

Population Structure, Habitat Use and Conservation of Ungulates in Mosaic Landscapes of Garhwal Himalayas, Uttarakhand

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ABSTRACT

We studied the population structure, habitat use and conservation problems of three sympatric ungulate species namely muntjac (*Muntiacus muntjak*), goral (*Nemorhaedus goral*) and sambar (*Cervus unicolor*) in mosaic landscapes of Garhwal Himalayas. The average group size of goral and muntjac was 1.61 ± 0.15 and 1.73 ± 0.18 , respectively. Mean group size was higher in winter followed by summer and monsoon. Sex ratio in all three species was female biased. Encounter rate of goral and muntjac was 0.336/km and 0.3/km, respectively. The encounter rate between seasons was not significantly different. The mean pellet group density of muntjac differed significantly between seasons ($F=9.059$, $P<0.003$), however, no such significant seasonal difference was found in mean pellet group densities of goral ($F=0.312$, $P>0.577$) and sambar ($F=0.432$, $P>0.432$). The mean pellet densities differed significantly between different habitats for muntjac ($F=2.7$, $P<0.001$), goral ($F=1.7$, $P<0.001$) and sambar ($F=1.5$, $P<0.001$). All three species showed positive correlation with altitude and overlapped maximum in oak forest above 1600m. Water limitation and habitat destruction are the key issues for the conservation of the ungulates in the study area.

Key Words: Group Size, Niche Overlap, Habitat Use, Phakot Watershed.

INTRODUCTION

Decisions about how to manage wildlife often rely on information whether populations are increasing or decreasing (James 1996). Studies of habitat selection of individuals or population continue to play an important role in the efforts to generate sufficient knowledge for effective wildlife management (Otis 1997). Differential habitat selection is one of the principal strategy which permits species to co-exist. Habitat selection has been found to depend upon the magnitude of environmental variance, intra-specific and inter-specific interaction including competition and predation. Spatial and temporal variability in composition of vegetation structure has long been assumed to be dominant factor in habitat selection (Karr 1971). Single species approach to conservation,

management, and monitoring are insufficient to combat the threat to overall biological diversity of the area. Multi species based monitoring approaches are needed to provide reliable, timely and informative measures of change in the status of population, communities and biological diversity (Manley et al. 2005).

Few studies on mammals have been carried in the Garhwal Himalayas and these have been confined to the protected areas. Hence results of such studies can not be generalized to whole of the Garhwal Himalayas. The present study was carried out to investigate population structure and habitat utilization of sambar (*Cervus unicolor* Kerr), goral (*Nemorhaedus goral* Hardwicke) and muntjac (*Muntiacus muntjak* Zimmermann) in Phakot watershed area in specific and to assess the conservation threat to mammalian fauna in general.

STUDY AREA

The study was carried out in Phakot Watershed (henceforth Phakot) and adjoining areas of Sonarkot and Udhkhanda of Saklana Range in Tehri District. With an area of about 5000 ha, Phakot represents the western part of lower and middle Himalayas. The area has an elevation gradient of about 1400 m, and ranges from 600m to 2000m. Such a high gradient within small area has resulted onto a steep slope of about 72°. The general vegetation is represented by dry deciduous forest with a cover density of up to 40% which occupies nearly one fourth of the area. A broad classification of the area led to distinction of seven habitat types including agriculture land and fallow land and forest patches represented by dominant species of *Quercus leucotricophora* Linn., *Pinus roxburghii* Linn., *Anogeissus latifolia* Wall. and *Shorea robusta* Roxb. Phakot has 20 villages and hamlets with a human population of 3000. General occupation of people is agriculture and labour. There are three seasons with average temperature varying from 10 to 35°C and average rainfall is about 1900 mm in a year. Much of this water is lost as runoff (14%) and soil loss of 2.0 $\text{tha}^{-1} \text{year}^{-1}$. Among agriculture, Ginger is grown as cash crop and in lower areas where water is available, rice is grown. Since only one third of the area is arable, therefore water is proving to be a limiting factor for the agriculture productivity. People rear cattle for milk and plough and over the years the cattle population has increased to about 1500 mainly comprising of buffalo and cows contributing more than 70%. People also require fuelwood for daily use. Despite people adapting to gas based stoves, the annual consumption is about 1588.7 tons of fuelwood.

