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Ecology and Conservation of Mountain Ungulates in Great Himalayan National Park, Western Himalaya

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SUMMARY

Ungulates form a major component of the mammalian fauna in the Himalaya. In total, 19 ungulate species belonging to four families viz., Moschidae, Cervidae, Bovidae and Equidae, inhabit the Himalaya, out of which eight species are reported from the state of Himachal Pradesh (HP). Apart from some surveys and short-term ecological studies on a few ungulate species of Western Himalaya, there has been no detailed study on ungulates of HP except for Himalayan ibex (Capra ibex sibirica). The available literature highlights the difficulties of studying rare and/ or elusive ungulates in Himalayan condition. Long term study on the ecology of theses species are needed for the conservation and monitoring.

Present study on the ecology and conservation of ungulates namely goral (Nemorhaedus goral), Himalayan musk deer (Moschus chrysogaster), Himalayan tahr (Hemitragus jemlahicus), in Great Himalayan National Park, Kullu district, HP, was conducted from January 1996 to November 1998. An intensive study area of ca. 90 km^2 was selected in the Southwestern region of the Park, which represents various ecological zones of the Park. The objectives of the study were (i) to determine the status, relative abundance and distribution of mammals in GHNP, (ii) to estimate the abundance and density of goral, Himalayan musk deer & Himalayan tahr in relation to human use, (ii) to determine the group size, composition & sex ratio of these animals, (iii) to study the habitat use pattern and (iv) to identify and discuss conservation issues, mitigation measures and to develop a long term monitoring programme.

Four trails (2.2 km each) were walked twice every month from January 1996 to November 1998 to estimate the encounter rates (ER) and density of goral and its pellet groups. The goral abundance was also estimated by scanning of three vantage points (n=37). Density of Himalayan musk deer was estimated using silent drive counts (n=6) in two areas. Four vantage points were systematically scanned to estimate the abundance of Himalayan tahr. Seasonal and diurnal variation in the group size of goral was estimated by regularly monitoring trails in the study area in different time periods supplemented by instantaneous scanning. Group size, composition and sex ratio of Himalayan musk deer and Himalayan tahr were determined by systematically traversing through their habitats and scanning. Habitat usage data of goral were collected on four trails and the availability were recorded at every 100 m distance in these trails (n=88). For Himalayan musk deer and Himalayan tahr, habitat availability were estimated based on 80 constrained random points each in their habitat with standard techniques and the usage was recorded for every sightings in the same area.

Thirty-one mammalian species, which are representative of six orders viz., Primates (two species), Carnivora (12 species), Artiodactyla (seven species), Insectivora (three species), Rodentia (six species) and Lagomorpha (one species) were recorded in the area. Current status, distribution and abundance of all the species have been discussed.

The ER and density of goral in the area ranged from 0.45±0.15 to 2.57±0.59/km and 3.69±1.30 to 26.38±4.88/km^2 respectively. Seasonal ER and density estimates varied significantly but the estimates were similar between years. The abundance estimates were higher in less disturbed areas. The density estimates of goral obtained by scan method ranged from 1.70±0.77 to 5.00±1.47/km^2. The pellet group ER for goral in the area ranged from 6.93±0.67 to 10.83±1.18 and varied significantly between seasons. The ER of goral in the area was strongly correlated (r^2=0.89) with the density estimates but the correlation was weak with pellet group ER. The density estimates for musk deer in Gumtharao and Dhela area were 3.33±0.29 and 0.72±0.49/km^2 respectively. Based on surveys the presence of musk deer was identified only in seven fragmented patches in the intensive study area. The density estimates for Himalayan tahr in the area ranged from 0.73±0.50 to 4.90±1.58/km^2. The abundance and density estimates of ungulates of GHNP were low when compared with estimates from other parts of western Himalaya.

Goral formed aggregations that varied spatio-temporally, fluctuating in size from one to 14 animals. The mean group sizes for winter, spring and autumn were 2.26, 1.88 and 1.61 respectively. Group size varied significantly between seasons, but was similar in different time of the day, except for winter evenings. Larger groups were formed in less disturbed areas (27%, n=256) in contrast to more disturbed areas (12%, n=189). Of the 857 gorals observed, only 146 (17%) were classified to sex and age classes. A total of 66 individuals of Himalayan musk deer were sighted from 65 encounters, of which 35% individuals could not be classified to sex and age classes. The adult male to female ratio of musk deer in the area was 1:1.6 with no detected seasonal variations. Himalayan tahr in the area formed aggregations that varied from one to 26 animals. The mean group size for spring and autumn was 5.14 and 5.15 animals/groups and there was no seasonal variation in the group size. Although larger groups were encountered in less disturbed areas (28%, n=53) compared to more disturbed areas (19%, n=31), the difference was statistically non-significant. Himalayan tahr in the area tends to remain in smaller groups (<6 individuals) throughout the study period. Adult sex ratio of Himalayan tahr showed a seasonal variation and was skewed towards females. Large number of male (28%) and female groups (57%) observed during spring suggests that sexes generally are segregated in Himalayan tahr. Contrary to the earlier reports, all male groups observed in the area were solitary.

Goral in the area preferred altitudes between 2301-2600m throughout the year. Southerly aspects were used relatively more in all seasons with a preference towards South and Southeast aspects. They were mainly observed in steeper (41-50^0) slopes. They mainly used areas with low tree cover (<20%), low shrub cover (<20%), moderate grass cover and rock and soil cover. Himalayan musk deer in the area avoided altitudes below 3200m. Except for western aspects all the aspects were used in proportion to the availability. Moderate slopes (21-50^0) were used through out the year and steeper slopes (>60^0) were consistently avoided. Himalayan musk deer mainly used areas with low tree cover (<10%), moderate to high shrub cover (21-60%), low grass cover

(<20%) and moderate rock and soil cover (11-40%). There was no significant difference in the use of covers by Himalayan musk deer except for grass cover. Himalayan tahr in the area preferred areas between 3301-3500m, in southern aspects and with steep slopes (51-70^0) throughout the year. They mainly used areas with low tree cover (<10%), low shrub cover (<20%), moderate grass cover (11-50%) and high rock and soil cover (51-60%).

Of the three ungulate species studied, Himalayan musk deer is most threatened within GHNP as well as through out the Western Himalaya. Low densities or complete absence of Himalayan musk deer in overgrazed and highly used areas indicate that these areas need immediate attention for conservation. Potential threats to goral and Himalayan tahr has also been identified. Conservation implications and management strategies have been discussed. Suggestions are given for further research, monitoring and overall conservation of GHNP with special reference to ungulates.

1.0 INTRODUCTION

1.1. THE HIMALAYA

The Himalaya embraces the complex system of nearly parallel ranges of Tertiary mountains. These mountains are one of the youngest formations and are mainly having a northwest to southeast orientation. The main range of the Himalaya comprises of three zones: the Outer Himalaya (up to 1500 m above msl), the Middle Himalaya (up to 5000 m) and the Greater Himalaya, the highest mountain range in the world, with peaks such as Everest, exceeding 8800 m (Wadia 1966, Jhingran 1981). The Shiwaliks run parallel to the Outer Himalaya on the southern side and to the north of the Indo-gangetic plains. The Fold Mountains, the Himalaya, had originated as a result of tectonic movements of continental plates and is believed to be still growing. The formation of the Himalaya resulted in new barriers and corridors, which influenced the dispersal of flora and fauna. Being the meeting point of two biogeographic realms, viz., the Oriental and the Palaearctic (Mani 1974), the Himalaya provided various habitats that were occupied by many primitive as well as newly evolved species.

The Himalayan region, one of the richest biogeographic zones in India, covers an area of about 42,200 km^2, nearly 15% of India's land surface. The location, climate and topography of the Himalaya have endowed it with rich and diverse life forms. Of the 372 mammalian species in India as many as 241 species (65%) are recorded in the Himalaya and as many as 29 (37%) of mammalian species listed under Schedule I of Indian Wildlife (Protection) Act (1972) occur in the Himalaya (Ghosh 1996). However, scientific information on many of these mammals is still lacking. With the exception of a few ecological studies which have been carried out in the recent past (Green 1985, Kattel 1990, Chundawat 1992, Sathyakumar 1994, Bhatnagar 1997 and Manjrekar 1997), all other information is based on status surveys (e.g., Schaller 1977, Gaston *et al*. 1981, 1983, Fox *et al*. 1988, 1991, 1992, Cavallini 1990, 1992, Gaston & Garson 1992, Lovari & Appollonio 1993, Sathyakumar 1993) and short term studies (Mishra 1993, Pendharkar 1993).

The Indian Himalayan region is inhabited by about 51 million people (6% of Indian population) (Anon. 1993). The human population in the area has increased over 170% since 1951 (Moddie 1981). Alterations in cropping patterns and development activities in the Himalaya have led to the shrinkage of much prime wildlife habitats. The existing and proposed network of Protected Areas (PAs) in the Indian Himalayan region covers ca. 9.2% of the total range (Rodgers & Panwar 1988). About 65% of these PA's are located between 2000 m and 4000 m, which is densely populated.

Biogeographically, the Himalaya is divisible into four provinces viz., Northwestern, Western, Central and Eastern (Rodgers & Panwar 1988), each characterized by distinctive flora and fauna. In the west, the Sutlej River is taken as a boundary between the western Himalaya and northwestern Himalaya (Mani 1974). The mountainous state of Himachal Pradesh, with elevations ranging from 300 to over 6000 m, accounts 17% of the area of the northwestern Himalayas. Bio-geographically the state can be divided into three distinct regions: the Trans-Himalaya, which include the cold deserts of northern Lahul and Spiti districts; the Greater Himalayas, high and middle mountains covering most of the state; and the semi Arid zone, consisting the hot dry foot hills in the south (Rodgers & Panwar 1988). Two National Parks and 29 Wildlife Sanctuaries have been set up so far in Himachal Pradesh covering 7.1% of the state area (Singh *et al*. 1990).

1.2. THE UNGULATES

Ungulates form a major component of the Himalayan mammalian fauna. They form the major prey base for the large mammalian predators. Ungulates often modify their activity pattern in response to habitat differences, seasons and disturbance factors, and their behaviour could be a sensitive indicator of habitat quality, protection and management (Owen-Smith 1979, Pachlatko & Nievergelt 1985). In total, 19 ungulate species belonging to four families viz., Moschidae, Cervidae, Bovidae and Equidae, inhabit the Himalaya (Bhatnagar 1993). The Himalaya and associated mountain ranges form the home to 12 of 31 species (38.7%) of Caprinae found worldwide, the richest in any part of the world (Shakleton 1997).

In Himachal Pradesh, nine species of ungulates are present. They are goral (*Nemorhaedus goral bedfordi*), Himalayan musk deer (*Moschus chrysogaster*), Himalayan tahr (*Hemitragus jemlahicus*), barking deer (*Muntiacus muntjak*), wild boar (*Sus scrofa)*, sambar (*Cervus unicolor*), serow (*Nemorhaedus sumatraensis*), Himalayan ibex (*Capra ibex sibirica*) and blue sheep or bharal (*Pseudois nayaur*). Present study focuses only on goral, Himalayan musk deer and Himalayan tahr, which occupy the middle and high altitudes (between 2000-4000 m), a zone of intensive human use in the Western Himalaya. Goral is regarded as one of the major prey bases for the apex predators in the area, such as common leopard. It mainly inhabits the steep south facing slopes in the temperate forests of GHNP, which has a considerable area under grassy slopes, which have developed due to frequent fires and grass cutting. Musk deer is one of the most endangered ungulates inhabiting the sub-alpine and alpine areas. GHNP had quite a few areas, which are used by musk deer (Gaston & Garson 1992). However, it is restricted to only few patches now. Himalayan tahr was one of the most hunted species in the area for meat until hunting was banned in 1984 (Gaston & Garson 1992). This species mainly inhabits the steep south facing slopes of upper temperate, sub-alpine and alpine regions.

1.3. REVIEW OF LITERATURE

1.3.1. Literature on Goral

Gorals (*Nemorhaedus* spp.) belong to the Family Bovidae, Sub-family Caprinae and Tribe Caprini. Three species of goral are recognised by Grubb (1993), viz., the Himalayan goral (*Nemorhaedus goral*), distributed in the Himalayan regions of India, Pakistan, Nepal and Bhutan; the Red goral (*N. bailey*), found in southeast Tibet, Yunnan, Myanmar and Northeastern states of India; and the Grey Chinese goral (*N. caudatus*), occurring in Russia, east China, east Myanmar and west Thailand. The Himalayan goral is represented by two sub-species: the Grey goral (*N. goral bedfordi*) of the western Himalaya and the Brown goral (*N. goral goral*) of the eastern Himalaya. The goral is a cliff-dwelling mountain ungulate, 65-70 cm high and weighing about 25-30 kgs (Prater 1980). The species is sexually monomorphic and has a short, (not more than 13 cm) sharp black horns that diverge slightly, and curve backward (Plate 1a). Grey goral is generally yellowish grey suffused with black in colour except the chin, upper lip, underside of jaws and throat which are white (Prater 1980).

Goral is found from 200 m above msl in the Shiwalik Hills to 4000 m in the main Himalayan range (Schallar 1977 and Johnsingh 1992). Information on goral is anecdotal mostly dealing with natural history and morphology (e.g., Jerdon 1867, Pocock 1908, 1914, Hayman 1961, Roberts 1977, Schaller 1977, Green 1981, Soma 1987, Heptener *et al.* 1989, Mead 1989). Among a few quantitative studies of its ecology and behaviour, Green (1987) studied the ecological separation of goral with other ungulates in Kedarnath Wildlife Sanctuary. He estimated a density of 2.6 gorals/km^2 in the sub-alpine zone. Mishra (1993) and Pendharkar (1993) quantified the habitat use of goral in Majhatal Sanctuary and Simbalbara Sanctuary respectively. Lovari & Appolino (1994) conducted a study on the habitat use, group size and activity pattern of goral in Majhatal Sanctuary. Sathyakumar (1994) studied the abundance, habitat use and status of goral in Kedarnath Sanctuary. He estimated a density of 15.5 groups/km^2 for low altitude oak-pine mixed forests and 3.8 groups/km^2 for middle temperate scattered tree and scrub forest, with a mean group size of 1.96. Goral in general, and the adult males outside the rut in particular, are solitary (Schallar 1977, Green 1987 and Mead 1989). Group size is reported to vary from 1 to 12. Except for Sathyakumar (1994), all other ecological studies were carried out either below 2000 m or above 3000 m altitudes. Information on the status and distribution of goral is also available from surveys conducted by Gaston *et al*. (1981) and Gaston & Garson (1992) in Great Himalayan National Park, Cavallini (1992) in Himachal Pradesh, Sathyakumar (1993) in Nanda Devi National Park and Govind Pashu Vihar and Mishra *et al*. (1994) in Mizoram. Gaston *et al* (1981) expressed the result as number encountered per hour search while the others expressed the encounter rate as number per km walk. No comprehensive survey investigating the status and distribution of goral has been conducted in India so far.

1.3.2. Literature on Himalayan Musk Deer

Himalayan musk deer is a member of the Family Moschidae, which is represented by four species (Grubb 1993). The other three species are the Siberian musk deer (*M. moschiferus*), distributed in east Siberia, north Mongolia, north China, west to Kansu and Korea, the Dwarf musk deer (*M. berezovskii*), found in southern and central China including Anhwei and north Vietnam and the Black musk deer (*M. fuscus*), distributed in west Yunnan, southeast Tibet, north Myanmar and Sikkim (Green 1986). The Himalayan musk deer (*Moschus chrysogaster*) is a small, solitary, cryptic and primitive deer-like ruminant, occurring in the forested areas of the Himalaya from 2500 to the 'treeline' (Plate 1b). It measures not more than 55 cm in height at shoulder and weighs between 10-13 kg. The general body colour is grey-brown with indistint pale transverse brands across the back. Green (1985) has described the physical attributes of the species in detail. The distinguished characteristic of the species is the absence of antlers and the facial glands, presence of gall bladder, musk gland and caudal gland.

Most of the information about distribution and habits of the musk deer was collected by hunters and amateur naturalists who began to explore the region during the 19th century (e.g., Jerdon 1867, Sterndale 1884, and Blanford 1891). Twentieth century knowledge about the Himalayan musk deer has remained fragmentary. The anecdotal nature of many of recent literature highlights the difficulties of studying such an elusive and rare animal in Himalayan conditions. It is listed in Schedule I of Indian Wildlife (Protection) Act, 1972 (Anon. 1992). Once of continuous distribution, it is now restricted to few isolated pockets in Himalaya due to large-scale poaching and extensive habitat destruction (Green 1985, 1986, Sathyakumar *et al*. 1993a and Sathyakumar 1994). Green (1989) has reviewed the status of captive musk deer in the world from 1959-1980. Sathyakumar *et al*. 1993b reviewed the status of captive musk deer in India. Available information on Himalayan musk deer is based on three intensive studies and a few status surveys. Green (1985) investigated the population, ranging behaviour, activity pattern, habitat use, feeding habits and ecological relationships with other ungulates in Kedarnath Wildlife Sanctuary. Kattel (1990) and Kattel & Alldredge (1991) studied the ecology of Himalayan musk deer in Sagarmatha National Park, Nepal using radio telemetry. Aspects of the ecology of musk deer living in a forested portion of the Tibet-Qinghai plateau were investigated during 1988-90 by Harris & Guiquan (1993) and estimated a density of 2-3/km^2. Sathyakumar (1994) studied the population, habitat use and status of Himalayan musk deer in Kedarnath Wildlife Sanctuary. Green (1985) reported the musk deer density as 3.2/km^2 for the sub-alpine forests of Kedarnath WS where as Sathyakumar (1994) estimated it as 3.7/km^2 for the same study area. Information on the status of musk deer is available from surveys conducted by Green (1978) in Langtang National Park, Upreti (1979) in Sagarmatha National Park, Gaston & Garson (1992) in Great Himalayan National Park and Sathyakumar (1993) in Nanda Devi National Park. All other information on musk deer is anecdotal (Schallar, 1977, Dang 1968, Prater 1980 and Tak & Kumar 1987).

1.3.3. Literature on Himalayan Tahr

Himalayan tahr (*Hemitragus jemlahicus*) represents one of the three species of the Genus *Hemitragus* classified under the Tribe Caprini (Grubb 1993). The other two species are the Nilgiri tahr (*H. hylocrius*) and the Arabian tahr (*H. jayakaeri*).

Himalayan tahr is a group living wild goat that inhabits the most inaccessible terrain, and is found in habitat with precipitous terrain of towering cliffs, rocks, scrub and forest between 2000 to 4000 m. (Plate II a&b). Males are larger than females and measures 90-100 cm at shoulder and weigh about 90 kg. (Prater 1980). Both males and females have massive horns almost of equal size. A detailed description of the species has been given by Sathyakumar (1994).

It is endemic to Himalaya and listed in Schedule I of the Indian Wildlife (Protection) Act, 1972. Two introduced populations exist, one in New Zealand and other in Cable Mountains in Africa (Grubb 1993, Caughley 1967, 1970). Once of continuous distribution, the Himalayan tahr is now restricted to isolated pockets due to loss of habitat and disturbances (Schallar 1977). Not much literature is available on the ecology of native population of Himalayan tahr. Green (1978) studied the population, habitat use and feeding ecology of Himalayan tahr in Langtang National Park and reported tahr densities to range from 5 to 46/km^2. Later Sathyakumar (1994) investigated the abundance and habitat use of tahr in Kedarnath Wildlife Sanctuary and estimated the tahr density as 5 to 6 groups/km^2 with a mean group size of 13.7. Surveys conducted by Gaston & Garson (1992) in Great Himalayan National Park and Sathyakumar (1993) in Nanda Devi National Park also give a preliminary status of the species. All other available information on Himalayan tahr is anecdotal (Schallar 1977 and Tak & Kumar 1987).

