz., the Himalayan musk deer (*Moschus chrysogaster* Hodgson) distributed in the Himalayas of north Afganistan, north Pakistan, north and north-east India, Nepal, central Tibet to central China; the Siberian musk deer *Moschus moschiferus* Linnaeus) distributed in east Siberia, north Mongolia, north China west to Kansu and Korea; the Dwarf Musk deer (*Moschus berezovskii* Flerov) distributed in southern and central China including Anhwei and north Vietnam; and the Black musk deer (*Moschus fuscus* Linnaeus) distributed in west Yunnan, south east Tibet. The only species present in the Himalayan region of the India is *Moschus chrysogaster* has not been well studied, yet.

The Himalayan musk deer (*Moschus chrysogaster*) is internationally recognised endangered species and has been listed as "Vulnerable" by the IUCN (1974) in the Red Data Book. It is 'schedule I' species as per the Wildlife protection Act (1972) of India. In India, it is distributed throughout the Himalayas in high altitude areas in Jammu & Kashmir, Himachal Pradesh, Kumaon, Garhwal, Sikkim and Arunachal Pradesh. A rapid decline in population of musk deer has been witnessed over the years. For centuries the musk deer has been exploited for its musk, a secretion of the preputial gland of the male which is used in perfumery and medicine. Musk is one of the most expensive animal product in the world, fetching upto US$ 45000 per kg in the international market (Green 1987).

Due to anthropogenic pressure, habitat loss, poaching and smuggling of musk the population of musk has been declining and the taxa listed in the category are liable to face extinction. The musk deer is least studied species of Indian region, the first ever ecological study was done by Green (1985) and later on by Satyakumar (1994) in Kedarnath Wildlife Sanctuary. No serious attempt has been made to under stand the status, distribution, ecology and threats to the conservation of Musk deer population in Garhwal Himalayas. Therefore, the present study is a modest attempt to understand the status, distribution, conservation threats and to contribute in conservation

planning of musk deer in Govind Pashu VIhar Wildlfie Sanctuary and National Park.

STUDY AREA

The field surveys were carried out in Govind Pashu Vihar Wildlife Sanctuary and National Park (77° 45'-78° 37'N and 30° 55'-31° 18' E) during post monsoon 2005. Govind National Park and Wildlife Sanctuary is located in District Uttarkashi of the state of Uttarakhand. Situated in the higher reaches of Garhwal Himalayas, the Park is bound in the north by Himachal Pradesh, to the east by a chain of mountain peaks, and to the south by the Tons/Yamuna watershed. The nearest railhead is 207 km south at Dehradun, and Dehradun is 235 km north of Delhi. It covers an area of about 957.969 sq. km and altitudinal variation from 1,290 m to 6,387 m above sea level. The sanctuary is a part of upper Tons valley and came into existence in 1955.

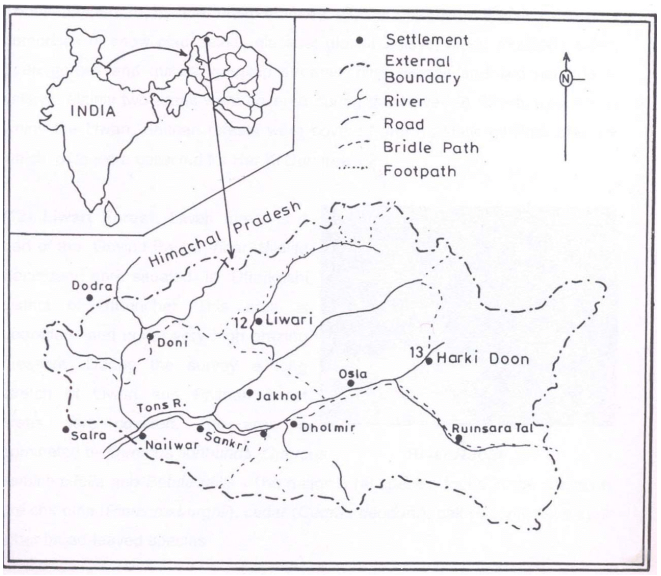

Figure 1. Map of the study area.

Initially, the name of the region was Tons, which was changed to Govind Pashu Vihar after notification. The Government of Uttar Pradesh notified its intention of constituting part of the sanctuary as Govind National Park with a core area of 472.08 sq km in 1991.