METHODS

A combination of direct and indirect methods was used for sampling ungulate populations. Trail Count (MaCaffery 1976) was utilized for recording direct sightings of ungulates. Six trails, which pass through almost whole of the area, were monitored. These trails were walked 34 times in total covering a distance of 204 km. The whole distance was covered in 90 hours. These trails were walked in the morning, mid-day and in the evening, though majority of trails were walked in the morning. Distance of trail and total time taken in completing the trail were recorded. Data on species, their number, age and sex were recorded. Sex and age

of different individuals was identified based on the morphological features and their size. Individuals were classified into five age categories namely adult male, adult female, sub-adult male and sub-adult female and fawn.

Since the direct sightings were limited, we relied on the indirect methods also. Pellet Group Count method was employed in quantification of indirect evidences. Pellet Group Count method was first described by Bennet et al. (1940) and has subsequently been used by a number of investigators (Eberhardt and Van Etten 1956) and others. Permanent circular plots of 10m radius were established in different habitats. Plots were randomly established maintaining an approximate distance of 250m between two plots. The presence of pellets groups indicate that the animal has used the area. The pellets of three species were distinguished from each other by their size, shape and color. Only fresh and well-shaped pellets were considered. Partially or completely disintegrated pellets were not included in the sample to avoid error. The sample plots were cleaned of any pellet before the onset of season and pellet groups were allowed to compile till the next sampling.

Statistical Analysis

Encounter rate was calculated (animal groups/km) both individually as well as season wise. Kruskal-Wallis One Way ANOVA was used to find out difference between encounter rate between species and seasons. All the data from direct sighting was pooled together for calculating group size and sex ratio. The number of pellet groups for each species in each plot was used to calculate pellet group density. The values were pooled together to calculate the mean pellet group density for each species vis-à-vis different habitat types. The values of the mean pellet group density were compared for different habitats to test for significant difference using One Way ANOVA. To find out the correlation between the pellet group densities of different mammalian species with habitat parameters, Pearson's Product Moment Correlation Coefficient were calculated. To understand the habitat use by the three ungulates, data were subjected to Principal Component Analysis (PCA). All the quantitative data based on indirect evidence in the data matrix were transformed using log and Arcsine transformation and were standardized following Zar (1999). Factor Analysis reduces the dimensionality of the habitat variable and this was done by pooling the whole data together. The

first two factors were used for interpretation as this explained maximum variance in the data. Pianka index was used for measuring species overlap using computer program Ecosim (Gotelli and Entsminger 2001). All other statistical tests were performed following Zar (1999) and using computer program SPSS.

RESULTS AND DISCUSSION

Population Structure

Trail counts resulted in encounters of 31 groups of muntjac consisting of 50 individuals, 22 groups of goral with 38 individuals and 5 groups of sambar having 5 individuals. The mean group size of muntjac and goral was 1.61 ± 0.15 and 1.73 ± 0.18 , respectively. The mean group size of muntjac and goral was higher in winter (2.0 ± 1.0 and 1.80 ± 0.58) than in summer (1.66 ± 0.17 and 1.73 ± 0.2), respectively. Group size was smallest in monsoon in both species (1.20 ± 0.2 and 1.50 ± 0.5 , respectively). There was however no significant difference in mean group size in three seasons. Sixty percent of goral groups had 2 to 5 individuals and 50% of Muntjac groups had one individual only.

Table 1. Encounter rate of goral and Muntjac in three seasons in Phakot Watershed Area.

Season	Goral	Muntjac
Summer	0.412	0.442
Monsoon	0.011	0.077
Winter	0.378	0.108

Goral population comprised of 52.6% females, 34.21% males and 13.1% fawns. The male to female to fawn ratio was 65:100:23. The population of muntjac comprised of 52% females, 32% males and 12% fawn and 4% individuals could not be classified. The male to female to fawn ratio was 65:100:25.

The overall encounter rates of goral and muntjac were 0.33/km and 0.30/km approximately one goral and muntjac was encountered after every 3 and 4 km of distance respectively. There was seasonal variation in encounter rates. Both goral and muntjac showed highest encounter rate in summer and lowest in

monsoon (Table 1). There was no significant difference in the encounter rates between species in different seasons.