1.4. OBJECTIVES

The perusal of literature shows that no detailed long-term study has been carried out on the ecological aspects of these ungulates in H.P. In order to get base line information on various ecological aspects of the species, the present study was carried out in GHNP, with the following objectives:

- To determine the status, relative abundance and distribution of mammals in GHNP
- To estimate the relative abundance of goral, Himalayan musk deer and Himalayan tahr in different human use zones
- To determine the group size, age and sex composition of these ungulates
- To study the habitat use patterns of these ungulates and their ecological separation
- To identify the conservation issues of ungulates and to suggest mitigation measures and to develop a long term monitoring programme for ungulates

1.5. SELECTION OF THE STUDY AREA

Surveys conducted during the Himachal Wildlife Project (HWP) by Gaston *et al.* (1981) led to the creation of GHNP. HWP in 1983 conducted surveys in the demarcated area of proposed GHNP and made suggestions for management strategies. A reappraisal survey undertaken by HWP in 1992 emphasized the need for further studies to create a base line data for the Park. The Wildlife Wing of Himachal Pradesh Forest Department visualized the role of Wildlife Institute of India (WII) as a nodal institution to undertake wildlife research and monitoring programmes in GHNP. Subsequently, under Forestry Research Education and Extension Programme (FREEP), a project entitled “An ecological study of the conservation of biodiversity and biotic pressure in the Great Himalayan National Park: An ecodevelopment approach” was launched by WII during June 1995. One of the major objectives of the project was to study biological diversity of GHNP with a view to establish base line data for future monitoring programmes on floral and faunal attributes of GHNP on a long term base.

1.6. ORGANIZATION OF THE CHAPTERS

The report is organized into seven chapters. After a brief introduction to the study area (Chapter 2), status, distribution and abundance of mammals are discussed in Chapter 3. The abundance and density estimates of ungulates are discussed in Chapter 4, followed by group size, age and sex composition in Chapter 5 and habitat use trends in Chapter 6. The specific methods, statistical analyses of the results and the discussions are presented in each Chapter separately. In conclusion (Chapter 7), the conservation issues, their possible mitigation and the long term monitoring of ungulates in the study area is presented.

2.0 STUDY AREA

This study was conducted in Great Himalayan National Park (GHNP), which is located in the Kullu district of Himachal Pradesh ($31^0 38'28''$ to $31^0 51'58''$ N & $77^0 20'11''$ to $77^0 45'52''$ E). The area is located at the junction of two faunal realms namely Palaearctic and Oriental (Mackinon *et al*. 1986). The Park is contiguous with the Rupi Bhaba Wildlife Sanctuary (295 km^2) in the Southeast, Pin Valley National Park (675 km^2) in the Northeast and Kanawar Wildlife Sanctuary (90 km^2) in the North (Fig. 2.1). The latter will be connected to GHNP through the proposed extension in the Parvati river catchment (Pandey, S. *pers*. *comm*.). These areas together constitute one large area (2231 km^2) of relatively undisturbed wildlife habitat in the North Western Himalaya and deserve the status of a Biosphere Reserve.

2.1. AREA AND LEGAL STATUS

The National Park encompases an area of 765 km^2 and includes 41 km^2 of Reserved Forests (RFs), 631.25 km^2 of demarcated Protected Forests (PFs), 91.86 km^2 of undemarcated Protected Forests Class-III and 0.74 km^2 of cultivated land. The initial notification of the Park (620 km^2) was issued in 1984 under the Wildlife (Protection) Act of India, 1972. In 1994, 90 km^2 area in the central portion of the Park was notified as Sainj Wildlife Sanctuary and an area of 235 km^2 of the upper portion of the Parvati Valley was added to the Park, making the total area of 765 km^2. For management and protection purposes, the GHNP conservation unit includes an Ecodevelopment Project Area of 255 km^2 extending upto 5 km from the Western boundary, the Sainj Wildlife Sanctuary (90 km^2) and the Tirthan Wildlife Sanctuary (61 km^2), thus covers an effective area of 1171 km^2 (Pandey and Wells 1997). Legal formalities for issue of final notification of the Park are in progress.

2.2. THE INTENSIVE STUDY AREA

An intensive study area of about 90 km^2 was selected in the southern region of the Park in the Tirthan Wildlife Range and part of Sainj Wildlife Range (Fig.2.1.). The selection was made based on a reconnaissance survey during autumn 1995. It is a representative of all the four valleys of GHNP with a wide altitudinal range, various aspect and slope categories and different vegetation types. The relatively easy assessibility and the presence of the study animals in different anthropogenic levels are the other justifications for the selection of the area. The intensive study area comprised of Rolla RF, parts of Homekhani RF, and parts of Rikhundi and Basu PFs. There are no roads inside the intensive study area and is approachable only along bridle paths through rugged terrain along the Tirthan and Sainj rivers. Important sites/locations in the intensive study areas include Rolla, Shilt, Basu, Khoilipoi, Rakhundi, Gumtharao, Nara and Kharongcha (Fig.4.1.).

2.3. CLIMATE

The climate of the Park is typical of the temperate and alpine regions of the Western Himalayas. The area experiences four distinct seasons viz., Winter (December-March), Spring (April-June), Summer (July-September) and Autumn (October-November). Precipitation is generally moderate (1100-1500 mm), being highest during summer/monsoon season. Snow falls throughout the Park in winter, and above 3000 m snow generally persists till April. The intensive study area also experienced similar weather conditions. At Rolla, temperatures vary between a mean minimum of -3.5^{0}C in January to a mean maximum of 33.1^{0}C in June (Fig. 2.3.). Nara recorded a mean minimum of -4.2^{0}C in January and a mean maximum of 28.2^{0}C in June (Fig. 2.4). The area experiences severe winter with heavy snowfall during January and February. Spring is characterised by snow melt and sprouting and fresh sprout of vegetation between April and June. In summer, vegetation growth is at its peak. With the onset of autumn there is a steady decline in daily temperature. Dry conditions and senescence of most plants continue till snowing occurs in November/December.

2.4. HYDROLOGY AND TOPOGRAPHY

GHNP constitutes the upper catchment of the Tirthan, Sainj, Jiwa and Parvati rivers, all flowing east to west and mingling into the river Beas. The Park has numerous streams with a drainage density of 15.79 m/ha and drainage texture of about 1.85 Nos/100 ha with order of streams varying from 1st order to 6th order (Negi 1997). The altitude ranges from 1344 m (near Seund at the confluence of Jiwa and Sainj rivers) to 6248 m (at an unnamed peak in Khirganga PF in the east of Mathaundhar). The terrain is characterised by numerous ridges (over 4000 m), deep gorges and precipitous cliffs, rocky crags, glaziers and narrow valleys. A little over half of the Park area lies above 4000m altitude. Much of the eastern part of the Park is perpetually under snow. As in other parts of Himalaya, Pleistocene glaciation has strongly influenced the topography of the area resulting in extensive moraines, river terraces and hanging valleys (Mani 1974). Tirthan river and several small nullas flow through the intensive study area. The altitude of the area ranges from 1800 m to 5200 m.

2.5. GEOLOGY AND SOILS

The main rock formations in the Park are quartzite, mica-schist, phyllite, dolomites, limestone, shale, slate, gneiss and granites. Limestone formations are common in Sainj valley from Nevli

Fig. 2.2 (Map)

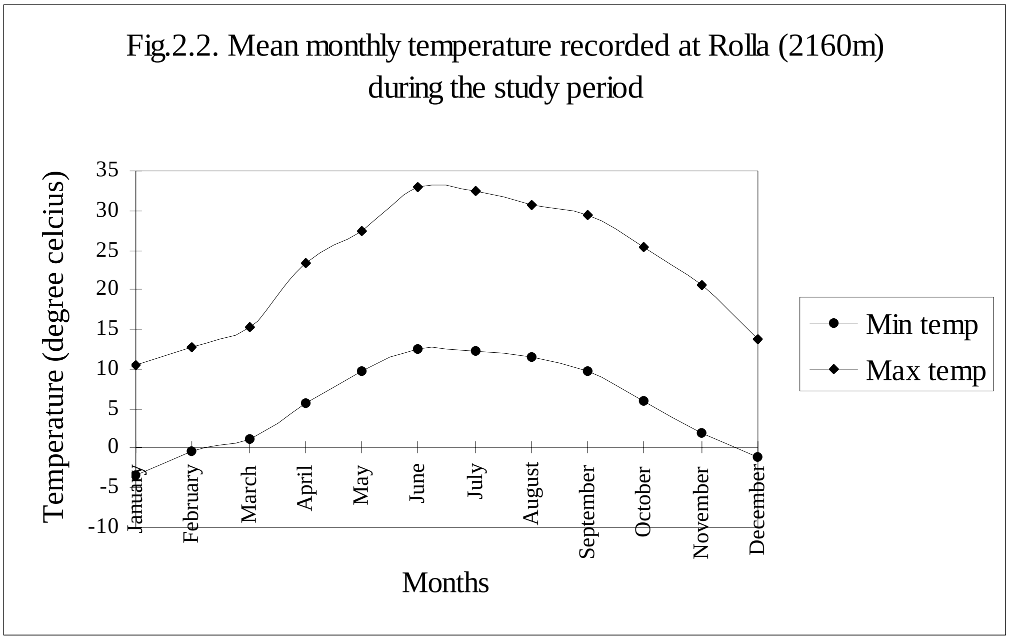


Fig.2.2. Mean monthly temperature recorded at Rolla (2160m)
during the study period
Temperature (degree celcius)
35
30
25
20
15
10
5
0
-5
-10
January
February
March
April
May
June
July
August
September
October
November
December
Months
Min temp
Max temp

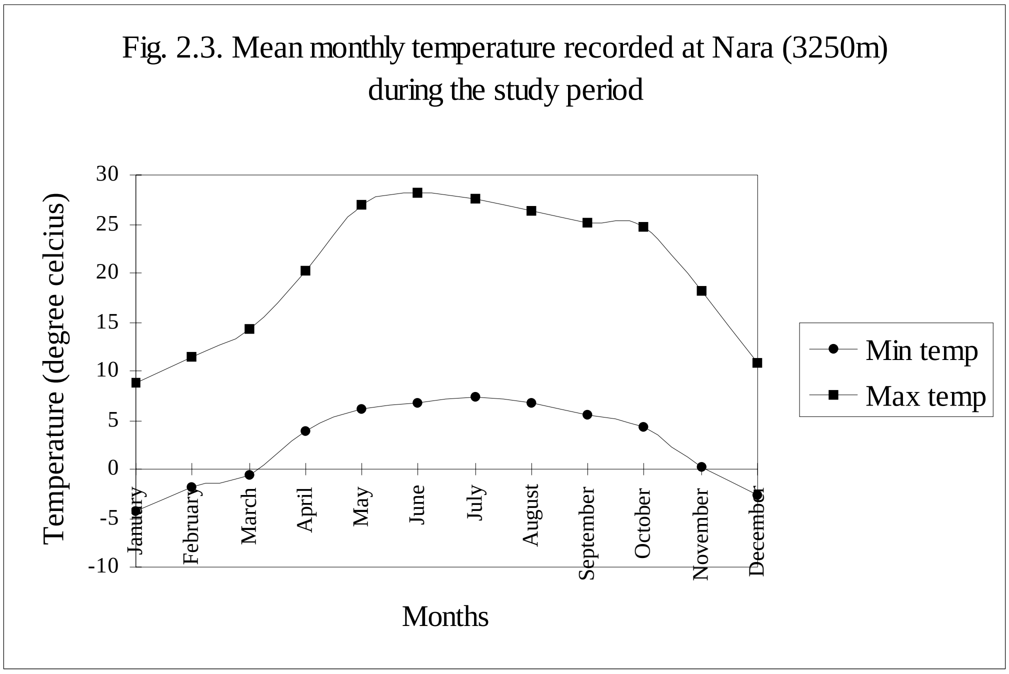


Fig. 2.3. Mean monthly temperature recorded at Nara (3250m)
during the study period
Temperature (degree celcius)
30
25
20
15
10
5
0
-5
-10
January
February
March
April
May
June
July
August
September
October
November
December
Months
Min temp
Max temp

extends up to Rakti. Quartzite is found in Parvati valley below Manikaran where as Beas Valley is dominated by gneiss and schist, which disintegrate into loam or clay (Sharma 1987). Alluvial soils are found in the basins of all the four rivers. The soil type in the intensive study area varies from sandy loam to podsolic and are mainly acidic in nature. The pH of the area varied from 5.52 ± 0.34 in the alpine region to 6.15 ± 0.42 in the temperate forests.

2.6. FLORA

The vegetation of the Park shows distinct altitudinal zonation, and the plant communities are representative of temperate and alpine regions. According to Champion and Seth's (1968) categories (14 forest types) of vegetation in GHNP include ban-oak forest 12/C(a), moist-deodar forest 12/C1(c), western Himalayan mixed coniferous forest 12/C1(d), moist temperate deciduous forest 12/C1(e), kharsu-oak forest 12/C2(a), western Himalayan upper oak-fir forest 12/C2, 12/C2(b), montane bamboo brakes 12/DS1, Himalayan temperate parkland 12/DS2, Himalayan temperate pasture 12/DS3, western Himalayan sub-alpine fir forest 14/C1(a), sub-alpine pasture 14/DS1, birch-rhododendron scrub forest 15/C1, deciduous alpine scrub 15/C2 and alpine pastures 15/C3. Gaston *et al*. (1981) reported the following five categories of forest in the area:

i) Sub-tropical pine forest, characterised by chir pine between 600 - 1700 m.,
ii) Himalayan moist temperate forest, characterised by both conifers and broad leaved species between 1250 - 3200 m.,
iii) Sub alpine forest dominated by birch and fir species between 3300 - 3600 m.,
iv) Moist sub-alpine scrub characterised by *Rhododendron* species between 3000 - 3500 m and
v) Dry alpine scrub characterised by *Juniperus* species between 3400 - 3800 m.

The intensive study area has vegetation types ranging from temperate forest to alpine meadows. Based on the physiognomy and dominance of the species, Singh (1999) classified the vegetation types of the area into the following types:
i) temperate broad leaved forests,
ii) temperate coniferous forest,
iii) upper temperate broad leaved and mixed conifer forest,
iv) sub-alpine (birch-rhododendron) forest,
v) alpine scrubs,
vi) alpine meadows and thatches,
vii) riverine forest,
viii) temperate grassy slopes and
ix) temperate secondary scrub near forest pastures and forest edges.

The undisturbed oak forests at low and middle altitudes are now rare outside the Park. The alpine meadows above 3300 m have a high diversity of herbaceous species, many of which have high economic value as a result of their medicinal or aromatic properties.

A detailed analyses of vegetation of GHNP has been carried out by Singh (1999). Based on his floristic inventory 832 plant species belonging to 427 genera and 128 families were identified in the Park. Of these 794 species are angiosperms, 11 are gymnosperms and 27 are ferns. According to the growth habits these species were distributed over 69 trees, 113 shrubs, 28 climbers, 6 parasites, 493 herbs, 96 graminoides and 27 ferns.

2.7. FAUNA

2.7.1. Reptiles and Amphibians

The common reptiles recorded in the area were Agama (*Agama tuberculata*), Himalayan pit viper (*Ancistron himalayensis*), skink and Indian rat snake (*Ptyas mucosus*). The detailed checklist of reptiles and amphibians are under preparation (Datta, S. *pers. comm.*)

2.7.2. Birds

GHNP falls within one of the globally important Endemic Bird Areas (D02: Western Himalaya) identified by the ICBP Biodiversity Project (ICBP 1992). Gaston *et al*. (1994) recorded 183 bird species from the Park. These include 51 non-passerines and 132 passerines, which is comparable with 71 non-passerines and 150 passerines recorded throughout the hilly regions of HP above 1500 m.. Five species of pheasants, viz., Western tragopan (*Tragopan melanocephalus*), Cheer pheasant (*Catreus wallichii*), Himalayan monal (*Lophophorus impejanus*), Koklas (*Pucrasia macrolopha*) and Kalij (*Lophura leucomelana*) are found in the Park. This is one of the only two National Parks in the world with a sizable population of Western tragopan (Collar and Andrew 1988). The endangered chir pheasant is rare in the area and are found on the steep, south-facing grassy slopes below 2200 m.. Monal and koklass are abundant in the area and inhabit the temperate and subalpine forests. The Western tragopan inhabits the temperate forest zone while kalij occurs in small numbers below 2200 m. The ongoing detailed study on birds by the Wildlife Institute of India is expected to come out with more ecological informations on these species (Ramesh, *in prep.*).

2.7.3. Mammals

The Park supports atleast 31 species of mammals (See Appendix-I) of which the existence of 27 species was confirmed in the intensive study area. Although the Park covers substantial area of prime wildlife habitat, the animals occur in low densities as like other areas in the Western Himalaya and are affected by people living in the adjacent areas.

Primates are represented by rhesus macaque (*Macaca mulatta*) and common langur (*Presbytis entellus*) and are distributed widely between 1440-3420 m.

Common leopard (*Panthera pardus*) and Asiatic black bear (*Ursus thibetanus*) have been sighted only rarely (1440-3660 m) but scats, footprints and feeding signs were recorded frequently from village fringes to the alpine zones. Snow leopard (*Uncia uncia*) was confirmed for the first time in GHNP on 15th July 1997 near Saketi (4200 m). Although snow leopard has been sighted only once (Vinod *unpublished*), secondary information suggests their presence in upper Sainj, Jiwa and Parvati areas (over 3600 m). Himalayan brown bear (*Ursus arctos isabellinus*) was sighted on the alpine meadows of Tirth, Dhela, Kamba, Rakti, Upper Jiwa and Parvati areas. Their scats were also found regularly in these areas. Red fox (*Vulpes vulpes*) has been encountered in the alpine pastures of Dhela and Tirth areas. Yellow-throated marten (*Martes flavigula*) was a commonly encountered in temperate and subalpine areas.

The most frequently encountered mammal in the area was goral (*Nemorhaedus goral*), which occupies a wide range of habitat form temperate to subalpine forests. Goral was sighted most frequently on open grassy slopes between 2400-2800 m (Vinod *et al.* 1997). Both Himalayan tahr (*Hemitragus jemlahicus*) and Himalayan musk deer (*Moschus chrysogaster*) have been sighted occasionally (2800-4000 m), the former being recorded on steep rocky slopes and the later in the '*krummholz*'. Gumtharao and Dhela are two known areas for musk deer, where as Gumtharao, Pardi, Nara, Kamba, Patl and upper Jiwa areas appear to be important for Himalayan tahr. Blue sheep (*Pseudois nayaur*) are reported from few areas in the upper Tirthan Valley.

Rarely encountered mammals include barking deer (*Muntiacus muntjak*), serow (*Nemorhaedus sumatraensis*), Himalayan ibex (*Capra ibex sibirica*) and Himalayan weasel (*Mustela sibirica*) (Gaston *et al*., 1983). Even though sightings of flying squirrels (*Petaurista* spp.) were low their feeding signs on Kharsu oak (*Quercus semecarpifolia*) leaves were recorded frequently. Pika or Himalayan mouse hare (*Ochotona roylei*) were encountered frequently in the alpine meadows.

2.8. HUMAN USE

There are two villages namely Kundar and Manjhan, inhabited by 12 families with a population of around 100 people, inside the Park (Pandey and Wells 1997). In addition to this, the Ecodevelopment Project area covers 12 revenue villages comprising near about 150 hamlets (Kumar 1998). People living in and around the Park claim traditional rights to use the resources of the Park. Local people use the park area mainly for grazing their livestock (sheep, goats and some cattle) and collecting medicinal herbs and mushroom. A large number of livestock (about 20000), resident as well as migratory, used to graze in the park during summer months. About 2500 people collect herbs (May-September) and mushroom (March-May) every year. Herb and mushroom collection is the most important and sometimes the only means of earning cash income for a majority of house holds who are reported to earn an income of Rs. 4000 to Rs. 15000 by selling these commodities (Kumar 1998). More than 300 people/year visit the Park for religious ceremonies.

Within the intensive study area (Tirthan Valley), about 8000 livestock graze every year during May and stay inside till the end of September. At least 300 people/year enter this area for herb (May-September) and mushroom (March-May) collection and about 100 people pass for religious ceremonies.