Two main areas were covered in the survey (i) Sanctuary area and (ii) National Park area. The major floral species found in the Govind Pashu Vihar (GPV) are chir pine (*Pinus roxburghii*), cedar (*Cedrus deodara*), oak (*Quercus* spp.) and other broad-leaved species. Going above 2,600 m above mean sea level, one can find blue pine (*Pinus wallichiana*), silver fir (*Abies pindrow*), spruce (*Picea smithiana*), yew (*Taxus baccata*), and broad-leaved species such as oaks (*Quercus* spp.), maples (*Acer* spp.), walnut (*Juglans regia*), horse chestnut (*Aesculus indica*), hazel (*Coryllus jacquemontii*) and rhododendron (*Rhododendron* spp). The park is also the natural habitat of several varieties of fauna including sambar (*Cervus unicolor*), musk deer (*moschus chrysogastor*) Himalayan black bear (*Selenarctos thibetanus*), leopard (*Panthera pardus*), Snow leopard (*Panthera unica*), Himalayan thar (*Hemitragus jemlahicus*h), bharal (*Pseudois nayaur*), serow, Indian porcupine (*Hystrix indica*), common otter (*Lutra lutra*), Himalayan yellow throated marten (Martes flavigula) barking deer (*Muntiacus muntjak*), goral (*Nemorhaedus goral*), Jackal (*Canis aureus*), Himalayan palm civet (*Paguma larvata*), Himalayn mouse hare or Indian Pika (*Ochotona roylei*), wild boar (*Sus scrofa*) and common langur (*Presbytis entellus*).

METHODS

Data Collection

Extensive field surveys were carried out in different localities of Govind Pashu Vihar during post monsoon 2005. All forest trails and tracks were searched to gather information on the status of musk deer. Direct and indirect evidences were sampled. Since direct evidences (sightings) of musk deer in a locality are generally low (Ilyas personal observation), greater emphasis were placed on sampling of indirect evidences (Pellet groups) along the forest trails, tracks and streams. The abundance of Pellet groups converted to the pellet group density which is a good and reliable index which has been used extensively by many workers for secretive, elusive species occurring in low abundance.

Sampling plots of 10 m radius on either sides of the trail were laid. The pellet group density, tree density, diversity and richness were assessed in 10 m radius circular plot. The 3 m radius circular plots were laid to estimate the shrub species density, diversity and richness. The disturbance factors such as tree cutting, lopping, grazing and cattle dung were recorded in 10 m radius circular plots. Four 50x50 cm quadrats were laid in four directions at each sampling plot to assess the

herb and grass density, diversity, richness. Tree cover was measured using a mirror of 25 x 25 cm dimension divided into equal grids of 5 cm x 5 cm. The cover was estimated at four location around the plot. The mirror was kept horizontally at 1.25 m above the ground level and all grids, which were covered by >50% tree foliage were counted and converted into percent tree cover. The ground cover was estimated by point intercept method (Canfield 1941). A meter tape was laid on the ground in four directions and intercepting materials (herbs, grass, litter, bare ground, weathered stone and rock) was recorded at 5 cm interval.

The poaching pressure and the man animal conflict across the sanctuary and national park were assessed and the whole nexus of poaching and trade of musk deer and its products were investigated in the sanctuary by using a variety of strategies.

Data Analysis

The species diversity and species richness of trees, shrubs, herbs and grasses for each plot were calculated by using Shannon-Weiner Index (H') species diversity and Marglef's index (RI) for species richness using the following formulae:

$H' = - \Sigma pi \log pi$ and

$RI = S-1/\ln N$,

where pi is the proportion of ith species in sample, S is the number of species in sample and N is the number of total individuals.

The sightings of musk deer were recorded. The indirect evidences such as pellet groups were used to calculate pellet group density for the species. A total of 63 plots were used. The number of pellet groups in each sampling plot was used to calculate pellet group density for musk deer vis-à-vis different sites and different habitat parameters. The value of mean pellet group density was compared vis-à-vis sites and habitat parameters to test for significant different using one way ANOVA and multiple comparison using Sheffie's test. All statistical tests were performed following Zar (1984) using computer program SPSS PC.