The size of group is often considered a fundamental attribute of social organization of a species (Jarman 1974). Usually the observed group size is explained as arising from a balance between various advantages and costs of living in groups (Pulliam and Caraco 1984). Group size of Muntjac in Phakot was 1.61 and Goral 1.73. These values were higher than Orus (2001) in Kumaon Himalayas and Barrett (1977) but similar in range to Mishra and Johnsingh (1996) in Majhatal Harsang Wildlife Sanctuary. Small group size, apart from being an anti predator strategy, can be explained on the feeding habit of the species. Small body size results in higher basal metabolic rates requiring selective feeding on high quality food items available in the habitat (Jarman 1974). Small group size of Indian Muntjac is based on the fact that it is a solitary, forest dwelling ruminant and inhabits dense shrub cover in the broad leaved forest (Teng 2004). Being a nibbler (Barrett 1977), it feeds on tender leaves, twigs, seed pods and shrub fruits. These items have higher protein and accessible plant cell content and tend to be small, distinct and spatially scattered foliage (Jarman 1974). Goral despite being a grazer, exploits comparatively more high quality grasses than low quality grasses (Orus Ilyas and Khan 2003), which too are scarce and scattered and may generally govern its small group size. But its ability to exploit cliffs or landscape, not often liked by predators, explains its higher group size than muntjac in the study area.

Female biased sex ratios have already been reported in many studies in India. The disparity in adult sex ratio in favor of females has been attributed to several factors such as misclassification of individual, higher mortality of male fawn, selective predation on males, and male's solitary habits (Schaller 1967, Mishra 1982, Johnsingh 1983, Karanth and Sanquist 1992, Khan 1995). Since no fawn mortality was reported from the study area it is possible that female biasness is mainly due to misclassification of the individuals. It is more possible because, both goral and Muntjac are shy animals and in hilly areas can hide in a fraction of moment increasing the possibility of misclassification. Out of all animals aged, young one constituted less than 10% and sub-adult constituted less than 20%. The population in both goral and Muntjac thus is mainly represented by adults and may not be considered growing.

Habitat Relationships

Pellet groups were counted in summer and winter seasons for all the three species. Mean pellet group density (per hectare) was highest for muntjac (6.06 ± 0.158) followed by goral (4.24 ± 0.121) and sambar (1.009 ± 0.07). One way ANOVA showed significant difference in the mean pellet group densities of Muntjac in two seasons ($F=9.05$, $P<0.003$). There was however, no significant difference in the mean pellet group densities of goral ($F=0.31$, $P>0.577$) and sambar ($F=0.43$, $P>0.432$) in two season.

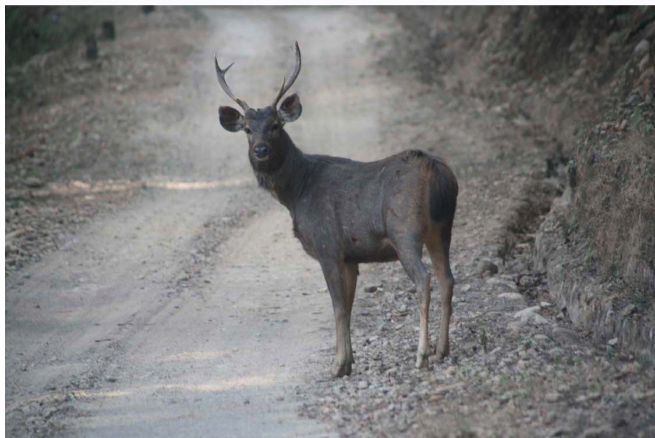
densities across different habitats ($F=2.7$, $P<0.001$). Mean pellet group density of goral was highest in pine forest (6.70/ha), and closely followed by oak forest (5.97). It was lowest in fallow land (1.42). The difference across different habitats was significant ($F=1.7$, $P<0.05$). Sambar was present only in three habitats (Table 2). Its pellet density was highest in oak forest (0.229/ha). The mean pellet density of sambar was significantly different in habitats ($F=1.5$, $P<0.05$).

Table 2. Mean pellet group densities (no./ha) of Muntjac, Goral and Sambar in different habitats in Phakot Watershed Area.

Habitat	Indian Muntjac	Goral	Sambar
Oak Forest	7.16	5.97	2.79
Mixed Sal	4.39	3.29	0.00
Mixed Bakli	8.25	2.36	1.18
Agriculture	5.62	1.87	0.00
Fallow land	5.66	1.42	0.00
Pine Forest	0.83	6.70	0.00
Miscellaneous	9.95	4.98	0.00



(a)



(b)

Figure 1. A general view of the habitat (a) and sambar (b) in the study area.