2.9. MANAGEMENT

The Wildlife Wing of the Himachal Pradesh Forest Department manages the Park. Till May 1999, the Divisional Forest Officer functions as the Director, assisted by an Assistant Conservator of Forest, and the fieldwork is carried out with the help of Wildlife Range Officers, Deputy Rangers and Wildlife Guards. Since June 1999, the rank of the Director, GHNP has been elevated to the level of Conservator of Forest (CF). At present there are four Range Officers, three Deputy Rangers and 15 Forest Guards in GHNP (Anon. 1995).

2.10. TOURISM

Current visitation levels are low due to the lack of publicity and facilities. At least 300 people visit the Park annually of which about 100 people/year visit the intensive study area. Foreign tourists account about 20% of the visitors and most of them are from UK, Germany and Canada. The Park is a potential area for community based Ecotourism.

2.11. GENERAL METHODS

The general methods and analyses followed in this study are described in this chapter. The specific methods and details of analyses are discussed in the relevant chapters. Severe climatic conditions, topography and logistics were the limiting factors, hence the regular data collection was done using established methods despite certain limitations. Problems associated with traditional sampling methods in context of Himalayan region and possible biases are discussed in subsequent chapters 4,5 and 6.

2.11.1.Study Period

A reconnaissance survey was conducted from September 1995 to November 1995. Selection of study area, testing of various methods, identification and marking of trails and vantage points were worked out during this period. Except for silent drive count, data collected during the reconnaissance survey is not included in the thesis. The intensive study was carried out from January 1996 to November 1998.

2.11.2. Logistics

The field station for the study was located at Banjar (1500 m), 15 km away from the Park. The base camp was located at Rolla (2160 m) from where studies on lower and middle temperate forests were done. First and second advance camps were located at Shilt (3000 m) and Nara (3280 m) respectively and were used for studying the upper temperate and sub-alpine areas. Gumtharao (3400 m) and Dhela (3600 m) served as the 3rd and 4th advance camps from where studies in alpine zones were carried out.

2.11.3. Levels of Disturbance

The entire study area was classified into two zones viz., less disturbed zone and more disturbed zone. The classification was made based on the number of people, livestock and domestic dogs encountered and also based on indirect evidences of biotic pressures such as lopping, fire etc.

2.11.4. Working Schedules

Except for summer, more than 20 days per month were spent inside the intensive study area. The heavy rainfall during summer/monsoon (July to September), resulting in landslides and poor visibility affected the normal field-working schedules. Many bridges in the study area were washed away during this season restricting the movements. Similarly during winter, heavy snow (>3 m) accumulated at certain places in the Valleys restricted the fieldwork up to 3300 m. The entire (intensive) study area was systematically covered twice a month during the study period. This study is largely based on direct sightings of the study animals, but an attempt was made to estimate relative abundance of goral based on indirect evidence (dung).

2.11.5. Habitat Parameters

An altimeter (up to 5m interval) was used to measure altitude. The altimeter was set to the base camp and advanced camps while working in the representative areas. Aspect was measured on an eight point scale (North: 337^0-22^0, Northeast: 23^0-67^0, East: 68^0-112^0, Southeast: 113^0-157^0, South: 158^0-203^0, Southwest: 204^0-247^0, West: 248^0-292^0 and Northwest: 293^0-336^0) using a Sunnto compass. The slope was measured on an eight point scale viz., 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70 and >70, using a Sunnto clinometer. Cover categories for canopy, tree, shrub, grass and rock & soil were measured on an eight point scale (0, 1-10, 11-20, 21-30, 31-40, 41-50, 51-60 and >60 %) based on visual estimation.

3.0 STATUS AND CONSERVATION OF MAMMALS

3.1. INTRODUCTION

The Indian Himalayan region is very rich in terms of biological diversity due to its unique location, climate and topographic conditions. Being the meeting point of two biogeographic realms, viz., the Oriental and the Palaearctic (Mani 1974), the Himalaya provided various habitats that were occupied by many primitive as well as newly evolved species. Mammalian fauna forms an important component of the rich and diverse life forms of Himalaya. About 65% of the 372 mammalian species in India were also reported in the Himalaya (Ghosh 1996). However, ecological information on many of these mammals is still lacking and is crucial for the conservation and management of the species.

The greatest threat to the biodiversity of Himalaya is due to the ever-increasing human population and related issues. The Great Himalayan National Park (GHNP) located in the upper catchment of Beas River is one such Protected area in the western Himalaya, rich in diversity but threatened by the human population in and around it. The available knowledge on animals in this area is based on status surveys conducted during 1979-81 and 1991 (Gaston et al. 1983, Gaston & Garson 1992), which aimed at obtaining baseline information on large mammals and birds. The present study was carried out to gather more information on the status and distribution of mammals in the area.

3.2. OBJECTIVES

The following were the objectives of the study:

- To determine the status, relative abundance and distribution of mammals in GHNP.
- To gather ecological information on mammalian fauna.

3.3. METHODS

Fieldwork lasting 36 months was carried out during 1995-1998. Based on a reconnaissance survey during autumn 1995, an intensive study area (Ca. 90km^2) was selected. During the survey and intensive study, existing trials were used to collect information on mammals. A total of 1157 km of trials were traversed during the study period (290 km in the Ecodevelopment area which mostly lies below 2000m, 481 km in the temperate forests inside the Park and 386 km in the sub-alpine and alpine meadows). During the trail/transect walk, a record was taken on all mammals excluding Chiroptera (Bats). The number of individuals with in the group, their activity and habitat details were also noted. All the indirect evidences such as dung, spoor, feeding signs etc. were also collected. The results were expressed either as number/km walk or as percent occurrence.

3.4. RESULTS

Thirty-one mammalian species, which are representative of six orders viz., Primates (two species), Carnivora (12 species), Artiodactyla (seven species), Insectivora (three species), Rodentia (six species) and Lagomorpha (one species) were recorded in the area, out of which only 27 were directly sighted during the study period (Table 3.1.). The presence of wolf, as reported in the earlier studies (Gaston et al. 1981), is yet to be confirmed in the area. The nomenclature for all mammal species follows Wilson and Reeder (1993).

3.4.1. Primates

Primates in the area were represented by two species, namely Rhesus macaque (*Macaca mulatta*) and common langur (*Presbytis entellus*), both of them were fairly common.

3.4.1.1. Rhesus macaque

Rhesus macaques were encountered more frequently in lower temperate forest areas especially below 2000m.. They used an altitudinal range of 1440-3420m. and were sighted mostly in northwestern, southern and southeastern aspects. A total of 43 troops were recorded in the area with a mean group size of 18.6 (Range 1-79). The visual encounter rates were higher in the ecodevelopment area when compared to the National Park area (See Table 3.2.).

Crop raiding in the ecodevelopment area were observed in few occasions (n=7). Local villagers are very aggressive towards rhesus macaque and used to chase them from agricultural fields. Domestic dogs are also trained to chase the rhesus macaque them from the agricultural fields/ orchids.

Table 3.2. Visual encounter rates of Rhesus macaque in GHNP.

Altitude Range (m)	N	Encounter Rates		Mean group size (Range)
		Groups/km	Individuals/km	
<2000	24	0.08	1.49	18.0 (1-63)
2001-3000	17	0.04	0.72	20.3 (1-79)
>3000	2	0.01	0.06	11.5 (7-16)
Overall	43	0.04	0.69	18.6 (1-79)

Table. 3.1. A checklist of the mammals of Great Himalayan National Park, Himachal Pradesh.

	Species (Scientific name)	Local Name	Evidences	Altitude Range (m.)**	C s
	PRIMATES				
1.	*Rhesus macaque (* Macaca mulatta *Zimmerman, 1780)*	Bandhar	*D & I*	*1440-3420*	*C*
2.	*Common Langur (*Presbytis entellus *Dufresne, 1797)*	Gooni	*D & I*	*1650-3660*	*C*
	CARNIVORA				*F*
3.	*Common Leopard (*Panthera pardus *Linnaeus, 1758)*	Bagh	*D & I*	*1440-3660*	
4.	*Snow Leopard (*Uncia uncia *Schrebar, 1775)*		*D & I*	*>3700*	*V*
5.	*Asiatic Black Bear (*Ursus thibetanus *G.Curvier, 1823)*	Kala Bhaloo	*D & I*	*1630-3300*	*R*
6.	*Himalayan Brown Bear (*Ursus arctos *Linnaeus, 1758)*	Lal Bhaloo	*D & I*	*>3300*	*R*
7.	*Jackal (*Canis aureus *Linnaeus, 1758)*	*Gidder*	*D*	*1440-2000*	*C*
8.	*Red Fox (*Vulpes vulpes *Linnaeus, 1758)*	Lomri	*D & I*	*3500-3670*	*C*
**9.*	*Wolf (*Canis lupus Linnaeus*, 1758)*		*S*	*Not Known*	*N*
10.	*Leopard Cat (*Felis bengalensis *Kerr, 1792)*	Bagh Billi	*D & S*	*>3000*	*V*
11.	*Jungle Cat (*Felis chaus *Guldenstaedt, 1776)*	Billi	*D & S*	*1440-2200*	*R*
12.	*Yellow-throated Marten (*Martes flavigula *Boddaert, 1785)*	*Gotu*	*D & I*	*1440-3340*	*F*
13.	*Himalayan Weasel (*Mustela sibirica *Pallas, 1773)*		*D*	*3320-3580*	*R*

14.	***Himalayan Palm Civet (*****Paguma larvata** ***Mamilton-Smith, 1827)***		***D***	***2990***	***V***
	ARTIODACTYLA				
15.	***Grey Goral (*****Nemorhaedus goral** ***Hardwicks, 1825)***	**Gorad**	***D & I***	***1140-3600***	***C***
16.	***Himalayan Musk Deer (*****Moschus chrysogaster** ***Hodgson, 1839)***	**Kastura, Bina**	***D & I***	***3000-3760***	***R***
17.	***Himalayan tahr (*****Hemitragus jemlahicus** ***Smith, 1826)***	**Karth, Bakiri**	***D & I***	***2800-4020***	***F***
**18.*	***Serow (*****Nemorhaedus sumatraensis** ***Bechstein, 1799)***	**Emu**	***I & S***	***2000-3600***	***V***
19.	***Barking Deer (*****Muntiacus muntjak** ***Zimmerman, 1780)***	***Kakkar***	***D***	***1400-2600***	***R***
20.	***Blue Sheep/Bharal (*****Pseudois nayaur** ***Hodgson, 1833)***	***Miatu***	***D & I***	***>3700***	***R***
**21.*	***Asiatic ibex (*****Capra ibex** ***Pallas, 1776)***	*Tangrol*	***S***	***>3700***	***N***
	RODENTIA				
22.	***House Mouse (*****Mus musculus** ***Linnaeus, 1758)***	**Chuha**	***D***	***1440-2200***	***C***
23.	***Common Giant Flying Squirrel (*****Petaurista petaurista** ***Pallas, 1766)***	*Aenu*	***D & I***	***1580-3710***	***C***
24.	***Kashmir Flying Squirrel (*****Hylopetes fimbriatus** ***Gray, 1842)***	**Aenu**	***D***	***>3300***	***R***
25.	***Royle's Vole (*****Alticola roylei** ***Gray, 1842)***		***D***	***>3000***	***C***
26.	***Indian Porcupine (*****Hystrix indica** ***Kerr, 1792)***	**Shail**	***D & I***	***1440-2200***	***C***
**27.*	***Hodgson's Porcupine (*****Hystrix hodsoni** ***Gray, 1847)***		***S***	***Not Known***	***N***

	LAGOMORPHA				
28.	***Himalayan Mouse Hare/ Pika* (Ochotona roylei *Ogilby, 1839)***	**Lal Chuha**	***D***	***>2800***	***A***
	INSECTIVORA				
****29.***	***Grey Musk Shrew* (Suncus murinus *Linnaeus, 1766)***	**Chuha**	***S***	***Not Known***	***N***
****30.***	***Himalayan Large Clawed Shrew* (Soriculus nigrescens *Gray, 1842)***	**Chuha**	***S***	***Not Known***	***N***
****31.***	***Himalayan Water Shrew* (Chimarrogale himalayica *Gray, 1842)***	**Chuha**	***S***	***Not Known***	***N***

*Based on secondary information ** Based on personal observation D – Direct observation, I – Indirect evidences, S – Secondary Data (Based on Gaston et al. 1981)

3.4.1.2. Common langur

Common langurs were encountered very frequently in the area from 1650-3660m. A total of 68 troupes were encountered during the study period with a mean group size of 15.7 (Range 1-52). The encounters were more in middle altitudes (n=41) facing southeast, northwest and northern aspects. They were seen in much higher elevation (3660m), even in the snow feeding on oak leaves and bark (Table 3.3). At lower altitudes (<2500m), feeding of Aesculus seeds were observed (n=9). No crop raiding by langurs were observed during the study period.

Inter-specific associations between common langurs and rhesus macaques were observed. Troops of both species were observed together in the same tree twice during winter near Rolla hut (2160m). More than 92% of the people interviewed reported that rhesus macaques caused crop damages, but only 20% made similar complaints about common langurs. The local name “goony” (one having positive characters) for langur in the area symbolises the local people’s perception about langurs and considered them as harmless gentle creatures.

Table 3.3. Visual encounter rates of common langur in GHNP

Altitude Range (m)	N	Encounter Rates		Mean group size (Range)
		Groups/km	Individuals/km	
<2000	11	0.04	0.74	19.4 (1-52)
2001-3000	41	0.09	1.25	14.7 (1-48)
>3000	16	0.04	0.79	15.6 (4-21)
Overall	68	0.06	0.92	15.7 (1-52)

3.4.2. Carnivores

3.4.2.1. Common leopard

Common leopard (*Panthera pardus*) was sighted on 14 occasions during the study period and evidences of leopards were obtained between altitudes 1440 to 3660m Sightings of leopard occurred in south, south-east, north-east and north-west aspects. Even-though direct sightings were low (n=2), indirect evidences showed (n=183) a higher encounter rate of leopards in the ecodevelopment area (Table 3.4.). The easy availability of domestic prey such as livestock (goat, sheep, cattle, horse, mules) and domestic dogs might be a reason for higher encounter rate in the area. Predation of leopards on livestock was reported in the area.

Table 3.4. Encounter Rate of Leopards in GHNP

Altitude range (m)	N	Encounter Rates	
		Sightings/100 km	Evidences/100 km
<2000	2	1	63
2001-3000	8	2	37
>3000	4	1	5
Overall	14	1	33

3.4.2.2. Snow leopard

Snow leopard (*Uncia uncia*) was confirmed for the first time in GHNP on 15 July, 1997 near Saketi (4200m). Although snow leopard has been sighted only once (Vinod, unpublished), secondary information suggests their presence in upper Tirthan, Sainj, Jiwa And Parvati areas above 3000m..

3.4.2.3. Red fox, Jackal & Wolf

Red fox (Vulpes vulpes) was one of the most frequently seen carnivores of the area (Table 3.5.). All the sightings of red fox were in the alpine meadows above 3500m (Altitudinal range 3500-3670m). Dhela thach has been identified as a potential area for red fox during this study. Canid lure traps were set to estimate the indices of red fox population in Dhela thatch during spring and autumn 1997. Red fox had responded to eight and six out of 10 traps set during spring and autumn with 80% and 60% trap success respectively. Red fox was observed chasing musk deer at Dhela area on two occasions. Five unsuccessful attempts by red fox to prey on Himalayan monal (Lophophorus impejanus) were also recorded during this study.

Jackal (Canis aureus) was sighted 17 occasions during the study period. All sightings were in areas <2000 m elevation, that is, mostly in the ecodevelopment area (Table 3.5.). No attempt was made to estimate the encounter rate of jackal scat in the area. However, they were fairly common in the ecodevelopment zone. Jackals were reported to scavenge near villages.

Although Gaston et al. (1981) had reported the presence of wolf (*Canis lupis*) in the area, no direct/indirect evidences of this species was obtained in the area during the study period.

Table 3.5. Encounter rates of Red fox and Jackal in GHNP

Species	N	Encounter Rates	
		Direct sightings/100km	Indirect evidences/100km
Red fox	32	8	31
Jackal	17	6	-

3.4.3. Bears

3.4.3.1. Asiatic black bear

Asiatic black bear (*Ursus thibetanus*) was encountered only 11 occasions during the study period. Indirect evidences such as scats and feeding signs (diggings) were observed throughout the Park, below 3300 m. (Table 3.6.). They mainly used forest areas lying in the northerly and southerly aspects with moderate slope class (40-50^0) and shrub cover. Feeding signs on tender bamboo shots (*Arundinaria spathiflora*) were observed in the area. All the villagers interviewed reported crop raiding by black bear, mainly maize. They also reported a drastic reduction in the bear population in the area, probably due to poaching for gall bladder, although the incidences of crop raiding were steady. A separate section on human-animal conflict is under preparation (Chouhan, N.P.S. under prep.)

3.4.3.2. Himalayan brown bears

Himalayan brown bears (*Ursus arctos isabellinus*) were sighted on seven occasions in the alpine meadows of Tirth, Dhela, Kamba, Rakti, Upper Jiwa and Parvati areas. Their scats were frequently encountered in these areas during spring and autumn. All records of brown bear were obtained between 3320-4450 m elevation (Table 3.6). They mainly used areas lying in Northeastern and southeastern aspects with 20-50^0 slopes.

Table 3.6. Encounter rates Asiatic black bear and Himalayan brown bear

	Asiatic black bear		Himalayan brown bear	
	Direct	Indirect	Direct	Indirect
<2000m	-	0.02	-	-
2001-3000m	0.02 (9)*	0.10	-	-
>3000m	0.01 (2)	-	0.02 (7)	0.76

* Parenthesis shows the total sightings in each zone

3.4.4. Small Carnivores

Himalayan yellow-throated marten (*Martes flavigula*) was one of the most frequently sighted small carnivores in the area, and were encountered mostly in lower and middle temperate forests. They used an altitudinal range of 1800-3400m and were sighted mostly in south, southeast and northwest facing slopes with 30-60^0 slopes (Table 3.7.). All the encounters were either of solitary animals (66.7%) or in pairs (33.3%). Himalayan Palm Civet (*Paguma larvata*) was one of the least sighted small mammals and was sighted only once near Shilt (2990m). Himalayan weasel (Mustela sibirica) was another rare small carnivore in the area and was sighted only twice, once near Rikkundi (3320m) and on other time near Gumtharao (3580m). Jungle cats (*Felis chaus*) were sighted on seven occasions, all <2000m where as leopard cats (Felis bengalensis) were encountered on three occasions near Gumtharao.

Table 3.7. Number of sightings of small carnivores in various altitudinal gradients in GHNPCA.

Species	<2000m	2000-3000m	>3000m	Overall
Yellow throated marten	5 (10.4)*	38 (79.2)	5 (10.4)	48 (100.0)
Himalayan Palm civet	-	1 (100.0)	-	1 (100.0)
Himalayan weasel	-	-	2 (100.0)	2 (100.0)
Jungle cat	5 (71.4)	2 (28.6)	-	7 (100.0)
Leopard cat	-	-	3 (100.0)	3 (100.0)

3.4.5. Ungulates

Among seven species of ungulates present in the area, five species viz., goral (*Nemorhaedus goral*), Himalayan tahr (*Hemitragus jemlahicus*), Musk deer (*Moschus chrysogaster*), Blue sheep (*Pseudois nayaur*) and Barking deer (*Montiacus muntjak*) were sighted during the study period. Goral was the most commonly encountered mammal (n= 445) and had a wide range of distribution from 1440m to 3600m. Himalayan tahr and Musk deer were encountered in the area above 2800m. Detailed ecological information of these three species has been given in subsequent chapters. Barking deer was sighted only twice, one in Jiwa valley (1960m) and second near Kharongcha (1820m). Once very frequent, the animal is in the verge of local extinction due to large scale poaching. Another highly poached animal in the area was serow (*Nemorhaedus sumatraensis*). Except for one unconfirmed sighting (Rawat, G.S. Pers. Comm.) and a pellet group, no other information could be gathered on this species during the study period. Serow pellet groups were also recorded in Apgaun thach in Jiwa Valley (Rawat, G.S. Pers. Comm.). Blue sheep was encountered four times during the study period. They were sighted thrice at Tirth area (Altitude Range: 4340m-4470m, Mean group size: 9.3, Range: 6-14) and once at Raktisar. Tirth and Raktisar areas of GHNP support substantial population of blue sheep. Secondary information suggests the presence of Asiatic ibex (*Capra ibex*) in Parbati valley. The Pin Valley National Park, located in the northeastern side of the study area supports substantial population of Asiatic ibex. Secondary data suggests seasonal migration of ibex from Pin Valley National Park (B.S. Rana Pers.comm..).