To understand the habitat use by musk deer, data were subjected to Principal Component Analysis (PCA). All the quantitative data in the data matrix were transformed using Log and Arcsine transformation following Zar (1984). Factor analysis was used to reduce the dimensionality of the habitat variables and this was done for pellet group data. The first two factors were used for interpretation as this explained maximum variation in the data set. Before using PCA most of the auto-correlated variables were dropped. PCA was performed using *Varimax* rotation and factor scores were saved. Extracted factors were subjected to Pearson Product Moment correlation analysis with habitat variables to find out significant correlations between habitat variables and factors. Availability and utilised plots were plotted in two dimensional space defined by PC I and PC II. All the extracted factors with *eigen* values of more than one were saved and used for the logistic regression analysis. Logistic regression was done on the random and animal centred plots.

Threat Estimation

All threat variables assessed in Govind Pashu Vihar were recorded in numbers and percentages. For each site i.e. National Park and the Sanctuary, the mean values for tree cutting, lopping cattle dung, grazing and fire were calculated.

RESULTS

Vegetation Structure

The tree density was higher in the sanctuary while shrub density was more in the National Park area. Herb and grass density were higher in the sanctuary (Table 1). Similarly tree diversity was greater in the sanctuary area while richness was more in the National Park. The diversity and richness of both shrubs and grasses were higher in the National Park area while herb diversity and richness were greater in the Sanctuary area of the Govind Pashu Vihar (Table 2).

The tree and shrub cover was also higher in the National Park area while ground cover was more in the sanctuary area (Table 3).

Table 1. Density of trees, shrubs, herbs and grasses at surveyed sites of Govind Pashu Vihar.

Vegetation	National Park	Sanctuary
Tree (no. ha^{-1})	277.7±48.22	323.6±57.0
Shrub (no. ha^{-1})	14591.4±2307.4	1907.6±1160.9
Herb (no. m^{-2}	122.9±32.3	149.4±15.35
Grass (no. m^{-2})	73.2±19.9	105.9±25.34

Distribution and Abundance of Musk Deer

The direct sighting of musk deer were recorded in terms of encounter rates (animal sighting per km) in national park and sanctuary areas. The encounter rate of musk deer in Sanctuary area was recorded 0.09 per km, while in national park it was recorded as 0.11 per km. The Direct sighting data of musk deer was not enough and more emphasis was given on the indirect data *i.e.* pellet groups of musk deer. Pellet groups of musk deer were recorded from the national park and the sanctuary area, and the density was found to be maximum in the National Park (14.33±4.10 per ha). In sanctuary area the pellet group density of musk deer was recorded 4.97±2.52 per ha but the results were not significant ($F_{1, 70}$=3.34; p<0.07).

Table 2. Diversity (D) and richness (R) of trees, shrubs, herbs and grasses in Govind Pashu Vihar.

Site	National Park		Sanctuary	
	D	R	D	R
Tree	0.181±0.03	1.78±0.02	0.25±0.03	1.09±0.053
Shrub	0.19±0.029	0.34±0.04	0.138±.02	0.21±0.03
Herb	0.25±0.02	0.38±0.046	0.51±0.04	1.03±0.07
Grass	0.12±0.03	0.15±0.04	0.028±0.05	0.03±0.01

Table 3. Vegetation cover (%) at the two sites of Govind Pashu Vihar

Vegetation	National Park	Sanctuary
Tree cover	23.28±3.9	19.38±3.3
Shrub cover	34.37±3.7	26.29±3.8
Ground cover	47.96±5.05	63.58±4.5

Habitat Occupancy of Musk Deer

The musk deer pellet group density was found to be maximum in Mixed *Betula* forest (2.6 per ha) followed by *Abies pindrow* (6.8 per ha) and *Betula* (3.53 per ha). No pellet groups were recorded in oak and revering habitat but the results were not significant ($F_{4, 67}$=0.52; P>0.72) and results were not significant. Table 4 shows the mean pellet group density of musk deer at different altitudinal zones and maximum (9.0979±5.2021) was recorded from the higher altitudinal zone i.e. 3501-4000 m, but the results were not found to be significant ($F_{2,69}$=1.08, p>0.338). Along with the preference of high altitude, musk deer also prefers the area with steep slopes. Musk deer pellet group density (18.19±13.64) was found to be maximum at the steep slopes (41-60) (Table 5), result was not significant ($F_{1, 70}$= 3.7 p>0.057). Among different aspects of slope, the musk deer pellet group density were recorded only from the west and southwest facing slope. The density was found to be maximum at west facing slope, and the results were not significant ($F_{5 66}$= 1.2, p>0.31).