Out of seven habitats, mean pellet density of Muntjac was highest in miscellaneous forest (9.95 pellet groups/ha) and lowest in pine forest (0.83 pellet groups/ha). There was significant difference in mean

All three species showed positive relation with altitude. Pellet group density was highest above 1800m and lowest in the middle altitude from 900m to 1500m. Sambar did not occur on the lower altitudes and was present only after 1500 m. Mean pellet densities differed significantly between different altitude categories for muntjac ($F=2.6$, $P<0.026$) and goral ($F=8.2$, $P<0.001$), respectively. Sambar pellet group density did not differ significantly ($F=1.743$, $P>0.131$). Among the four aspects, muntjac showed highest density on the southern aspect followed by east and north. Goral on the other hand, showed affinity with eastern aspect followed by north. Sambar pellet group density was highest on northern aspect followed by south. However there was no significant difference in the mean pellet group densities between different aspects for all ungulate species.

All three species seemed to avoid the vicinity of the human habitation. Pellet density was highest at a distance of more than 2 km from nearest human habitation. Pellet group density of goral was highest at 0.5 to 1 km distance, probably due to its liking for cliffs and rocks, abundant in Nadumka, which was at

Table 3. Percentage overlap of three ungulate species along different topographic and habitat categories.

Variable	Variable Category	Species	Percent	rs overlap	P	
Altitude	600-1100m 1100-1600m 1600-2100m	Muntjac*Sambar	27	0.238	0.231	
		Muntjac*Goral	35	0.121	0.403	
		Muntjac*Goral	48	0.052	0.775	
		Muntjac*Sambar	34	0.145	0.420	
		Goral*Sambar	41	0.292	0.099	
Aspect	East	Muntjac*Goral	48	0.230	0.133	
		Muntjac*Sambar	35	0.281	0.065	
		Goral*Sambar	26	0.272	0.072	
	North	Muntjac*Goral	11	-0.146	0.404	
		Muntjac*Sambar	21	0.050	0.774	
		Goral*Sambar	50	0.522	0.001	
	South	Muntjac*Goral	60	0.393	0.071	
		Muntjac*Sambar	48	0.441	0.041	
		Goral*Sambar	25	0.156	0.488	
Tree cover	No tree cover	Muntjac*Goral	33	-0.182	0.552	
		Muntjac*Goral	33	0.123	0.324	
	0-30%	Muntjac*Sambar	17	0.072	0.568	
		Goral*Sambar	28	0.135	0.280	
		Muntjac*Goral	54	0.263	0.215	
		Muntjac*Sambar	36	0.311	0.139	
Shrub cover	0-20%	Muntjac*Goral	39	0.126	0.431	
		Muntjac*Sambar	30	0.303	0.054	
		Goral*Sambar	47	0.476	0.002	
	20-40%	Muntjac*Goral	29	0.012	0.943	
		Muntjac*Sambar	15	0.000	1.000	
		Goral*Sambar	23	0.205	0.238	
40-60%	Muntjac*Goral	53	0.449	0.054		
	Muntjac*Sambar	84	0.309	0.199		
	Goral*Sambar	31	-0.081	0.742		
60-80%	Muntjac*Goral	63	0.447	0.267		
	Grass cover	0-20%	Muntjac*Goral	48	0.163	0.271
			Muntjac*Sambar	39	0.271	0.069
Goral*Sambar			44	0.338	0.022	
20-40%		Muntjac*Goral	20	0.012	0.943	
		Muntjac*Sambar	24	0.064	0.788	
		Goral*Sambar	58	0.506	0.023	
40-60%	Muntjac*Goral	35	0.276	0.252		
	Muntjac*Sambar	35	0.276	0.252		
	Goral*Sambar	0	-0.056	0.821		
60-80%	Muntjac*Goral	58	0.261	0.296		
	Habitat	Oak	Muntjac*Goral	49	0.077	0.701
			Muntjac*Sambar	34	-0.079	0.697
Goral*Sambar			45	-0.333	0.093	
Mixed Bakli		Muntjac*Sambar	57	0.509	0.133	
Fallow Land		Muntjac*Goral	25	0.068	0.776	
Miscellaneous Forest		Muntjac*Goral	57	0.285	0.268	

a distance of about 1 km from Katkore village. Unlike goral and sambar, muntjac seemed tolerant to the human presence. The Pellet group density of muntjac and goral was higher in non grazed area than grazed ones. However, sambar pellet group density was highest on grazed plots.