3.4.6. Small Mammals

Six species of small mammals were sighted during the study period, of which five belong to order Rodentia and the remaining one belongs to Lagomorpha. Number of sightings of these animals in various altitudinal gradients is given in Table 3.8.. Himalayan mouse hare or Pika (*Ochotona roylei*) was the most frequently seen small mammal in the area (n=99) and their distribution ranged from 2900m to 4700m. Common giant flying squirrel (*Petaurista petaurista*) and Royle's vole (*Alticola roylei*) were also sighted frequently, the former being recorded (n=46) between 1530m to 3560m where as the later was sighted only above 3000m. (n=40). The rarely sighted small mammals in the area were Kashmir flying squirrel (*Hylopetes fimbriatus*) (n=4) and Indian Porcupine (*Hystrix indica*) (n=5), but ample indirect evidences of porcupine were recorded in the area below 2200m..

Table 3.8. Number of sightings of small mammals in various altitudinal gradients in GHNPCA.

Species	<2000m	2000-3000	>3000m	Overall
House mouse	14 (70.0)	6 (30.0)	-	20 (100.0)
Indian giant flying squirrel	57.5 (23)	45.8 (11)	8.0 (12)	46 (100.0)
Kashmir flying squirrel	-	-	4 (100.0)	4 (100.0)
Indian porcupine	3 (60.0)	2 (40.0)	-	5 (100.0)
Royle's Vole	-	-	40 (100.0)	40 (100.0)
Himalayan mouse hare	-	5 (5.1)	94 (94.9)	99 (100.0)

3.5. DISCUSSION

Great Himalayan National Park supports at least 31 species of mammals and is comparable with other Protected Areas (PA's) in the Western Himalaya, such as Langtang National Park (32 Species, Green 1981) and Kedarnath Wildlife Sanctuary (31 Species, Sathyakumar 1994). The people living in and around the GHNP poses threat to wildlife because conservation of wildlife must reconciled with the needs of local people. There is an urgent need for zonation of Park into areas of different conservation status. The prime wildlife habitat should be declared as core zone and should be completely protected from biotic pressures.

Although hunting mostly ceased after the Park's establishment in 1984, it still persists in the case of certain species such as Musk deer and Asiatic black bear. Apart from hunting, most mammalian species in the area are adversely affected wherever the habitat is used by man (e.g. Grey goral and Musk deer). If the Park authority can stop the degradation of habitat (mainly due to biotic pressure) and poaching in the area, no specific measures need to be taken to preserve the mammalian fauna in the area.

4.0 ABUNDANCE AND DENSITY ESTIMATES

4.1. INTRODUCTION

The Himalaya offer great challenges to wildlife biologists in studying aspects of ecology, conservation and management of animals. The low density of animals and harsh climatic conditions are the major reasons for this. The varied topography of the area does not allow systematic sampling using the conventional methods. Ungulate forms an important component of biodiversity and acts as indicators of habitat quality in the Himalaya. However, status, distribution and relative abundance of many of the Himalayan ungulates are not fully known. Density estimates for the Himalayan ungulates have been sparsely reported. Problems in identifying and using a suitable population estimation technique have posed limitation in estimating density of the ungulates of this region.

In the Western Himalaya, the existing informations on ungulate abundance are mainly through surveys (Schaller 1977, Gaston *et al*. 1981, 1983, Fox *et al*. 1988, Cavallini 1990, Gaston and Garson 1992 and Sathyakumar 1993) and a few systematic studies (Green 1985, Mishra 1993, Pendharkar 1993 and Sathyakumar 1994). However only Green (1985) and Sathyakumar (1994) have estimated density of goral. The first report on the density of musk deer was by Green (1985) in Kedarnath Wildlife Sanctuary, followed by Kattel (1990) in Sagarmatha National Park. Sathyakumar (1994) in Kedarnath Wildlife Sanctuary reported the abundance and density of major ungulates viz. goral, musk deer, Himalayan tahr, barking deer, serow and sambar. There have been no detailed studies on mountain ungulates in Himachal Pradesh except for the studies on Himalayan ibex (Bhatnagar 1997 and Manjerkar 1997). All existing information is based on surveys (Gaston *et al*. 1981, 1983, Cavallini 1990, Gaston & Garson 1992) and a few short studies (Mishra 1993 and Pendharkar 1993). Surveys and short term studies could give only seasonal estimates.

In GHNP, field surveys conducted by Gaston *et al*. (1981) and Gaston & Garson (1992) provide only preliminary information about few ungulates. Information on the ungulate abundance and densities in various parts of the Park and also factors influencing the abundance and density, would be needed for the conservation and management of these species. In this study, an attempt has been made to estimate the abundance and density of major ungulates viz., goral, Himalayan musk deer and Himalayan tahr, in different habitats of GHNP covering various seasons, years and along the gradients of anthropogenic disturbances.

Map

4.2. OBJECTIVES

The following questions have been addressed in this study:

- What are the abundance and density estimates for goral, musk deer and Himalayan tahr in GHNP?
- Do the abundance and density estimates vary between areas, seasons and years? Are the estimates comparable with the estimates from other PAs?
- Is there any correlation between animal encounter rates, animal density and pellet group encounter rates?
- How ungulate abundance correlate with anthropogenic pressures?
- Which is the most suitable technique for estimating abundance and density of these species in the area? To what extent can front line staff execute these techniques?

Finding answers to above questions may be vital and useful for the conservation and management of the species in this park and other areas of western Himalaya.

4.3. METHODS

Based on recent literature and initial fieldwork, the following techniques were employed.

4.3.1. Goral

4.3.1.1. Line transects

This method involves walking along transects and counting the number of animals sighted on either side. King census technique (Overton and Davis 1969) was used for estimating the density. Four transects, namely Kharongcha-Rolla (KHRO), Rolla-Shilt (ROSH), Rolla-Basu (ROBA) and Chalocha-Nara (CLNA), each 2.2 km were laid in the study area covering various habitats (Fig. 4.1.). Each transect was walked twice a month from January 1996 to November 1998. The characteristics of these transects are shown in Table 4.1. All transects were walked between 06.00 h and 09.00 h. Data on time of sighting, number of animals, sex of the individuals, sighting angle, sighting distance and animal activity were recorded for every animal sighting. The poor visibility and extreme weather conditions in summer restricted transect walks to only 4 times over the entire period. This technique was used to estimate abundance of goral in Western Himalaya by Sathyakumar (1994).

4.3.1.2. Scanning technique

This method involves careful scanning from vantage points using spotting scope and/ or binoculars for a specified period of time. Gorals were scanned for three seasons other than summer from three vantage points namely Kharongcha, Rolla and Chidor (Table 4.2.). Area of scan was measured on the ground. The scanning was done between 06.00 h to 09.00 h and 15.00 h to 18.00 h. Scan duration varied from one to three hours depending on the weather conditions. The number of animals seen, their age, sex and activity patterns were recorded for every sighting. The various habitat parameters were also recorded around 10 m radius of the animal sighted whenever possible. In order to increase the scanning efficiency, two people scanned independently from two corners of the vantage points. Recording the time of animal sightings helped in eliminating double counts.

4.3.1.3. Pellet group count

Bennett et al. (1940) formalized this technique. Rowland et al. (1984) used pellet group plots to measure trends in deer and elk populations. Rodgers (1991) and Sathyakumar (1994) have used this technique in recent studies. In GHNP, three transects laid for estimating encounter rates and densities were also used for estimating the pellet group encounter rates. Pellet groups were counted twice a month within a 1 m belt along the transect. The pellet groups were removed after every count in order to avoid double counting during next sampling. As pellet group is an indicator of animal presence in the area, an attempt was made to compare the pellet group ER with ER and density estimates based on direct sightings.

4.3.2. Himalayan musk deer

4.3.2.1. Silent drive count technique

This technique, is a modified form of block count, which involves drive in a small patch of habitat, using 10 to 12 people who walk along a line abreast and record the animals sighted. Also two or more observers were positioned strategically above the forest level to spot the animals which otherwise might have flushed undetected from the area. Green (1985) used this method for Himalayan musk deer, first in Kedarnath Wildlife Sanctuary followed by Kattel (1990) in Sagarmatha National Park and Sathyakumar (1994) in Kedarnath Wildlife Sanctuary. In GHNP, this technique was used in Gumtharao (Tirthan Valley) and Dhela (Sainj Valley) areas (Fig. 4.1.). This technique could be used only in spring and autumn, as these areas were inaccessible during summer and winter. This method was not applicable in other musk deer areas of GHNP due to, inaccessibility and a major limiting factor could be the absence of logistics in planning and conducting counts.

4.3.3. Himalayan Tahr

4.3.3.1. Scanning technique

Himalayan tahr were scanned from four vantage points at Chidor, Nara, Pardi and Gumtharao as mentioned in section 4.3.1.2.(See Table 4.2. & Fig 4.1.). Since Himalayan tahr range remain in the higher altitude (>2800 m), scanning was done only in spring and autumn. The scanning was done between 6.00 h to 9.00 h and 15.00 h to 18.00 h. Scan duration varied from one to three hours depending on the weather conditions. The number of animals has seen, their sex and activity patterns were recorded for every sighting. The various habitat parameters were also recorded around 10 m radius of the animal sighted whenever possible. In order to increase the scanning efficiency, two people scanned from two corners of the vantage points. Recording the time of animal sightings, multiple count of the same animal was avoided. Green (1978) used this technique in Langtang National Park, Nepal and Sathyakumar (1994) in Kedarnath Wildlife Sanctuary.

Table 4.1. Characteristics of transects (L=2.2 km each) in the Study Area.

Transect Name	Vegetation Type	Altitude Range (m)	Aspect	Extent of Human use	No. of walks (1996-98)
Kharongcha-Rolla (KHRO)	TMBF	1900-2200	SE, NW	High	44
Rolla-Shilt (ROSH)	MBCF, TMCF	2200-3000	SE	High	44
Rolla-Basu (ROBA)	MBCF, TMCF	2200-2700	NW	Low	44
Chalocha-Nara (CLNA)	TCOF, MCOF	2400-3100	S, SW	Low	44

TMBF - Temperate Mixed Broad leaved Forest, MBCF - Mixed Broad leaved and Coniferous Forest, TMCF - Temperate Mixed Coniferous Forest, TCOF - Temperate Coniferous and Oak Forest, MCOF - Mixed Coniferous and Oak Forest with *Arundinaria* under growth, SE - South East, S - South, SW - South West, NW - North West

Table 4.2. Characteristics of Scanning Areas in the Study Area

Slope Name	Area (km^2)	Altitude Range (m)	Aspect	Extent of Human use	No. of scans
Kharongcha	0.7	2200-2600	SE	High	37
Rolla	0.6	2400-2700	SE	High	37
Chidor	0.8	2700-2900	S	Low	37
Nara	0.9	3300-3600	S	Low	24
Pardi	0.9	3200-3600	NW	Low	24
Gumtharao	0.8	3200-3600	S	Low	24

4.4. ANALYSIS

The encounter rates and density estimates of animals and pellet groups were calculated for every transect walk. The following formulae were applied to the data.

Animal Encounter Rate = n/L, where 'n' and 'L' are the number of animals sighted and the length of transect walked respectively.

Pellet group Encounter Rate = n/L, where 'n' and 'L' are the number of pellet groups recorded and the length of transect walked respectively.

Density = n/2Lr, where 'n' is the number of animals sighted, 'L' the length of transect and 'r' is the mean sighting distance.

Density estimates using silent drive count and scanning methods were calculated as D = n/A, where 'n' is the number of animals counted/seen and 'A' the area covered / scanned.

Two-tailed Mann-Whitney U test and Kruskal-Wallis test with 95% confidence limits were performed using SPSS/PC statistical computer package (Norusis 1990) to detect any difference in encounter rates or density estimates in different areas, between seasons, between years and with the human disturbance to habitat. In order to find the relationship between goral encounter rates and density, the data were subjected to tests of association such as correlation and regression analyses. Zar (1984) was followed during statistical treatment of data.

4.5. RESULTS

4.5.1. Goral

4.5.1.1. Line transect sampling

4.5.1.1.1. Encounter rate (ER)

Except for goral, no other ungulate was sighted in all four transects during the study period. The overall encounter rate of goral in transects namely KHRO, ROSH, ROBA and CLNA were 0.54±0.10, 1.14±0.14, 1.12±0.16 and 1.62±0.26 per km walk respectively (Table 4.3.). The ER between transects were different (Kruskal-Wallis Test, c^2=16.92, df=3, p=0.001). A nonparametric multiple comparisons (Zar 1984) showed that the ER was similar in ROSH, ROBA and CLNA, but was different in transect KHRO. Kruskal-Wallis test identified significant variations in ER between seasons (c^2=11.22, df=3, p=0.011, Fig. 4.2.). A nonparametric multiple comparison analyses showed a significantly higher ER during winter compared to other seasons. There was no significant variation in the yearly ER for goral in the area (See Table 4.5. and Fig.4.4.). Goral ERs were different in more disturbed and less disturbed areas (Table 4.7., Mann Witney U Test, U=3091.0, p=0.018), the less disturbed area had a higher ER.

4.5.1.1.2. Density estimates

The overall density estimates for goral in transects KHRO, ROSH, ROBA and CLNA were 4.84±0.96, 13.47±1.80, 15.22±2.16 and 16.09±2.84/km^2 respectively. Except for KHRO, in all other transects winter density estimates were higher compared to other seasons (See Table 4.4. and Fig. 4.3.). The density estimates varied significantly between transects (Kruskal - Wallis Test, c^2=22.46, df=3, p=0.000). Density estimates were similar in transects ROSH, ROBA and CLNA, but was different in KHRO (Nonparametric multiple comparisons, Zar 1984). Seasonal density estimates varied significantly in the area (Kruskal - Wallis Test, c^2=11.28, df=3, p=0.010), where as no significant difference in density estimates were observed between years (Table 4.6. & Fig. 4.5.). Disturbance played a vital role in the density of animals observed (Mann Witney U Test, U=2987.5, p=0.008), the less disturbed area had a higher density.

4.5.1.2. Scanning

The ER (No./scan, No./hour) and density estimates of goral using scan technique was given in Table 4.8. The estimates were higher during winter compared to other seasons. There was no significant variation in the ER and density estimates between seasons and years (Table 4.8. & Table 4.9.), where as density estimates varied significantly between scan areas (Kruskal- Wallis Test, c^2=6.35, df=2, p=0.042). The estimates were similar in Rolla and Chidor, but were different in Kharongcha area. The ER and density estimates were similar in areas with low and high levels of disturbance.

4.5.1.3. Pellet group counts

Except for goral pellet groups, no other ungulate's pellet groups were encountered in transects during the study period. The overall pellet group ER for goral in ROSH, ROBA and CLNA transects were 8.88±0.50, 8.60±0.55 and 7.58±0.39/km walk respectively. The pellet ER were similar between seasons in various transects (Table 4.10. & Fig.4.6.), but varied between years (Table 4.11. & Fig 4.7, Kruskal Wallis Test, c^2=6.02, df=2, p=0.049). Nonparametric multiple comparisons showed that the pellet group ER was similar in transects ROSH and ROBA but was different in CLNA. The pellet group ER did not vary significantly in areas of low and high levels of disturbance.

Table 4.3. Seasonal Encounter Rates (#/km walk ± SE) for Goral in the Study Area (January 1996 - November 1998).

Transect	Winter (N=12)	Spring (N=16)	Summer (N=4)	Autumn (N=12)	Overall (N=44)
KHRO	0.45 ± 0.15	0.60 ± 0.18	0.23 ± 0.23	0.64 ± 0.22	0.54 ± 0.10
ROSH	1.36 ± 0.19	1.22 ± 0.30	0.79 ± 0.34	0.91 ± 0.20	1.14 ± 0.14
ROBA	1.70 ± 0.29	1.19 ± 0.26	0.45 ± 0.19	0.64 ± 0.23	1.12 ± 0.15
CLNA	2.57 ± 0.59	1.65 ± 0.48	0.68 ± 0.23	0.95 ± 0.21	1.62 ± 0.26
Overall	1.52 ± 0.20 (N=48)	1.17 ± 0.16 (N=64)	0.54 ± 0.13 (N=16)	0.79± 0.11 (N=48)	1.10± 0.09 (N=176)

(Kruskal Wallis Test, χ^2=11.22, df=3, p=0.011)

Table 4.4. Seasonal Density estimates (#/km² ± SE) for Goral in the Study Area (January 1996 - November 1998).