Table 4. Mean pellet group density (no. ha ± SE) of Musk deer in different altitude zones

Altitude, m	Mean pellet group density
2500-3000	0
3001-3500	7.1486±2.8266
3501-4000	9.0979±5.2021

Table 5. Mean pellet group, density (density/ha ± SE) of musk deer in different slope categories

Slope categories	Mean Pellet group density
0-20 °	7.58±4.34
21-40 °	5.45±2.43
41-60 °	18.19±13.64

Table 6 shows that the Musk deer pellet group density was maximum in the high tree density area (14.15 ±10.76), high herb density (9.79±5.56), high shrub height (42.46±28.08) and medium grass density (18.19±11.74) with low shrub density (12.38±6.37) areas. Table 7 shows the presence of mean pellet group density at different cover categories. The mean pellet group density of the musk deer were recorded maximum in the area with high tree cover (31.84±0) with medium shrub cover and medium ground cover (10.19±4.39 & 11.5±5.7 respectively).

Table 6. Mean pellet group density (number ha^{-1} ± SE) of musk deer in different categories of tree, shrub, herb and grass density.

Categories	Trees	Shrub	Herb	Grass	Shrub height
No cover	6.36±4.60	3.18±3.18	13.93±7.1	11.94±11.9	0
Low	3.03±3.03	12.38±6.37	5.97±4.33	4.89±2.20	3.29±1.83
Medium	10.61±4.45	7.49±4.34	1.76±1.76	18.19±11.7	1.07±4.74
High	14.15±10.76	5.30±3.86	9.79±5.56	7.07±4.68	42.46±28.08

Table 7. Mean pellet group density (number ha^{-1} ± SE) at different tree, shrub and ground cover categories

Categories	Trees cover	Shrub cover	Ground cover
No cover	4.59±	4.5	0
Low	3.08±1.7	2.0215±3.92	3.98±2.7
Medium	16.85±7.2	10.19±4.39	11.5±5.7
High	31.84±0	7.96±7.96	6.3684±3.1

The first three principal components accounted for 36.05% of variance musk deer data matrix (Table 8). The PCI was positively correlated with shrub height ($r = 0.874$, $p<0.05$), shrub density ($r = 0.793$, $p<0.05$), shrub diversity ($r=0.742$, $p<0.05$) and shrub richness ($r = 0.777$, $p<0.005$). PC II was positively correlated with litter cover ($r = 0.759$ $p<0.05$), tree diversity ($r = 0.628$, $p<0.05$) and negatively correlated with grass density ($r = 0.661$, $p<0.05$) and percent grass cover ($r = -0.684$, $p<0.05$). Figure 2 shows the distribution of utilised and available plots in relation to the first and second components. The logistic regression model had an efficiency of 85.712% correct classification of available and utilised plots.

Conservation Threats for Mammals

Table 9 provides data on threat factors in national park and sanctuary area of the Govind Pashu Vihar. Mean tree cutting (0.77±0.15), mean tree lopping (0.61±0.18), mean cattle dung pile (6.29±1.11) and grazing (38.06 ±6.17) were recorded maximum in Sanctuary area in comparison to the national park. Evidence of fire was also recorded from sanctuary while no evidence of fire was recorded from the national park. The other major threats to musk deer in Govind Pashu

Table 8. Principal component analysis of indirect data of musk deer in Govind Pashu Vihar Wildlife Sanctuary and National park.