The first two components extracted by PCA accounted for 27.48% of variance for goral, 25.76% for muntjac and 27.26% for sambar in the data sets. The first component, in case of goral, was positively correlated with shrub density, shrub cover, grass height, and tree height and negatively with herb density. The second component was positively correlated with herb density, herb diversity and herb cover. The first component for muntjac, was highly positively correlated with shrub density, shrub cover, grass height and grass cover. The second component was positively correlated with altitude and distance from nearest human habitation. For sambar first component was positively correlated with shrub density, shrub height and cover. Second component was positively correlated to herb richness and grass diversity.

Muntjac prefers mixed bakli and oak forest whereas goral showed preference for pine and oak forest. Affinity of goral with pine forests has earlier been reported by Mishra and Johnsingh (1996). Preference of mixed bakli forest by muntjac can be explained on the fact that this habitat occurred in the vicinity of water source. Since water availability was limited, so muntjac preferred to be close to it. Pellet group densities of both goral and muntjac were high in oak forests. Orus Ilyas and Khan (2003) analyzed food quality in Binsar Wildlife Sanctuary and found that crude protein values in oak forest were comparatively higher thus arguing for the use of oak forest. Small forest ungulates like goral and muntjac chose to inhabit and hide in thick cover to avoid predation (Geist 1974, Chapman et al. 1993, McCullough et al. 2000). Oak forest had maximum tree cover and well developed understory. Seeking dense canopy cover by muntjac is an important thermal strategy in winter (Mysterud and Ostbye 1995) and provides a means to avoid heat stress during summer (Sargeant et al. 1994). Since temperature is an important factor in temperate areas like Phakot, this may explain the preference of muntjac. Similarly goral used dense understory as anti-predator strategy. Oak forest had the advantage that it was close to agriculture and follow land and also had rocky cliffs liked by goral. Sambar's preference for structured forests is already known. Schaller (1967) believed that since sambar has an oriental origin

therefore it is adapted to forested habitats. Sambar, which is predominantly a browser (Schaller 1967, Mishra 1982), explained its affinity for shrubs.

Table 3 gives the overlap percentage between muntjac, goral and sambar generated using Pianka's Index with selected habitat variables. Overlap percentages signify competition between three species. All the three species overlap maximum in oak forest patch above 1600m altitude. The maximum overlap between goral-muntjac and muntjac-sambar was on the southern aspects whereas overlap between goral and sambar was highest on northern aspect.

Oak forest lies on the southern slopes and at present it is comparatively less disturbed. Shrub cover in the range of 40 to 60% and tree cover in the range of 30 to 60% made it ideal for muntjac and sambar. It was also in continuity with forest patch beyond the study area. In order to avoid direct competition the three ungulate species have evolved a strategy of occupying three different areas within the forest. Sambar occupied the northern aspect and Muntjac occupied lower side of southern aspect whereas goral occupied the higher elevations of southern aspect represented by *nadumka* cliff. Competition between two species with considerable overlap in their tree and shrub cover may be avoided by showing different preference for food items (Green 1985). Goral is a grazer (Green 1987, Mishra and Johnsingh 1996, Orus Ilyas and Khan 2003) whereas Muntjac is a browser which feeds on shrubs and forbs utilizing a diverse range of plant species (Orus Ilyas and Khan 2003).

Both reserve and civil land is grazed by local people and shepherds. These shepherds also clear the ground vegetation for spreading salt licks. Being accompanied by trained dogs which may chase and even kill any wild animal. The disturbance, competition and threat for life may be forcing these ungulate especially goral to move to upper areas or altogether leave the area. Since the formation of Uttarakhand state, there has been increased demand for connectivity in terms of roads and electricity. There seems to be increased tendency among villagers to see a road being constructed up to their village. Some new roads are been constructed in the study area. National Highway 94 passes through the area and divides the watershed into two parts. Being a lifeline to the Uttarkashi and Tehri districts, this road carries a heavy vehicular traffic. Ungulates were found reacting negatively to the road. The movement of traffic for 24 hours acts as a barrier to the natural movement of the wild animals.

This has resulted into the fragmentation of the area and creates isolated population.

Water is an important factor for the distribution and survival of a species. Phakot has perennial sources of water in the form of *hemal* river and *birnu khala*. There are various natural springs which wild animal and human population may have been utilizing. However, over the years these springs have been covered with concrete walls and roofs. Thus these water points are no longer used by wild animals. Among the most threatening weed, *lantana* is spreading fast in the area. It was present in one fourth of the sampling plots. It has spread up to 1457m. It is feared that in due course the weed will continue its upward journey and may dislocate the native shrubs like *Colobrookia oppsi-tifolia* Smith, thus further degrading the available ungulate habitats.

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