Transect Name	Winter (N=12)	Spring (N=16)	Summer (N=4)	Autumn (N=12)	Overall (N=44)
KHRO	3.69±1.30	5.96±1.88	1.62±1.63	5.58±2.04	4.84±0.96
ROSH	16.90±2.77	13.20±3.80	9.09±3.08	11.86±3.10	13.47±1.80
ROBA	26.38±4.88	14.14±2.99	6.16±2.37	8.50±2.85	15.22±2.16
CLNA	23.40±5.22	17.99±6.15	5.79±2.00	9.68±2.56	16.09±2.84
Overall	17.59±2.27 (N=48)	12.82±2.04 (N=64)	5.67±1.25 (N=16)	8.91±1.33 (N=48)	12.41±1.07 (N=176)

(Kruskal Wallis Test, χ^2=11.28, df=3, p=0.010)

Fig.4.2. Seasonal encounter rates for goral in the study area

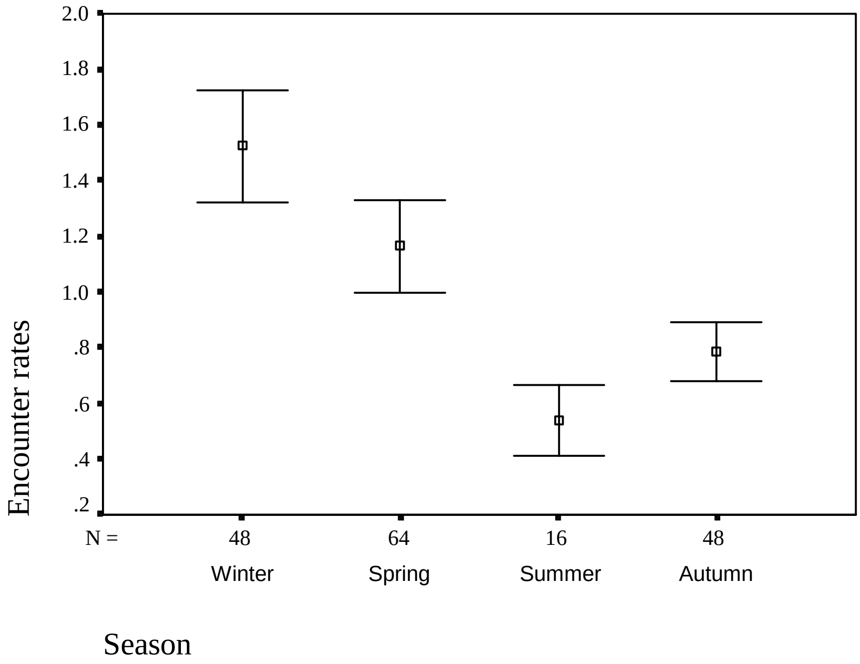


Fig.4.3. Seasonal density estimates for goral in the study area

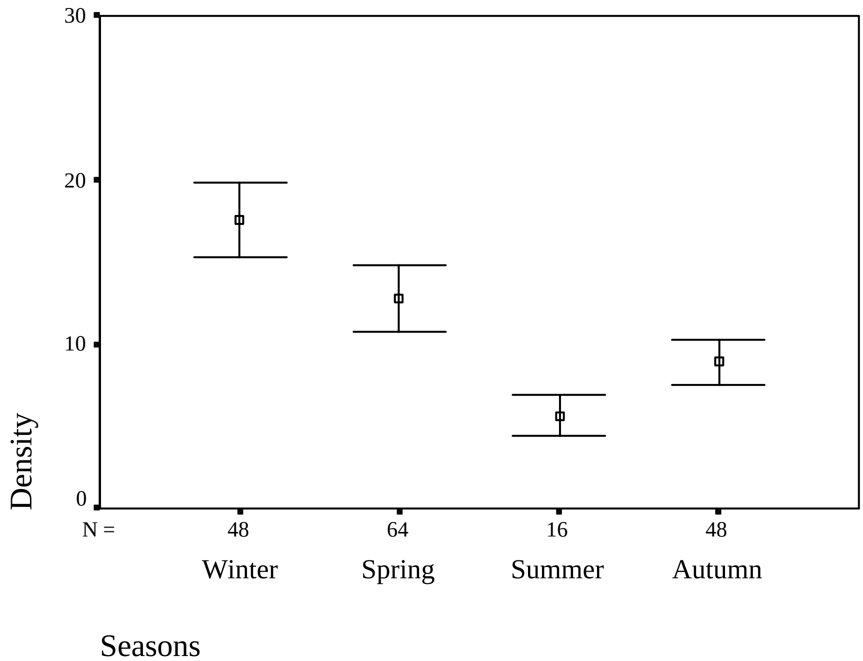


Table 4.5. Yearly Encounter Rates (#/km ± SE) for Goral in the Study Area (January 1996 - November 1998)

Transect Name	1996 (N=12)	1997 (N=12)	1998 (N=20)	Overall (N=44)
KHRO	0.42 ± 0.16	0.91 ± 0.24	0.38 ± 0.11	0.54 ± 0.10
ROSH	1.19 ± 0.35	1.12 ± 0.21	1.11 ± 0.17	1.14 ± 0.14
ROBA	1.18 ± 0.31	0.80 ± 0.24	1.27 ± 0.23	1.12 ± 0.15
CLNA	1.19 ± 0.52	1.59 ± 0.52	1.94 ± 0.37	1.62 ± 0.26
Overall	1.0 ± 0.18 (N=48)	1.10 ± 0.17 (N=48)	1.17 ± 0.13 (N=80)	1.10 ± 0.09 (N=176)

(Kruskal Wallis Test, c^2=2.53, df=2, p=0.29)

Table 4.6. Yearly Density Estimates (#/km²± SE) for Goral in the Study Area (1996-98). Transect Name 1996

Transect Name	1996 (N=12)	1997 (N=12)	1998 (N=20)	Overall (N=44)
KHRO	3.06 ± 1.18	9.42 ± 2.54	3.17 ± 0.97	4.84 ± 0.96
ROSH	13.76 ± 4.65	14.23 ± 2.76	12.87 ± 2.23	13.47 ± 1.80
ROBA	14.74 ± 3.58	10.12 ± 2.77	18.76 ± 3.91	15.22 ± 2.16
CLNA	11.71 ± 5.72	19.13 ± 6.54	17.16 ± 3.45	16.09 ± 2.84
Overall	10.82 ± 2.11 (N=48)	13.21 ± 2.05 (N=48)	12.99± 1.56 (N=80)	12.41 ± 1.07 (N=176)

(Kruskal Wallis Test, χ^2=3.58, df=2, p=0.17)

Fig.4.4. Yearly encounter rates for goral in the study area

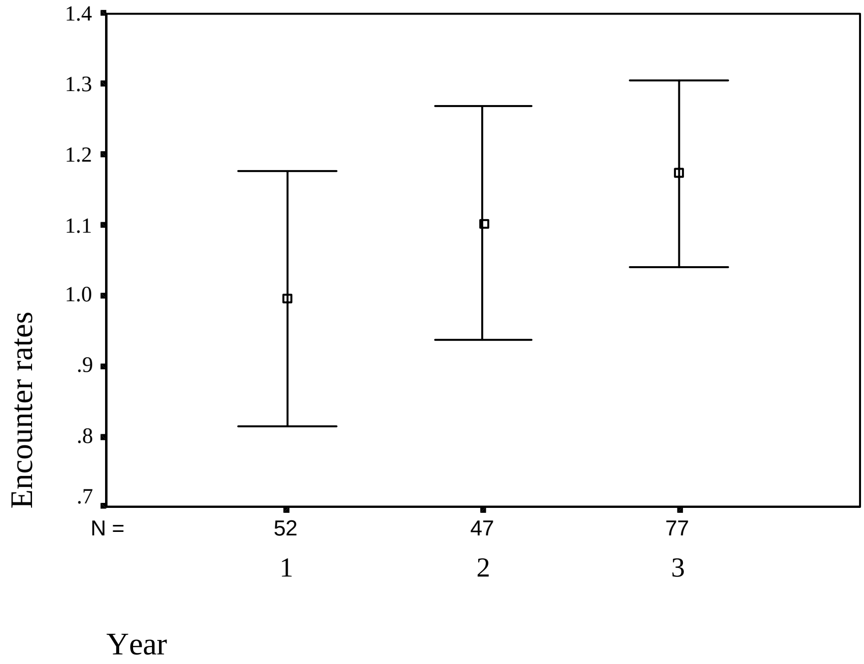


Fig.4.5. Yearly density estimates for goral in the study area

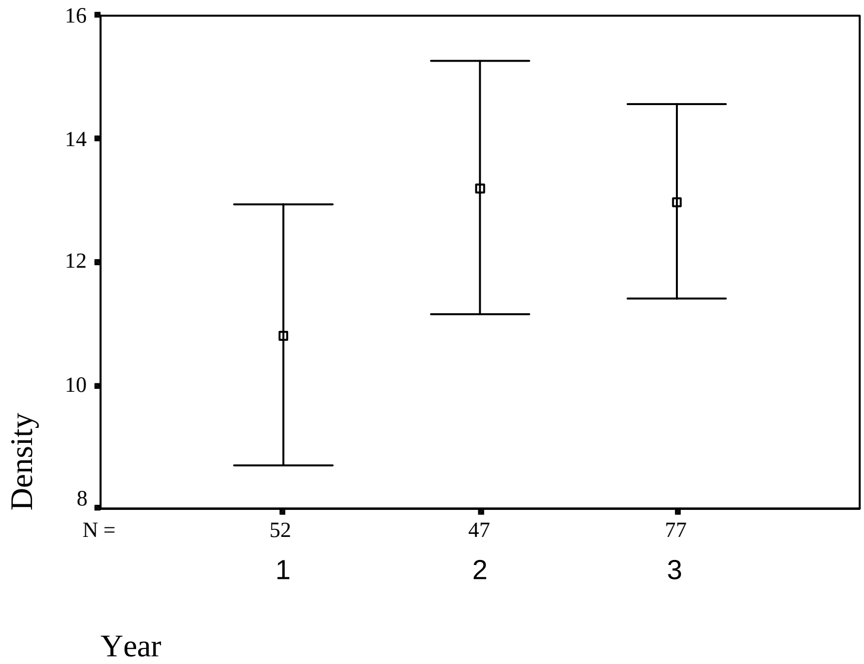


Table 4.7. Abundance estimates for goral in relation to disturbances in GHNP (January 1996 - November 1998).

Levels of disturbance	ER ± SE	Density ± SE	PER ± SE
High (N=88)	0.84 ± 0.09	9.16 ± 1.11	8.88 ± 0.45
Low (N=88)	1.37 ± 0.15	15.65 ± 1.77	8.09 ± 0.34

(K W Test, χ^2=5.58, df=1, p=0.018, χ^2=7.05, df=1, p=0.008, χ^2=2.58, df=1, p=0.11)

Table 4.8. Seasonal Encounter Rates (#/scan ± SE) and Densities (#/km^2 ± SE) of goral using Scan method (1996-1998) in GHNP

Location		Winter (N=9)	Spring (N=16)	Autumn (N=12)	Overall (N=37)
Kharongcha	No./km	2.44±1.07	1.69±0.55	1.18±0.54	1.73±0.39
	No./km^2	3.49±1.53	2.41±0.79	1.70±0.77	2.47±0.55
Rolla	No./scan	2.78±0.55	2.31±0.66	2.00±0.39	2.32±0.33
	No./km^2	4.63±0.91	3.85±1.10	3.33±0.65	3.87±0.56
Chidor	No./scan	4.00±1.18	2.81±0.96	1.67±0.31	2.73±0.52
	No./km^2	5.00±1.47	3.52±1.20	2.08±0.35	3.41±0.65
Overall	No./scan	3.07±0.55	2.27±0.41	1.64±0.24	2.26±0.25
	No./km^2	4.37±0.75	3.26±0.57	2.40±0.37	3.25±0.34

(Kruskal Wallis Test, χ^2=6.35, df=2, p=0.042)

Table 4.9. Yearly Encounter Rates (#/scan ± SE) and Densities (#/km² ± SE) of goral using Scan method (1996-1998) in GHNP.

Location		1996 (N=12)	1997 (N=10)	1998 (N=13)	Overall (N=37)
Kharongcha	No./scan	2.93±0.82	1.50±0.62	0.62±0.24	1.73±0.39
	No./km^2	4.18±1.15	2.14±0.89	0.88±0.34	2.47±0.55
Rolla	No./scan	2.71±0.73	2.10±0.48	2.08±0.40	2.32±0.33
	No./km^2	4.52±1.23	3.50±0.80	3.46±0.67	3.87±0.56
Chidor	No./scan	1.93±0.61	4.00±1.37	2.62±0.80	2.73±0.52
	No./km^2	2.41±0.76	5.00±1.71	3.27±1.01	3.41±0.65
Overall	No./scan	2.52±0.41	2.53±0.54	1.77±0.33	2.26±0.25
	No./km^2	3.70±0.61	3.55±0.70	2.54±0.45	3.25±0.34

(Kruskal Wallis Test, χ^2=1.45, df=2, p=0.48)

Table 4.10. Seasonal Encounter Rates (groups/km ± SE) for Goral pellet groups in the Study Area (January 1996 - November 1998).

Transect Name	Winter (N=12)	Spring (N=16)	Summer (N=4)	Autumn (N=12)	Overall (N=44)
ROSH	8.33±0.84	9.37±0.85	8.18±1.29	9.01±0.85	8.88±0.50
ROBA	10.83±1.18	7.42±0.82	8.41±1.41	8.03±0.91	8.60±0.55
CLNA	8.64±0.56	7.56±0.82	6.48±0.39	6.93±0.67	7.58±0.39
Overall	9.27±0.54 (N=36)	8.11±0.49 (N=48)	7.69±0.64 (N=12)	7.99±0.48 (N=36)	8.36±0.27 (N=132)

(Kruskal Wallis Test, χ^2=5.34, df=3, p=0.15)

Fig.4.6. Seasonal goral pellet groups encounter rates

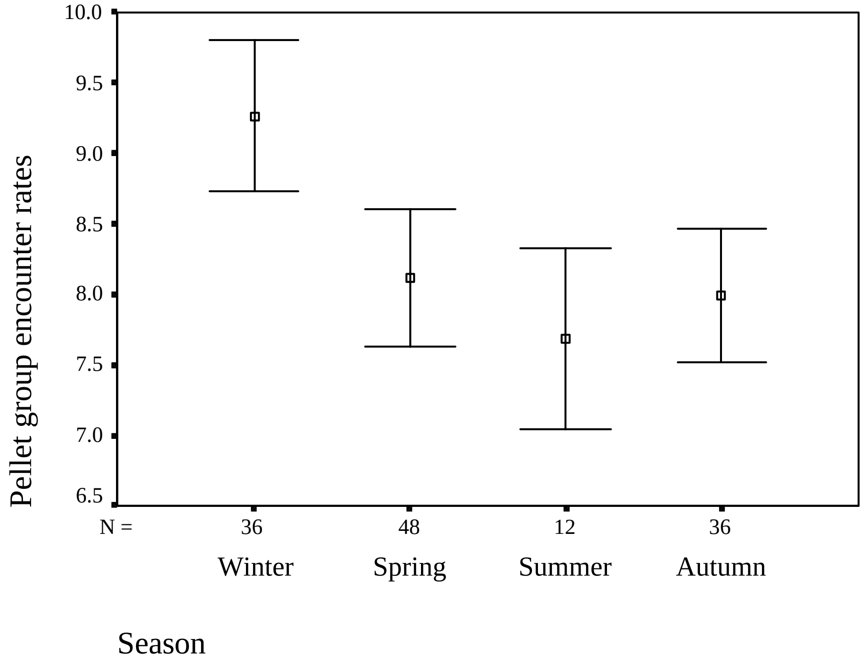


Fig.4.7. Yearly goral pellet group encounter rates

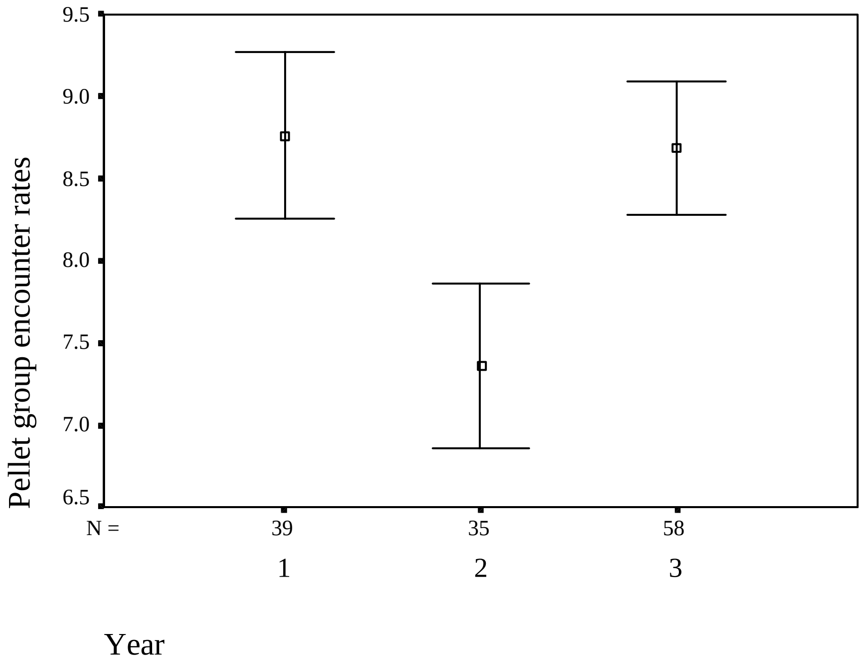


Table 4.11. Yearly Encounter Rates (groups/km± SE) for Goral pellet groups in the Study Area (January 1996 - November 1998)

Transect Name	1996 (N=12)	1997 (N=12)	1998 (N=20)	Overall (N=44)
ROSH	9.12 ± 0.92	8.39 ± 0.83	9.00 ± 0.68	8.88 ± 0.50
ROBA	9.02 ± 0.86	6.59 ± 0.98	9.59 ± 0.86	8.60 ± 0.55
CLNA	8.15 ± 0.89	7.20 ± 0.79	7.44 ± 0.46	7.58 ± 0.39
Overall	8.86 ± 0.53 (N=36)	7.88 ± 0.54 (N=36)	7.84 ± 0.41 (N=60)	8.36 ± 0.27 (N=132)

(Kruskal Wallis Test, χ^2=6.02, df=2, p=0.49)

4.5.2. Himalayan Musk Deer

4.5.2.1. Silent Drive Count

Results of density estimates for musk deer using silent drive counts in Gumtharao and Dhela areas were 3.70±0.37 and 0.47±0.48/km^2 in spring and 2.96±0.37 and 0.95±0.95/km^2 in autumn respectively (Table 4.12.). The overall estimates for musk deer in the area was 2.02±0.48/km^2

Table 4.12. Density estimates (#/km^2) for musk deer using silent drive count

Month & year	Gumtharao	Dhela
October 1995	3.33	0.00
June 1996	3.33	2.86
October 1996	3.33	0.00
May 1997	3.33	0.00
June 1998	4.44	1.43
October 1998	2.22	0.00
Mean density ± SE	3.33 ± 0.29	0.72 ±0.49

4.5.3. Himalayan Tahr

4.5.3.1. Scanning

Himalayan tahr encounter rate and density estimates in four vantage points are given in Table 4.13. ER and density estimates were not different (Mann Whitney U Test, $p>0.05$). However, spring had higher ER and density estimates. The lowest and highest density estimates were 0.73±0.50 and 4.90±1.58 respectively. The overall density estimates of tahr in the area ranged from 1.46±0.49 to 4.64±1.31. Disturbance played a major role in density estimates (Mann Whitney U Test, $p=0.033$), the low disturbance area had a higher density estimates. The ER and density estimates of Himalayan tahr in the area did not vary significantly between the years (See Table 4.14.).

Table 4.13. Seasonal Encounter Rates (#/scan ± SE) and Densities (#/km^2 ± SE) of Himalayan tahr using Scan method (1996-1998) in GHNP

Location		Spring (N=12)	Autumn (N=12)	Overall (N=24)
Chidor	No./scan	1.75±0.65	0.58±0.40	1.17±0.39
	No./km^2	2.19±0.82	0.73±0.50	1.46±0.49
Nara	No./scan	2.50±1.05	1.42±0.70	1.96±0.63
	No./km^2	2.78±1.16	1.57±0.78	2.18±0.70
Pardi	No./scan	3.75±1.90	1.58±0.81	2.67±1.03
	No./km^2	4.17±2.12	1.76±0.90	2.96±1.14
Gumtharao	No./scan	3.91±1.54	3.50±1.52	3.71±1.05
	No./km^2	4.90±1.58	4.37±2.86	4.64±1.31
Overall	No./scan	2.98±0.67	1.77±0.48	2.38±0.41
	No./km^2	3.51±0.79	2.11±0.81	2.82±0.49

(M-U Test, $U=992.5$, $p=0.199$)

Table 4.14. Yearly Encounter Rates (#/scan ± SE) and Densities (#/km² ± SE) of Himalayan tahr using Scan method (1996-1998) in GHNP

Location		Year 1 (N=8)	Year 2 (N=8)	Year 3 (N=8)	Overall (N=24)
Chidor	No./scan	0.88±0.58	1.00±0.65	1.63±0.85	1.17±0.39
	No./km^2	1.09±0.72	1.25±0.83	2.03±1.05	1.46±0.49
Nara	No./scan	2.17±1.38	0.90±0.64	3.13±1.34	1.96±0.63
	No./km^2	2.40±1.53	1.00±0.71	3.47±1.49	2.18±0.70
Pardi	No./scan	2.00±1.02	4.25±2.70	1.75±1.16	2.67±1.03
	No./km^2	2.22±1.13	4.72±3.00	1.95±1.29	2.96±1.14
Gumtharao	No./scan	2.63±1.02	3.00±2.05	5.50±2.19	3.71±1.05
	No./km^2	3.28±1.27	3.75±2.57	6.88±2.74	4.64±1.31
Overall	No./scan	1.90±0.47	2.20±0.83	3.00±0.75	2.38±0.41
	No./km^2	2.24±0.55	2.58±0.97	3.58±0.91	2.81±0.49

(Kruskal Wallis Test, χ^2=1.38, df=2, p=0.5)

4.6. Discussion

4.6.1. Goral

4.6.1.1. Line transect sampling

Line transect sampling technique was found to be the most suitable and reliable method for estimating the relative abundance and density estimates for goral in GHNP. A combination of line transect sampling, scanning and silent drive count was found suitable for goral in some areas of Kedarnath Wildlife Sanctuary (Sathyakumar 1994) but in most of the cases line transects and scanning were found to be suitable.