Habitat variables	PC1	PC2	PC3
Altitude	-0.134	-0.03	0.359
% Slope	0.034	0.122	-0.097
Tree density	0.424	0.628*	0.124
Tree diversity	0.336	0.691*	0.187
Tree richness	0.294	0.561	0.136
% Tree cover	0.175	0.642	-0.046
Shrub density	0.793*	0.089	-0.192
Shrub diversity	0.742*	0.312	0.067
Shrub richness	0.777*	0.254	0.017
% Shrub cover	0.688*	0.119	-0.208
Shrub height	0.874*	0.163	-0.087
Herb density	-0.062	-0.208	0.225
Herb diversity	-0.13	-0.140	0.866*
Herb richness	-0.124	-0.136	0.91*
Grass density	-0.091	-0.661*	0.262
Grass diversity	0.03	-0.097	-0.061
Grass richness	0.101	0.028	-0.076
% Ground cover	-0.142	-0.612	0.298
% Grass cover	-0.138	-0.684*	0.180
% Herb	-0.202	-0.234	0.210
% Bare ground	0.012	-0.110	-0.252
% Rock	0.182	0.024	-0.183
% Litter	0.124	0.795	-0.119
Bamboo	0.244	-0.087	-0.003
% Lichen	0.136	0.023*	0.048
% Moss	0.027	-0.046	0.069
% Grazing	-0.53	-0.111	0.301
% Fire	-0.109	0.015	-0.002
Cut trees	0.028	-0.087	0.334
Lopped trees	-0.324	0.17	0.37
Cattle dung	-0.24	-0.18	0.429
Distance from nearest human habitation	0.073	-0.103	-0.73*
Variation	13.06	12.504	10.487
Cumulative variation	22.4	35.31	46.11

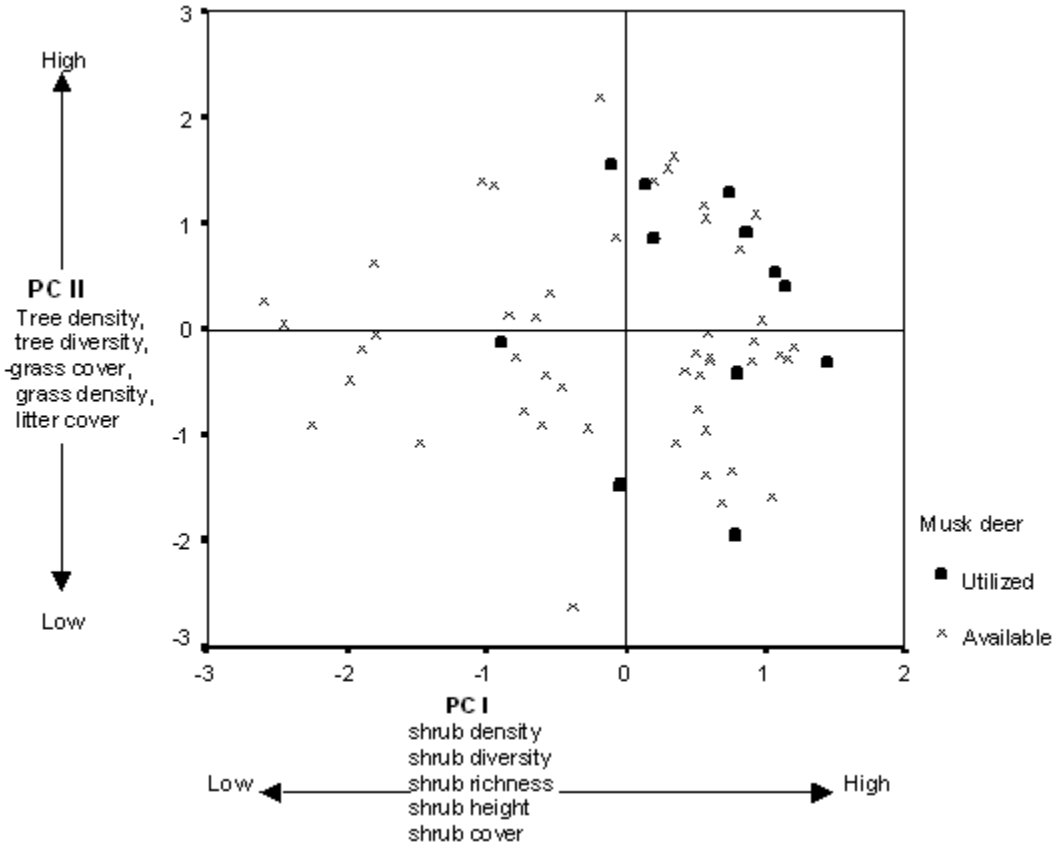

Figure 2. Ordination of available and utilized plots of musk deer in Govind Pashu Vihar wildlife sanctuary and National Park

Table 9. Mean number of cut trees, lopped trees, cattle dung piles per plot, grazing and percent of fire in national park and sanctuary area of Govind Pashu Vihar

Disturbance factor	National Park	Sanctuary
Mean Tree cutting plot^{-1}	0.31±0.16	0.77±0.15
Mean Tree lopping plot^{-1}	0.09±0.05	0.61±0.18
Mean Cattle dung pile plot^{-1}	1.13±0.43	6.29±1.11
% of Fire	0	0.81±0.81
% Grazing	9.06±3.84	38.06±6.17

Vihar wildlife sanctuary and national park are the poaching pressure and the man animal conflict across the sanctuary were assessed and the whole nexus of poaching, trade of mammal and its products were investigated in the sanctuary. Considerable time was spent with the locals to gain their confidence and than gathered valuable bits of information from casual talks.

Trading Routes of the Animal Products

As it is obvious, largely local influential inhabitants are involved in poaching with the help of licensed or unlicensed fire arms. But they are primary link of the well oiled trading pattern of the banned animal products and drugs. Usually they could not get the expected value of the product infact the traders having links with national and international market buy the banned products very cheep. Such network needs comprehensive study to understand the magnitude and pattern of trades in banned animal products. After primary links the products pass into the hand of intermediately who carries the product to the markets like one situated near Shimla, Chandigarh and Delhi, where the products finally passes into the hands of the traders. For conservation strategy

we need to keep in mind the working of such network and to find substitution of banned animal products.

DISCUSSION:

The musk deer was distributed throughout the higher altitude in the Himalayas. It has now disappeared from many forest patches. However, there were very few direct sighting of the musk deer in different patches, which suggests extremely low abundance of the species. The extremely low abundance of the species is due to high poaching pressure and the habitat loss. During the surveys, poaching was found to be common.

The rugged and forested terrain of the study area as well as the extremely low abundance of musk deer completely ruled out the possibility of use of distance sampling (Burnham et al. 1980, Buckland et al. 1993). Therefore apart from monitoring of trail, the use of indirect method was found to be ideal. The abundance for musk deer was slightly higher in national park areas. Most of the time musk deer was recorded in the group of one individual.

The technique to investigate the habitat use of different ungulate species by pellet group count method has been used extensively by various workers (e.g. Eberhardt and Van Etten 1956, Rodgers *et al.* 1958, Green 1985, Khan 1993 and Ilyas et al. 2003) in India and outside. The pellet group densities recorded in different habitat types showed that musk deer utilized the areas with high shrub density, diversity and cover with high shrub height. Most of the time they were recorded in the areas having the dominated shrub species *Rhododendron companulatem, which is present* above the 3000m at sea level with steep slopes. This habitat is known as the alpine scrub. The presence of the musk deer in the alpine scrub forest is due to the fact that musk deer is a species associated with 'tree line' which is considered to be its optimum habitat (Green 1985, Satyakumar et. al. 1993b). Understory in the form of *Rhododendron companulatum* and Mountain bamboo (*Thalmocalmus spathiflorus*) are the crucial determinant of musk deer habitat suitability in this case. Alpine scrub with its interspersion with alpine meadows and rocks provides adequate food and escape cover for musk deer.

The habitat factors, identified by the PCA analysis, which govern the micro habitat use of Musk deer in Govind Pahu Vihar were identified in macro habitat use. These are requirements for closed canopy, thickly wooded areas, which have diverse and thick shrub storey with diverse herb layer. This matches with the factors identified by comparison of available and utilised plots by musk deer. The major difference in case of musk deer between PCA results and that of pellet group density is the role of shrub cover. It again emerges as most powerful factor influencing habitat gradient associated with PC I.

Though, musk deer density in the Himalayas is largely influenced by poaching, its impact remains largely un-assessed. The other major factor is habitat destruction. Musk deer needs dense shrub cover or undergrowth for its shelter and food (Green. 1985). Musk deer depends on bamboo substantially for food during autum and winter (Green 1985).

The high altitude of Garhwal Himalayas used to be extensively covered with the alpine and sub alpine forest, but due to excessive grazing by the graziers by staying in the higher altitudes for duration of three to seven months during spring and summer has left the areas in very fragmented state. These camps are situated in the tree line areas as shelter, water; fire wood and fodder are easily available. This leads to use of not only the alpine pasture but also the grass and shrub cover of forested areas by goat and sheep (Rawat and Rodgers 1990).