4.6.1.1.1. Encounter rate

Surveys conducted by Gaston and Garson (1992) in GHNP expressed the ER of goral as number seen/hour effort. Transects in the present study pass through various altitudinal ranges and the searching effort varied with time of the day and seasons. Hence, the ER of goral in the present study was expressed as number seen/km walk. Except for the transect KHRO, all other transects had a similar ER. The altitudinal range of KHRO transect was only 1900-2300 m, which is lower than the preferred altitudinal range of goral in GHNP (See Chapter 6).

There was a significant difference in the ER of goral in all transects between seasons. Winter had the highest ER and summer had the lowest. This could be attributed to the fact that goral do form bigger groups during winter, due to low availability of snow free areas to feed (See chapter 5). There was a decline in the ER of goral during spring, autumn and summer. During these seasons, the animal could be dispersed to more snow free areas; water and forage were plenty not restricting their movements. Another reason for the low ER may due to the higher ambient temperature in late spring, summer and earlier autumn (See Fig. 2.3.) which would have made the animal to restrict to cooler valleys, away from the transects. The higher ER in less disturbed areas suggested that goral do respond adversely to human disturbances. As all transects of the present study are the representative of goral habitats in GHNP, the overall ER of 1.10±0.09/km can be taken as the ER of goral in the goral habitat of GHNP. The ER of goral in the area is lower than the estimates made for other parts of Western Himalayas. The overall ER for goral in Temperate pine -oak forest in Kedarnath Wildlife Sanctuary was 3.11/km walk (Sathyakumar 1994), which is much higher than the present estimate. However the ER in temperate scattered tree and scrub forest in Kedarnath Wildlife Sanctuary was 0.50 and 1.18/ km walk, which is slightly lower than the present estimate.

4.6.1.1.2. Density

The Kings method used for density estimates is a robust and flexible method, and has been acknowledged to be good for getting estimates for monitoring trends of the populations (Rodgers 1988). Transects in the area were not always straight and there was a considerable heterogeneity within transect. But in all transects, the shrub/ground cover exceeding the height of goral was less than 15%. This reduces the chances of the animal to move away without being seen and hence this method has been the most accurate method for estimating goral density in GHNP. This method was found suitable for goral in Kedarnath Wildlife Sanctuary by Sathyakumar (1994).

Density estimates for goral show a trend similar to ER in the area. Density estimates were higher in winter compared to other seasons and were higher in transects ROBA and CLNA compared to other transects. The human activities were relatively low in these two transects compared to other areas. There was a declining trend in density estimates from winter season to autumn season. During spring and autumn, the animal could be dispersed to more snow free areas and water and forage were plenty not restricting their movements. Another reason for the low ER may due to the higher ambient temperature in late spring, summer and earlier autumn (See Fig. 2.3.) which would have made the animal to restrict to cooler valleys, away from the transects. The density estimates in the area ranged from 1.62±1.63 to 26.38±4.88/km^2. The overall density estimates for goral in the area was 12.41±1.07/km^2, which is lower than the estimates from other areas of Western Himalayas such as Kedarnath Wildlife Sanctuary, 13.92/ km^2 in temperate pine-oak forest (Sathyakumar, 1994). However, the present estimate is much higher than that estimated in temperate scattered tree and scrub forest of Kedarnath Wildlife Sanctuary (4.20/km^2, Sathyakumar 1994). Goral ER and density estimates in the area showed a positive correlation (Fig.4.8., $r^2 = 0.89$, $p = 0.000$). Thus goral ER in the area may be taken as a reliable indicator for goral density.

4.6.1.2. Scanning

The goral density estimate obtained by scanning was 3.25±0.34, which is less than one-third of the density estimates made by transect sampling using King's method. The overall estimate based on scan count for goral in the area was 2.26±0.25/scan and was lower than the estimates made in temperate pine-oak forest of Kedarnath Wildlife Sanctuary (6.0±0.28, Sathyakumar 1994). The density estimates were higher in winter and there was a decline in the density estimates during spring and autumn. Goral in the area probably disperse depending on the weather and disturbance. Scan cannot be recommended to estimate the density of goral in the area. But scanning will be helpful to study the group size and activity pattern of the animal. This technique seems to be good for monitoring goral in the area.

4.6.1.3. Pellet group counts

Pellet group counts were done only for goral as no other animal pellets were encountered during transect walks. There was no significant difference in the ER of goral pellet groups in various areas between seasons. The animal ER and pellet group ER in the area showed a positive relationship (Fig.4.9.) but were weakly correlated. Similarly the pellet group ER and animal density also showed a weak correlation (Fig.4.10.).

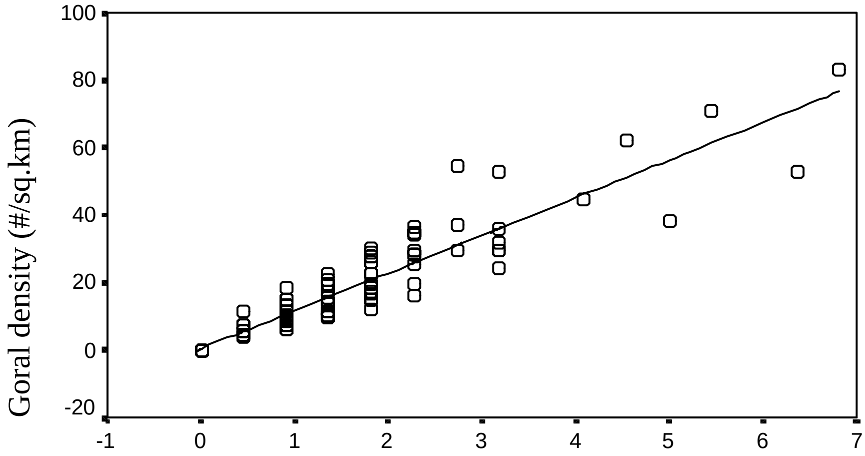
4.6.2. Himalayan Musk Deer

4.6.2.1. Silent Drive Counts

From the silent drive counts (n=12) in the study area, the overall musk deer density was estimated as 2.02±0.48 musk deer/km^2 in the musk deer habitats, which is lower than the estimates of Green, 1985 (3.2/km^2) and Sathyakumar, 1994 (3.7/km^2) in Kedarnath Wildlife Sanctuary. The highest density was observed in Gumtharao area (3.33±0.29/km^2) compared to Dhela area (0.72±0.49/km^2). This is because Gumtharao is away from villages and had a low level of biotic pressure, where as Dhela is very near to villages and had a greater intensity of human activities.

Fig. 4.8. Correlation between goral encounter rates and density (N = 176)

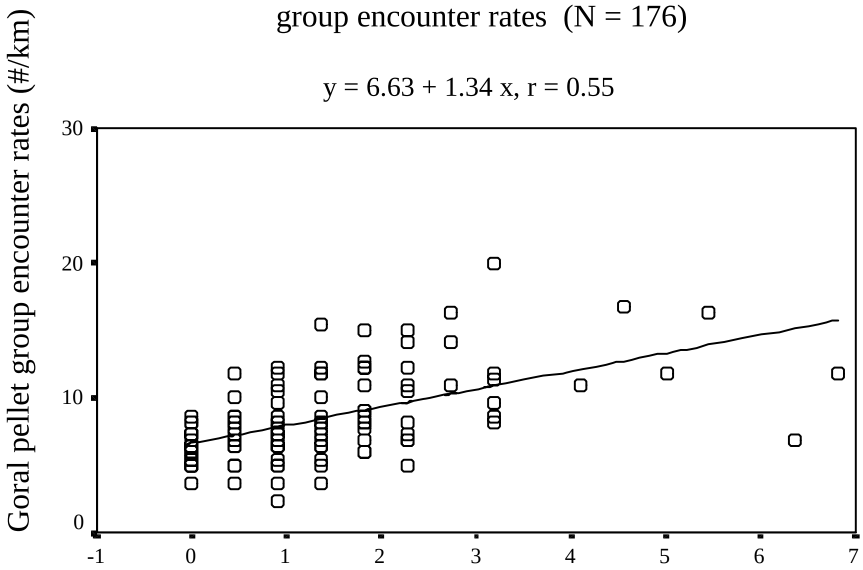
y = 0.52 + 11.16 x, r = 0.94



Goral encounter rates (#/km)

Fig. 4.9. Correlation between goral and its pellet group encounter rates (N = 176)

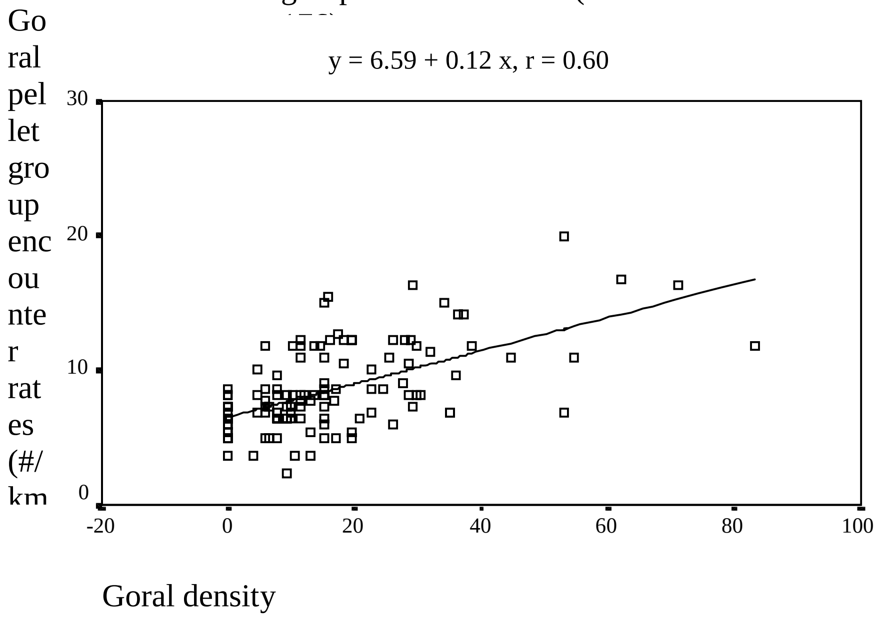
y = 6.63 + 1.34 x, r = 0.55



Goral encounter rates (#/km)

Fig.4.10. Correlation between goral density and its

group encounter rates (N =



4.6.3. Himalayan Tahr

4.6.3.1. Scanning

Scanning was found to be the only suitable method for estimating the abundance and density estimates for Himalayan tahr. The overall density estimates for Himalayan tahr in the area was 2.81±0.49 animals/km^2. Density estimates were higher in spring compared to autumn. Gumtharao had recorded highest density estimates (4.64±1.31/km^2) in the area. This could be due to relatively low level of human activities in the area. The density estimates were again lower than the estimates from Kedarnath Wildlife Sanctuary (25.7/km^2, Sathyakumar 1994) and Langtang National Park (5 to 46/km^2, Green 1978).

4.7. CONCLUSION

For goral it was found that a combination of line transect sampling and scanning provided reliable estimates. These two methods are very simple and the frontline staff can execute the same with out difficulty. The present study, scanning provided only 1/3rd of the actual density of goral. Silent drive count is the most appropriate method for estimating the Himalayan musk deer density in the area where as Himalayan tahr in the area could be monitored by using scanning technique. The abundance and density estimates for ungulates were low in GHNP compared to other parts of Western Himalayas. This may be due to less protection provided to this area in the past. The creation of National Park in the area in 1984 has led to improved protection. But the ever-increasing human activities in the Park, especially mushroom and medicinal herb collections in recent time, are a major concern in the conservation and management of the species. The occasional poaching of ungulates in the area, particularly musk deer and Himalayan tahr, causes great concern.

5.0 GROUP SIZE, AGE AND SEX COMPOSITION

5.1. INTRODUCTION

Habitat types often influence the group size and composition of ungulates. Although the data on group size and composition alone may reveal little information about the dynamics of ungulates populations, they do provide useful insights to population characteristics and trends. Responses to the food supply and predators are important factors determining group size in many species (Jarman, 1974). Group size may be influenced by food conditions, availability and foraging efficiency. Disturbance can be a major factor affecting the population of mountain ungulates and modifying interactions among species in the communities (Connel, 1978).

Most members of the Families ‘Cervidae’ and ‘Bovidae’ are highly gregarious and were studied in detail (Clutton-Brock et al 1982, Geist 1971, Nievergelt 1981, Rice 1984, Rodgers 1977, Scaller 1967, 1977, Soma 1987). Estes (1974) compiled data on social organization and habitats of African bovids and suggested that species living in closed habitats are usually primitive, solitary, small, and cryptically coloured browsers which hide from danger. Jarman (1974) indicated that graziers which are largely generalistic feeders, may present in larger groups in areas where grass is abundantly available where as, browsers which are much more selective feeders, live in small groups or solitary. However, information about the most primitive taxa of Caprinae (Rupicaprids) is mostly anecdotal (Cavallini 1992, Gaston et al. 1981, 1983, Gaston & Garson 1992, Mead 1989, Prater 1980, Roberts 1977 and Soma 1987). This chapter documents the variation in group size and composition of goral, Himalayan musk deer and Himalayan tahr observed in relation to season, time of the day and levels of disturbance in GHNP during January 1996 to November 1998.

5.2. OBJECTIVES

The study was conducted with following specific objectives.

- To study the variation in size and composition of groups of goral, musk deer and Himalayan tahr in GHNP in relation to seasons, time of the day and disturbance factors.
- To determine the sex ratio of these ungulates.

5.3. METHODS

Data on group size and sex of goral were collected by regularly monitoring four trails (2.2 km each) passing through various levels of disturbance, supplemented by instantaneous scan sampling (Altmann, 1974) from vantage points. The trails were traversed at various time periods between 06.00h and 18.00h, 6 to 8 times/month. Number of animals per group and time of sighting were noted for every sightings. Two groups were considered distinct if they were separated by a distance greater than the greatest width of either of the units, as seen from the observer's position (Barrette 1992). Diurnal variation in group size was examined during three time periods: morning (06.00 to 09.00h), day (09.01 to 15.00h) and evening (15.01 to 18.00h). The sex of individuals identified whenever possible by observing their genitalia and horn-base thickness. In spring, an adult goral followed by a young was considered as female. G-test was carried out to find the diurnal and seasonal variations in group sizes.

Group size and sex of Himalayan musk deer were recorded by systematically traversing through known musk deer habitats at regular intervals. Four vantage points were selected to scan opposite slopes during various time periods for the group size and composition of Himalayan tahr, supplemented by instantaneous scanning. All the data were subjected to G-test to find out significance.

5.4. RESULTS

5.4.1. Goral

In total, there were 445 groups observed, comprising 857 individuals. Gorals formed aggregations showing spatio-temporal variation with group size from one to 14 animals. The distribution of group size was skewed due to preponderance of sightings of solitary individuals in all seasons (Winter = 41%, Spring = 47% & Autumn = 56%, Fig.5.1.). The mean group sizes for winter, spring and autumn were 2.26, 1.88, and 1.61 individuals respectively, with an annual mean group size of 1.92 individuals per group. A G-test indicate a significant variation in the size of groups formed between seasons ($n=445$, $G=18.1$, $df=4$, $p<0.005$). The group size observed in winter season were significantly different from that observed in spring ($G=7.6$, $p<0.05$) and autumn ($G=16.2$, $p<0.001$). The low frequency of larger group sizes and statistical restriction, (Zar, 1984) required merging of larger group size categories. Clumped data for the entire study period did not show any significant differences in size of groups formed in different parts of the day ($n=445$, $G=5.9$, $p>0.05$). However, when comparing data seasonally between parts of the day, significantly larger groups were observed ($n=160$, $G=15.6$, $p<0.005$, Table 5.1) only during winter evenings (43.8%, $n=64$). No significant differences were found in the diurnal variation of group sizes during spring and autumn.

Table 5.2. Show the group sizes along two levels of disturbance. Clumped data for the entire study period indicate a significant difference in group size between less disturbed and more disturbed areas ($n=445$, $G=29.6$, $df=4$, $p<0.005$). Larger groups formed in less disturbed areas (27%, $n=256$) in contrast to more disturbed areas (12%, $n=189$). Similarly, except for spring ($n=174$, $G=3.2$, $p>0.05$) seasonal analyses indicated a significant variation in group size between

less disturbed and more disturbed areas both in winter (n=160, G=11.9, $p<0.05$) and in autumn (n=111, G=22.4, $p<0.005$). Larger groups were encountered in less disturbed areas in all seasons viz., winter (40%, n=90), spring (22%, n=106) and autumn (17%, n=54) as compared to more disturbed areas (17%, n=64 in winter, 12%, n=68 in spring & 5%, n=57 in autumn respectively). Of the 857 gorals observed, only 17% could be classified to sex and age classes. Of these, adult males, females and young ones formed 34, 53 and 13 % respectively. The sex of majority of the groups (83%) could not be identified. So no further attempt was made to categorize and compare the social organization and its sex ratio.

Table 5.1. Seasonal and diurnal variation in group size of goral in GHNP during 1996-98.

Season	Time period (h)	N	Group size		
			1	2	≥ 3
Winter	06.00-09.00	62	27	18	17
	09.01-15.00	34	21	9	4
	15.01-18.00	64	17	19	28
Spring	06.00-09.00	76	37	24	15
	09.01-15.00	29	11	12	6
	15.01-18.00	69	34	25	10
Autumn	06.00-09.00	45	25	15	5
	09.01-15.00	26	17	6	3
	15.01-18.00	40	20	16	4
Overall	06.00-09.00	183	89	57	37
	09.01-15.00	89	49	27	13
	15.01-18.00	173	71	60	42

Table 5.2. A comparison of sightings of different group sizes of goral observed in more disturbed and less disturbed areas (1996-98).

Season	Levels of disturbance	N	Group size		
			1	2	≥ 3
Winter	More disturbed	64	35	18	11
	Less disturbed	96	30	28	38
Spring	More disturbed	68	36	24	8
	Less disturbed	106	46	37	23
Autumn	More disturbed	57	44	10	3
	Less disturbed	54	18	27	9
Overall	More disturbed	189	115	52	22
	Less disturbed	256	94	92	70

5.4.2. Himalayan Musk Deer

A total of 66 individuals of Himalayan musk deer were sighted in 65 encounters, of which 35% individuals were unclassified. Adult males, females and young ones composed 24, 38 and 3 % respectively of the total sightings. Adult sex ratio (Male : female) were 1 : 1.42 and 1 : 1.79 in spring and autumn respectively with no detectable seasonal variation (G=0.1, df=1, p>0.05).

Fig.5.1. Goral group sizes (%) in GHNP (n=445). One sighting of 14 individuals not included.