Musk deer owes its endangered status to large scale hunting and poaching which is still widespread in Himalaya. On the authority of Tom MiUiken, Director of the Trades Records Analysis of Flora and Fauna in Commerce (TRAFFIC), Japan, it is shocking to note that Japan imported 1,488 kg of musk from Nepal between the year 1972 and the first quarter of 1981; 275 kg from India during 1972 to 1974; and 168 kg from Hong Kong during the last decade. The Japanese trade could, possibly, represent a total of about 280,000 deer. In 1978, Hong Kong exported a meagre 3 kg of musk to Japan, but by 1983 it traded 133 kg and the possibility of the origin of the musk from the Himalaya cannot be ruled out (Oza 1988).

The nuisance of poaching of musk deer which fetch handsome money in international market needs to be restricted by not only effective enforcement of wildlife protection laws but also by preventing such incidences at field level. Intensive patrolling by a well organised group of wildlife staff. It is extremely desirable that effective steps are taken to strengthen the infrastructure of PA's now.

Raising awareness among local communities about conservation values by quoting their values and ethos enshrined in sacred texts, which is part of our cultural life and this may be an effective tool to safeguard survival of the musk deer and several other mammalian species. It is indeed a difficult task but possibly is the only option.

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REFERENCES

Buckland, S.T., Anderson. D.R., Burnham, K.P. and Laake, J.L. 1993. Distance Sampling: Estimating Abundance of Biological Population. Chapman & Hall, London. 446 pages.

Burnham, K.P., Anderson, D.R. and Laake, J.L. 1980. Estimation of Density from Line Transect Sampling of Biological Population. Wildlife Monograph No. 72, The Wildlife Society, U.S.A. 202 pages.

Canfield, R. 1941. Application of the line intercept method in sampling range vegetation. Journal of Forestry 39: 388-394.

Eberhardt, L. and Vanetten, R.C. 1956. Evaluation of the pellet group count as a deer census method. Journal of Wildlife Management 20: 70-74.

Green, M.J.B. 1985. Aspects of the Ecology of Himalayan Musk Deer. Ph.D. dissertation, University of Cambridge, Cambridge, U.K. 280 pages.

Grubb, P. 1993. Order Artiodactyla. pages 377-414, In: Wildson, D.E. and Reeder, D.M. (Editors), Mammal Species of the World. A Taxonomic and Geographic Reference. Smith-sonian Institute Press. Washington, DC.

Ilyas, O. 2001. Status and Conservation of Ungulates in the Kumaon Himalayas with Special Reference to Aspect of Ecology of Barking Deer (*Muntiacus muntjak*) and Goral (*Nemorhaedus goral*). Unpublished PhD Thesis, AMU, Aligarh, 281 pages.

Khan, J. A. 1993. Ungulate Habitat Relationship in Gir Forest Ecosystem and its Management Implications. Ph.D. Thesis, Aligarh Muslim University. Aligarh. U.P. India. 185 pages.

Oza, G. M. 1988. The Himalayan Musk Deer: Encashed for Extinction. The Environmentalist 8 (4): 301-304.

Rawat, G.S., and Rodgers, W.A. 1990. The alpine measows of Uttrakhand. Pages 119-137, In: Singh, P. (Editor). Proceedings of National Rangeland Congress, New Delhi.

Rodgers, W. A., Panwar, H.S. and Mathur, V.B. 2000. Wildlife Protected Area Network in India: A Review (Executive Summary). Wildlife Institute of India, Dehradun. 44 pages.

Satyakumar, S., Prasad, S. N. and Walker, S. 1993 Status of captive Himalayan Forest Musk deer (*Moschus c. chrysogaster*) in India. International Zoo Yearbook (Zoological Society of London) 32: 32-38.

Satyakumar, S. 1994. Habitat Ecology of Major Ungulate in Kedarnath Musk Deer Sanctuary, Western Himalayas. Ph.D. Dissertation, Saurashtra University, Rajkot. 244 pages.

Zar, J.H. 1984. Biostatistical Analysis. Prentice-Hall, Engelwood Cliffs, N.J. 718 pages.