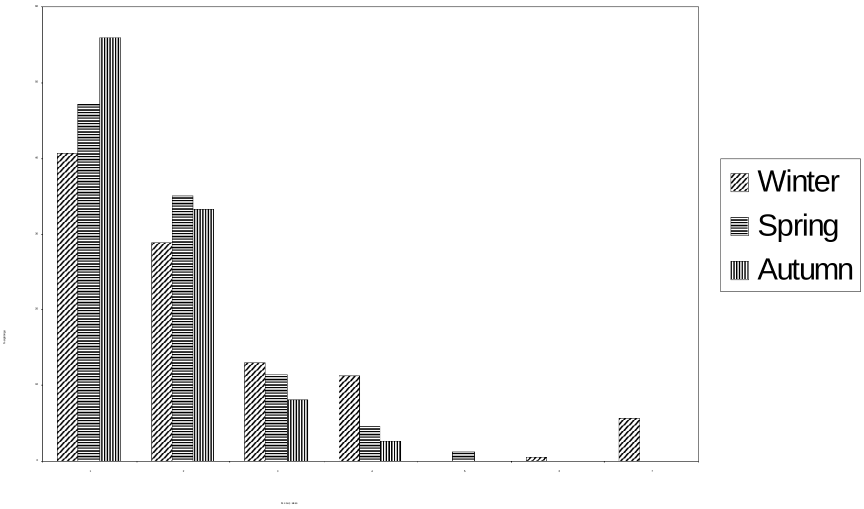
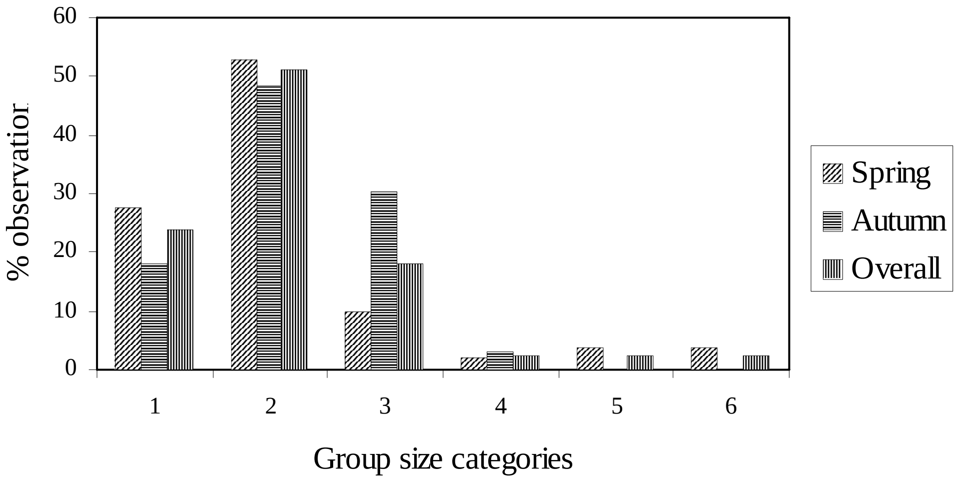


Fig.5.2. % observation of Himalayan tahr group sizes in GHNP (n=84)



5.4.3. Himalayan Tahr

Himalayan tahr in the area formed groups that varied from one to 26 animals (Fig.5.2). A total of 84 groups comprised of 445 individuals were observed during the study period. The mean group sizes for spring and autumn were 5.14 and 5.15 respectively. A G- test did not indicate any significant difference in the size of groups formed between the two seasons (n=84, G=2.3, p>0.05). Although larger groups were encountered more in less disturbed areas (28%, n=53) compared to more disturbed areas (19%, n=31), the difference was statistically non-significant (n=84, G=3.6, df=2, p>0.05, Table 5.3.). Groups with 1-6 individuals made up 80% (n=51) and 67% (n=33) of observations in spring and autumn respectively (Fig. 5.2.). Female groups were numerous in all seasons, but frequencies of observed group types varied seasonally (G=12.4, df=3, p<0.05). All the male groups observed were solitary and were more numerous in spring (28%, n=51, Fig.5.3.). Mixed groups were also observed in both seasons and were larger, consisting of >7 individuals/group (79%, n=14, Fig.5.4.). Of 445 Himalayan tahr observed, 91% could be classified to sex and age classes. Of these, adult males, females and young ones composed 12.5, 77.5 & 10% respectively. Adult sex ratio (Male : female) was 1 : 8.2 and 1 : 4.6 in spring and autumn respectively with a significant seasonal variation (G=3.9, df=1, p<0.05). Adult female : young ratios were 1 : 0.122 and 1 : 0.145 in spring and autumn with no detectable seasonal variation (G=0.2, df=1, p>0.05).

Table 5.3. A comparison of sightings of different group sizes of Himalayan tahr observed in more disturbed and less disturbed areas.

Season	Levels of disturbance	n	Group size					
			1	2-6	7-11	12-16	17-21	>21
Spring	More disturbed	17	3	11	2	1	0	0
	Less disturbed	34	11	16	3	0	2	2
Autumn	More disturbed	14	2	9	3	0	0	0
	Less disturbed	19	4	7	7	1	0	0
Overall	More disturbed	31	5	20	5	1	0	0
	Less disturbed	53	15	23	10	1	2	2

5.5. DISCUSSION

5.5.1. Goral

Small body size, high metabolic rate and selective feeding would favour a solitary life for goral (Cavallini 1992, Green 1987, Mead 1989, Pendharkar 1993 and Soma 1987). Present data also support the hypothesis that gorals were not particularly social and were predominantly solitary. Males were observed largely solitary interacting with female groups only during the rut (Pendharkar & Goyal 1995). The result of the present study also showed similar trend. The largest aggregations of 14 animals observed in the study area represents the upper limit of group sizes for gorals (18–Mishra 1993, 12–Engelmann 1938, 11–Pendharkar & Goyal 1995, Lovari & Apollonio 1992, 10–Geptner et al. 1989, 9–Cavallini 1992, Sathyakumar 1994, 6–Green 1981).

Data from this study indicate that goral group size varies seasonally with larger groups encountered more in winter (31%. n=160) than any other seasons. This was contrary to the findings of Sathyakumar (1994) in Kedarnath Wildlife Sanctuary where he recorded no significant seasonal variations in group sizes (Range 1.77 to 2.21). These larger groups seem to reflect a response to snow cover. During winter the availability of snow free areas are limited and animals would be aggregating to the snow free south facing slopes. The larger group size might also be an antipredation strategy. In open areas, animals presumably use each other as cover in an environment otherwise lacking cover (Barrette 1991). The increased group sizes observed during evening hours were resting or feeding aggregations. In spring and autumn, the increased forage availability would allow goral to restrict activity closer to cover and to live in comparatively smaller groups. Eventhough there was no significant diurnal variations in group size during spring and autumn, goral in the area had a tendency to use more forested areas with rise in ambient temperature. Lovari and Apollonio (1993) and Mishra (1993) also reported similar observations.

Contrasting to the earlier findings of Pendharkar & Goyal (1995), larger groups were encountered in less disturbed areas during all the seasons. Although forage abundance was not quantified, changes were apparent with levels of disturbances. Due to heavy grazing and other biotic activities the forage abundance and quality would be low in more disturbed areas and are unlikely to support big groups, goral may, therefore break into smaller foraging groups. The high intensity of poaching especially with firearms could be another reason for small group formations. On the other hand, in less disturbed areas, larger group formations may increase the foraging efficiency by exploiting the benefits of gregariousness, such as improved vigilance, predation dilution etc.

5.5.2. Himalayan musk deer

The present study, although with limited data also support the solitary nature of Himalayan musk deer as shown by Green (1985). Out of the 65 sightings, one occasion only two unidentified individuals were sighted together. The sex ratio of the study population was in favour of females throughout the year. The present result did not agree with the 1:1 sex ratio reported by Green (1985) but were similar to that reported (1:2.2) by Sathyakumar (1994) in Kedarnath Wildlife Sanctuary.

5.5.3. Himalayan tahr

The mean group size of Himalayan tahr in the study area were much lower than that reported in Kedarnath Wildlife Sanctuary by Sathyakumar (1994) and in Langtang National Park by Green (1981) (Mean group size: 13.5, Range: 1 to 72). Himalayan tahr in the area tends to remain in smaller groups (1-6 individuals) throughout the study period. Gaston *et al*. (1981) also reported very small group size for Himalayan tahr (Mean group size: 1.7) during their survey in GHNP. Habitat degradation due to heavy biotic pressure such as over grazing and medicinal herb collection along with severe poaching might be the reasons for smaller group size.

A large number of solitary male groups (28%) and female groups (57%) observed during spring suggests that sexes generally are segregated in Himalayan tahr. Adult sex ratio of Himalayan tahr showed a seasonal variation. The sex ratio was in favour of females throughout the year. Sathyakumar (1994) reported similar observation (1:2.2 to 1:3.2) in Kedarnath Wildlife Sanctuary.

6.0 HABITAT USE

6.1. INTRODUCTION

The basic requirement for the conservation and management of ungulates is the sound knowledge of their specific habitat use pattern. In the western Himalaya, only a few recent studies have been focused on the association between ungulates and their habitat components (e.g. Fox *et al*. 1988, Ben-Shahar 1990, Mishra 1993, Sathyakumar 1994 and Bhatnagar 1997). The selection of an area by a species depends on the availability of specific resources on that particular area, which can fulfill the requirement of the species.

The habitat use of ungulates are generally determined by factors such as food and water availability, shelter, escape cover and the extent of human use (Duncan 1983, Hanley 1984, Putman 1986, Gordon 1989 a&b, Beirer & Mc Cullough 1990 and Thirgood 1995). In the Himalaya, altitude, aspect and slope determine the distribution of plant species and hence contribute a major role in determining the habitat use. Most seasonal variation in habitat use by ungulates have been associated with seasonal changes in the availability of food and protective cover. The abundance of predators and the anti-predatory strategies are also important in determining preferred habitats by mountain ungulates (Mishra 1993, Mishra & Johnsingh 1997 and Sathyakumar 1994).

In India, studies on habitat use patterns of goral were carried out in Kedarnath Wildlife Sanctuary (Green 1985 & Sathyakumar 1994), Majahtal Wildlife Sanctuary (Mishra 1993 and Lovari & Apollonio 1994). Himalayan musk deer habitat use and ranging pattern was studied by Kattel (1990) in Sagarmatha National Park and Green (1985) & Sathyakumar (1994) in Kedarnath Wildlife Sanctuary. Sathyakumar (1994) studied the habitat use of Himalayan tahr in Kedarnath Wildlife Sanctuary. In Himachal Pradesh virtually no information is available on the habitat use patterns of Himalayan musk deer and Himalayan tahr. Only short-term studies were carried out on habitat use patterns of goral. So through the present study, an attempt had been made to identify the major factors that are affecting the habitat use by these animals in Himachal Pradesh with particular reference to GHNP.

6.2. OBJECTIVES

The present study was carried out with the following objectives

- To determine seasonal habitat selection trends in goral, musk deer and Himalayan tahr
- To study the availability-utilization patterns of various factors by these ungulates

6.3. METHODS

To quantify the availability-utilization of goral, existing four trails were used since it was not feasible to lay the transects randomly due to the terrain features. Ten metre plots were laid at every 100m interval along these trails following Marcum & Loftgaarden (1980). Data on the availability of habitat variables were recorded seasonally. For quantifying the utilization, the trails were walked twice every month. Whenever an animal/group was encountered the habitat variables were noted at the centre of activity within a radius of 10m. Habitat availability of musk deer and Himalayan tahr were recorded during spring and autumn by systematically laying 10m plots (n=80) within their habitat. These habitats were regularly traversed to get the utilization data. For every animal encounter, the habitat variables were noted at the centre of activity within a radius of 10m as mentioned in Table 6.1.

Habitat selection was evaluated by comparing the habitat availability with the number of animals seen in each habitat. The Chi-square goodness of fit test (Neu *et al*. 1974, Byers *et al*. 1984) was one of the most commonly used method of statistically comparing resource use and availability. A computer programme 'PREFER' (Prasad & Gupta 1992) based on Neu et al. (1974) technique was used to compare the availability-utilization of various habitat variables. In order to have a multivariate persprctive, Principal Components Analyses ordination (Norusis 1990) was used.

Table 6.1. Habitat variables and their categories used in quantifying the habitat selection by ungulates in GHNP.

Habitat variables	Description
Altitude	Elevation in metres
Aspect	N (338-23), NE (24-68), E (69-113), SE (114-158), S (159-203), SW (204-248), W (249-293), NW (294-337)
Slope	Angle estimated in degrees at every 50 intervals
Canopy cover	Recorded in % in units of 5 (within a 10m radius plots)
Tree cover	Recorded in % in units of 5
Shrub cover	Recorded in % in units of 5
Grass cover	Recorded in % in units of 5
Rock & soil cover	Recorded in % in units of 5

6.5. RESULTS

6.5.1. Goral

Of the 445 sightings of goral, data on use of habitat factors were collected only for 184 observations as the rest of the sightings were during deliberate searching of specific areas and known individuals.

6.5.1.1. Use of altitude, aspect and slope

Goral mainly used areas between 2301 m and 2600-m altitude in all seasons (Table 6.2.). Areas above 3000 m were consistently avoided by goral. There was no significant difference between the use of altitudes between seasons (Kruskal Wallis Test, c^2=0.785, df=2, p>0.05). Gorals in the study area were sighted more in areas with altitudes between 2301m and 2600m and sightings were low in altitudes below 2200m and above 2900m (c^2=249.03, df=8, p<0.05, Table 6.3.). Southerly aspects (Southeast, South and Southwest) were used relatively more during all seasons (Table 6.2.) with an affinity toward South and Southeastern aspects throughout the year (c^2= 85.23, df=7, p<0.05, Table 6.3.). Goral showed a tendency to occur more equitably among aspects throughout the year (Kruskal Wallis Test, c^2=4.00, df=2, p>0.05). Gorals were mostly sighted in steep slopes with an angle of 31^0 to 70^0 (Table 6.2.). Slopes with an angle of 31^0 to 60^0 were used more in winter (92 %) and autumn (87 %), while in spring they used 41^0 to 70^0 (89.7 %). Kruskal Wallis Test showed a significant seasonal difference in the usage of slope by goral (c^2=19.18, df=2, p<0.05). Goral in the study area preferred steep (41-50^0) slopes and avoided gentle (<30^0) slopes (c^2= 34.83, df=4, p<0.05, Table 6.2.).

6.5.1.2. Use of tree cover, shrub cover, grass cover and rock and soil cover

Goral mainly used areas with <20 % tree cover through out the year (Table 6.3., Kruskal Wallis Test, c^2=3.34, df=2, p>0.05). Goral preferred areas with low tree cover (<10%) throughout the year and avoided all areas were tree cover exceeds 20% (Winter: c^2=38.40, df=3, p<0.05, Table 6.5.; Spring: c^2=61.86, df=3, p<0.05, Table 6.6.; Autumn: c^2=8.23, df=3, p<0.05, Table 6.7.). They were mostly sighted in a wide range of shrub cover categories (1-10 % to 21-30 %) during spring and autumn but mostly 1-20% shrub cover categories were used in winter (Kruskal Wallis Test, c^2=8.4, df=2, p<0.05). But they preferred areas with less shrub understorey and avoided all areas where shrub cover exceeds 20% (Winter: c^2=31.29, df=4, p<0.05, Spring: c^2=23.11, df=4, p<0.05, Autumn: c^2=16.11, df=4, p<0.05, Table 6.4.). Goral used a wide range of grass cover and rock and soil cover during spring and autumn but mainly restricted to areas with 11-40 % grass cover and rock &soil cover categories during winter. There was a significant seasonal difference in the usage of grass cover (Kruskal Wallis Test, c^2=41.02, df=2, p<0.05) and rock & soil cover (Kruskal Wallis Test, c^2=16.01, df=2, p<0.05) by goral in the study area.

Goral in the area preferred moderate grass cover (Winter: c^2=56.45, df=6, $p<0.05$, Spring: c^2=16.70, df=6, $p<0.05$, Autumn: c^2=9.99, df=6, $p<0.05$, Table 6.4.) and rock and soil cover (Winter: c^2=74.37, df=6, $p<0.05$, Spring: c^2=68.79, df=6, $p<0.05$, Autumn: c^2=28.81, df=6, $p<0.05$, Table 6.4.)

Factorial analyses using PCA on altitude (natural log), slope, canopy cover, tree cover, shrub cover, grass cover and rock and soil cover (arcsine transformed) extracted two factors that explained 61.04, 60.78 and 60.86% of the variation in the data during winter, spring and autumn respectively. During winter Factor 1 (PC1) explained 41.06% of variation in the data and Factor 2 explained 19.98% of variation. During spring, Factor 1 showed 35.14% of variation in data and Factor 2 showed 25.64% of variation in the data whereas during autumn Factor 1 explained 36.35% variation as compared to 24.51% variation by Factor 2. Ordination based on Principal Component Analyses showed seasonal differences in the use of habitat variables (See Fig. 6.1., 6.2. & 6.3.).

Table 6.2. Use (%) of altitude, aspect and slope by goral in GHNP during 1996-1998.

Habitat factors	Winter (n=62)	Spring (n=77)	Autumn (n=45)	Overall (n=184)	*Intensity of use
Altitude (m)					
<2200	1.6	1.3	0.0	1.1	Low
2201-2300	8.1	5.2	0.0	4.9	Moderate
2301-2400	24.2	23.4	26.7	24.5	High
2401-2500	19.4	22.1	20.0	20.7	High
2501-2600	19.4	23.4	31.1	23.9	High
2601-2700	9.7	3.9	4.4	6.0	Low
2701-2800	4.8	9.1	8.9	7.6	Low
2801-2900	12.9	9.1	8.9	10.3	Moderate
>2900	0	2.6	0.0	1.1	Low
Aspect					
North	1.6	0.0	0.0	0.5	Low
Northeast	0.0	0.0	0.0	0.0	Low
East	0.0	1.3	8.9	2.7	Moderate
Southeast	37.1	23.4	44.4	33.2	High
South	37.1	62.3	28.9	45.7	High
Southwest	6.5	7.8	4.4	6.5	Low
West	0.0	0.0	0.0	0.0	Low
Northwest	17.7	5.2	13.3	11.4	Low
Slope categories					
<30					
31-40	1.6	1.3	2.2	1.6	Low
41-50	21.0	9.1	17.8	15.2	Moderate
51-60	45.2	22.1	46.7	35.9	High
61-70	25.8	45.5	33.3	35.9	Moderate
	6.5	22.1	0.0	11.4	Moderate

* Calculated using the programme “PREFER”

Table 6.3. Use (%) of tree cover, shrub cover and grass cover by goral in GHNP during 1996-1998.

Cover categories	Winter (n=62)	Spring (n=77)	Autumn (n=45)	Overall (n=184)
Tree cover (%)				
0	38.7	42.9	24.4	37.0
1-10	24.2	26.0	33.3	27.2
11-20	33.9	27.3	33.3	31.0
21-30	3.2	3.9	8.9	4.9
Shrub cover (%)				
0	4.8	6.5	6.7	6.0
1-10	48.4	26.0	31.1	34.8
11-20	41.9	42.9	48.9	44.0
21-30	4.8	18.2	11.1	12.0
>30	0	6.5	2.2	3.3
Grass cover (%)				
<10	4.8	1.3	0	2.2
11-20	14.5	7.8	2.2	8.7
21-30	56.5	23.4	22.2	34.2
31-40	17.7	35.1	33.3	28.8
41-50	4.8	18.2	22.2	14.7
51-60	0	9.1	11.1	6.7
>60	1.6	5.2	8.9	4.9
Rock & soil cover (%)				
<10	9.6	0	4.4	4.3
11-20	14.5	7.8	6.7	9.8
21-30	27.4	23.4	24.4	25.0
31-40	27.4	20.8	26.7	24.5
41-50	21	24.7	20.0	22.3
51-60	0	15.6	13.3	9.8
>60	0	7.8	4.4	4.3

Table 6.4. Availability-utilization of tree cover, shrub cover, grass cover and rock and soil cover by goral in GHNP during winter, spring and autumn.

Cover categories	Winter		Spring		Autumn	
	N	*Intensity of use	N	*Intensity of use	N	*Intensity of use
Tree cover (%)						
0	24	High	33	High	11	Moderate
1-10	15	Moderate	20	Low	15	Moderate
11-20	21	Moderate	21	Moderate	15	Moderate
21-30	2	Low	3	Low	4	Low
Shrub cover (%)					3	
0	3	Moderate	5	Moderate	14	Moderate
1-10	30	High	20	High	22	Moderate
11-20	26	High	33	High	5	High
21-30	3	Low	14	Moderate	1	Moderate
>30	0	Low	5	Moderate		Low
Grass cover (%)						
<10	3	Low	1	Low	0	Low
11-20	9	Moderate	6	Moderate	1	Low
21-30	35	High	18	Moderate	10	Moderate
31-40	11	Moderate	27	Moderate	15	Moderate
41-50	3	Moderate	14	Moderate	10	Moderate
51-60	0	Low	7	Moderate	5	Moderate
>60	1	Moderate	4	Less utilized	4	Moderate
Rock & soil cover (%)						
<10	6	Low	0	Low	2	Low
11-20	9	Moderate	6	Low	3	Low
21-30	17	Moderate	18	Moderate	11	Moderate
31-40	17	High	16	Moderate	12	Moderate
41-50	13	High	19	High	9	Moderate
51-60	0	Low	12	Moderate	6	Moderate
>60	0	Low	6	Moderate	2	Moderate

* Calculated using the programme “PREFER”

Fig. 6.1. Principal Components Analyses ordination of the goral habitat usage data during winter

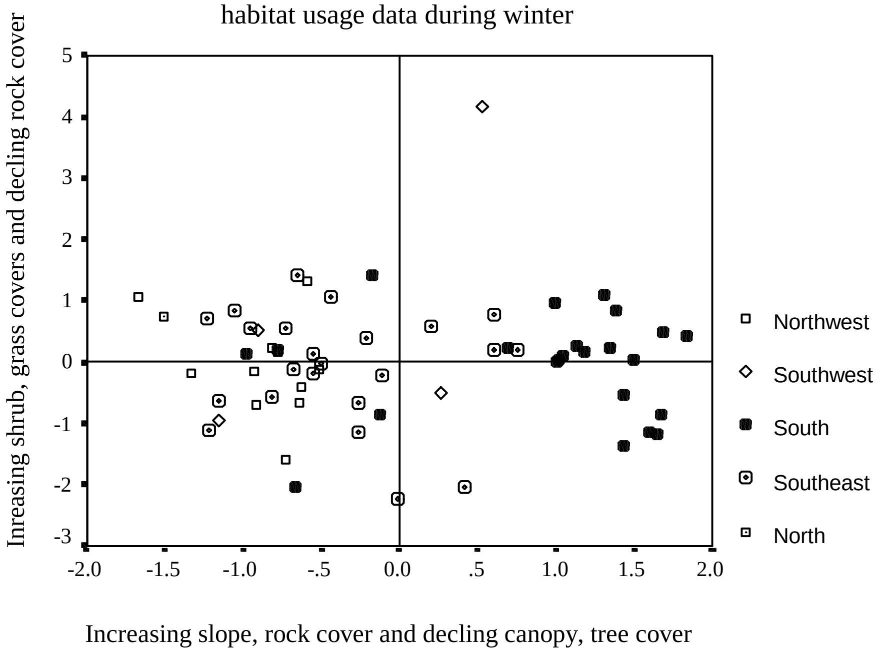


Fig. 6.2. Principal Component Analyses ordination of the goral habitat usage data during spring

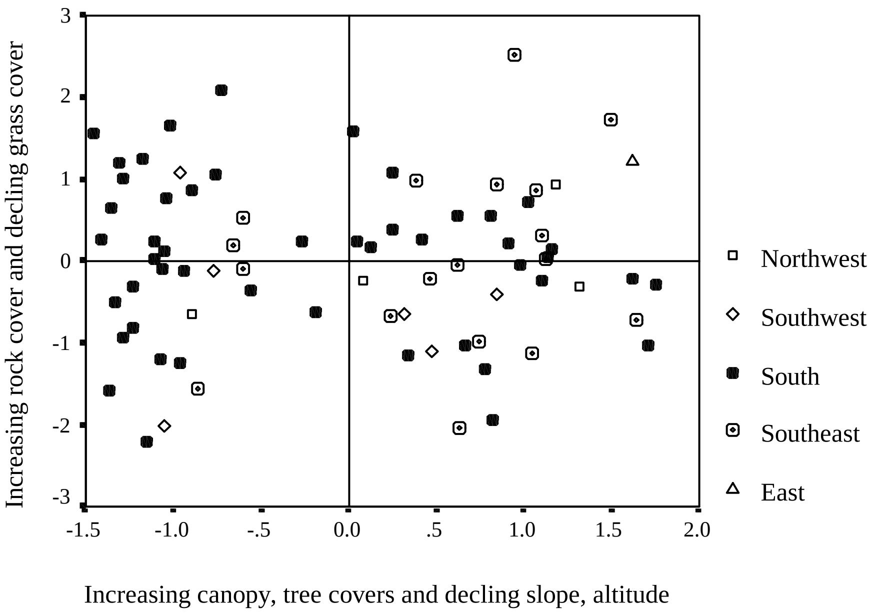
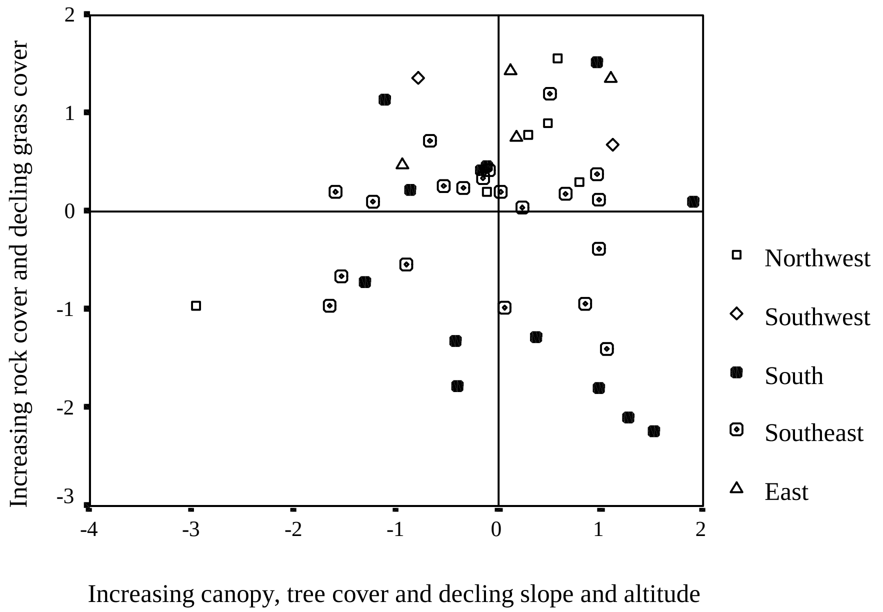


Fig. 6.3. Principal Component Analyses ordination of the goral

habitat usage data during autumn



6.5.2. Himalayan Musk Deer

A total of 65 sightings of Himalayan musk deer occurred during the study period. Data on habitat parameters were collected only for 48 sightings as the rest of the sightings occurred during silent drive counts.

6.5.2.1. Use of altitude, aspect and slope

Himalayan musk deer were only sighted in areas between 3200m and 4000m with a slight seasonal variation in use. They used slightly lower altitudes (3301 m to 3500 m) during spring compared to autumn (Mann Witney U Test, U=230.5, $p<0.05$, Table 6.5.). Musk deer in the area avoided altitudes below 3200m (c^2=13.30, df=7, $p<0.05$, Table 6.9.). Except for Western aspect, all other aspects were used in proportion to the availability (c^2=3.93, df=7, $p<0.05$, Table 6.5.). Moderate (21^0 to 50^0) slopes were used through out the year and steeper slopes (>60^0) were consistently avoided (c^2=21.62, df=4, $p<0.05$, Table 6.9.). Although there were no significant differences in the seasonal use of slope categories (Mann Witney U Test, U= $p>0.05$), 73.1 % of the sightings during spring occurred in gentler slopes (21^0 to 40^0) whereas 86.3 % of sightings during autumn occurred in slightly steeper slopes (31^0- 50^0)

6.5.2.2. Use of tree cover, shrub cover, grass cover and rock and soil cover

Himalayan musk deer mainly used areas with low tree cover (<10 %), moderate to high shrub cover (between 21-30 % to 51-60 %), low grass cover (<20 %) and moderate rock & soil cover (11-40 %) (Table 6.6). Musk deer in the area preferred areas with low tree cover (c^2=18.69, df=3, $p<0.05$, Table 6.11.) and usually avoided areas with low shrub cover (c^2=10.37, df=5, $p<0.05$, Table 6.6.) and high grass cover (c^2=27.49, df=6, $p<0.05$). They also preferred moderate rock & soil cover (c^2=31.92, df=4, $p<0.05$). There was no significant differences in the use of covers by Himalayan musk deer except for grass cover (Mann Whitney U Test, U=177.0, $p<0.05$).

Factorial analyses using PCA on altitude (natural log), slope, canopy cover, tree cover, shrub cover, grass cover and rock & soil cover (arcsine transformed) extracted two factors that explained 60.54% of the variation in the data. Factor 1 (PC1) explained 32.96% of variation in the data and Factor 2 (PC2) explained 27.58% of variation in the data. Ordination based on Principal Component Analyses did not show seasonal differences in the use of habitat variables (See Fig. 6.4.).

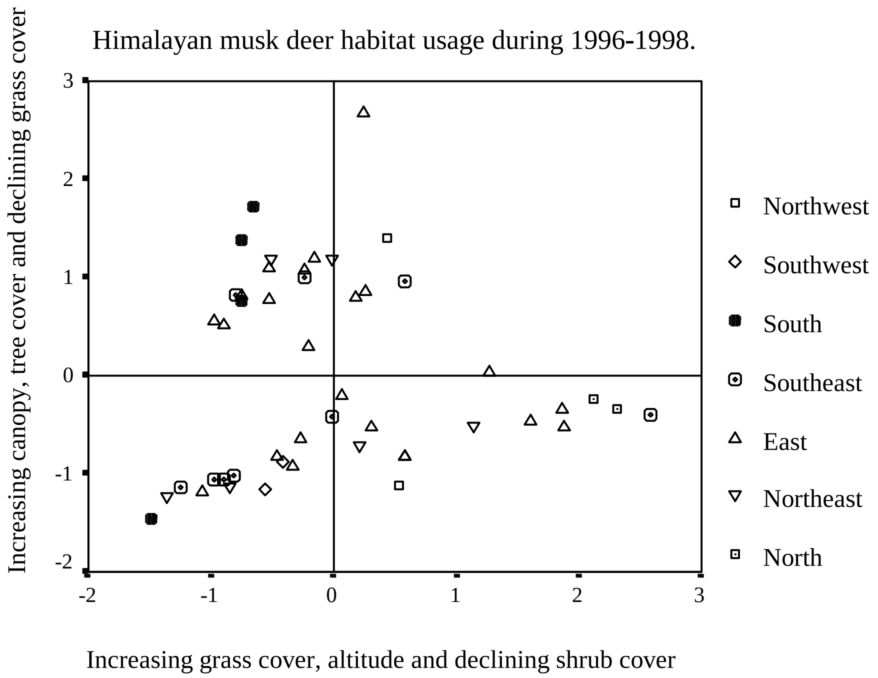
Table 6.5. Use (%) of altitude, aspect and slope by musk deer in GHNP during 1996-1998.

Habitat factors	Spring (n=26)	Autumn (n=22)	Overall (n=48)	Intensity of use
Altitude (m)				
3201-3300	7.7	4.5	6.3	Moderate
3301-3400	42.3	18.2	31.3	Moderate
3401-3500	34.6	31.8	33.3	Moderate
3501-3600	7.7	22.7	14.6	Moderate
3601-3700	3.8	18.2	10.4	Moderate
3701-3800	3.8	0.0	2.1	Moderate
>3800	0.0	4.5	2.1	Moderate
Aspect				
North	3.8	4.5	4.2	Moderate
Northeast	7.7	18.2	12.5	Moderate
East	50.0	45.5	47.9	Moderate
Southeast	19.2	18.2	18.8	Moderate
South	11.5	4.5	8.3	Moderate
Southwest	9.7	0.0	4.2	Moderate
West	0.0	0.0	0.0	Low
Northwest	0.0	9.1	4.2	Moderate
Slope categories				
<20	0.0	4.5	2.1	Low
21-30	23.1	9.1	16.7	Moderate
31-40	50.0	22.7	37.5	Moderate
41-50	19.2	63.6	39.6	Moderate
51-60	7.7	0.0	4.2	Low

Table 6.6. Use (%) of tree cover, shrub cover and grass cover by musk deer in GHNP

Cover categories	Spring (n=26)	Autumn (n=22)	Overall (n=48)	Intensity of use
Tree cover (%)				
0	57.7	50.0	54.2	Moderate
1-10	34.6	50.0	41.7	High
11-20	7.7	0	4.2	Low
Shrub cover (%)				
<10	11.5	4.5	8.3	Low
11-20	7.7	9.1	8.3	Moderate
21-30	15.4	18.1	16.7	Moderate
31-40	11.5	45.5	27.1	Moderate
41-50	15.4	9.1	12.5	Moderate
51-60	30.8	13.6	22.9	Moderate
>60	7.7	0	4.2	Low
Grass cover (%)				
0	26.9	0	14.6	High
1-10	30.8	22.7	27.1	Moderate
11-20	19.2	36.4	27.1	Moderate
21-30	7.7	13.6	10.4	Moderate
31-40	0	13.6	6.3	Moderate
41-50	0	4.5	2.1	Low
51-60	3.8	4.5	4.2	Low
>60	11.5	4.5	8.4	Low
Rock & soil cover (%)	0	4.5	2.1	Low
<10	50.0	31.8	41.7	Moderate
11-20	30.8	45.5	37.5	High
21-30	15.4	18.1	16.7	Moderate
31-40	3.8	0	2.1	Moderate

Fig. 6.4. Principal Component Analyses ordination of the Himalayan musk deer habitat usage during 1996-1998.



6.5.3. Himalayan Tahr

A total of 84 sightings of Himalayan tahr were had in the study area during the study period.

6.5.3.1. Use of altitude, aspect and slope

Himalayan tahr were sighted in a wide altitude range (2801-4000m) in the study area (Table 6.7.) and they mainly preferred areas between 3301 and 3500m (c^2=70.63, df=10, $p<0.05$, Table 6.7). They were mostly sighted in the southerly aspects (Southeast, South & Southwest) but preferred Southern aspects through out the year (c^2=46.69, df=7, $p<0.05$, Table 6.7.). Himalayan tahrs were mostly sighted in steeper slopes (510-700) and slopes below 400 were consistently avoided (c^2=91.28, df=3, $p<0.05$, Table 6.7.). Mann Witney U Test did not show any significant difference in the use of altitude, aspect & slopes by Himalayan tahr between spring and autumn.

6.5.3.2.Use of tree cover, shrub cover, grass cover and soil and rock cover

All the sightings of Himalayan tahr occurred in areas with less than 10% tree cover (c^2=100.14, df=3, $p<0.05$, Table 6.8.). They used areas with low shrub cover in proportion to availability and avoided areas where the shrub cover exceeds 20% (c^2=49.75, df=4, $p<0.05$, Table 6.8.). They avoided low (<10%) and high (>50%) grass cover areas (c^2=57.92, df=5, $p<0.05$, Table 6.8.) and usually preferred areas with 51-60% rock & soil cover (c^2=135.59, df=5, $p<0.05$, Table 6.8.).

Factorial analyses using PCA on altitude, slope, canopy cover, tree cover, shrub cover, grass cover and rock & soil cover extracted two factors that explained 62.7% of the variation in the data. Factor 1 (PC1) explained 32.67% of variation in the data and Factor 2 (PC2) explained 29.99% of variation in the data. Ordination based on Principal Component Analyses did not showed seasonal differences in the use of habitat variables (See Fig. 6.5.).

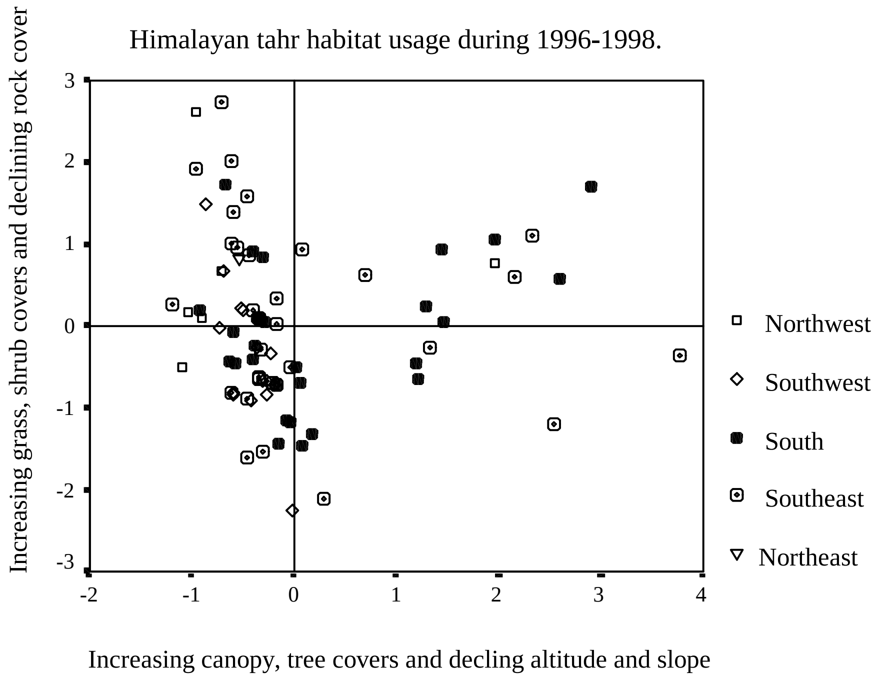
Table 6.7. Use (%) of altitude, aspect and slope by Himalayan tahr in GHNP during 1996-1998.

Habitat factors	Spring (n=51)	Autumn (n=33)	Overall (n=84)	*Intensity of use
Altitude (m)				
2801-2900	13.7	3.0	9.5	Moderate
2901-3000	2.0	0.0	1.2	Low
3001-3100	7.8	6.0	7.1	Low
3101-3200	3.9	3.0	3.6	Moderate
3201-3300	5.9	3.0	4.8	Moderate
3301-3400	23.5	33.3	27.4	High
3401-3500	25.5	36.4	29.8	High
3501-3600	7.8	6.0	7.1	Moderate
3601-3700	5.9	0.0	3.6	Moderate
3701-3800	2.0	3.0	2.4	Moderate
>3800	2.0	6.0	3.6	Moderate
Aspect				
North	0.0	0.0	0.0	Low
Northeast	2.0	0.0	1.2	Low
East	0.0	0.0	0.0	Low
Southeast	33.3	48.5	39.3	Moderate
South	31.4	39.4	34.5	High
Southwest	21.6	12.1	17.9	Moderate
West	0.0	0.0	0.0	Low
Northwest	11.8	0.0	7.1	Moderate
Slope categories				
<40	2.0	0.0	1.2	Low
41-50	5.9	12.1	8.3	Low
51-60	49.0	48.5	48.8	High
61-70	43.1	39.4	41.7	High

Table 6.8. Use (%) of tree cover, shrub cover and grass cover by Himalayan tahr in GHNP

Cover categories	Spring (n=51)	Autumn (n=33)	Overall (n=84)	*Intensity of use
Tree cover (%)				
0	82.4	81.8	82.1	High
1-10	17.6	18.2	17.9	Moderate
11-20	0	0	0	Low
Shrub cover (%)				
0	17.6	33.3	23.8	Moderate
1-10	58.8	54.5	57.1	Moderate
11-20	21.6	12.1	17.9	Moderate
21-30	2.0	0	1.2	Low
>30	0	0	0	Low
Grass cover (%)				
<10	3.9	0	2.4	Low
11-20	15.7	30.3	21.4	Moderate
21-30	54.9	45.5	51.2	Moderate
31-40	17.6	15.2	16.7	Moderate
41-50	5.9	6.1	6.0	Moderate
>50	2.0	3.0	2.4	Low
Rock & soil cover (%)				
<20	0	0	0	Low
21-30	3.9	6.1	4.8	Low
31-40	7.8	9.1	8.3	Low
41-50	21.6	15.2	19.1	Moderate
51-60	31.4	27.3	29.8	High
61-70	35.3	36.4	35.7	Low
>70	0	6.1	2.4	Low

Fig. 6.5. Principal Component Analyses ordination of the Himalayan tahr habitat usage during 1996-1998.



6.6. DISCUSSION

6.6.1. Goral

6.6.1.1. Use of Altitude, Aspect & Slope

Goral in the study area used a wide altitudinal range extending from 1900 to 3200m and preferred the 2301-2600m range. There was no seasonal altitudinal movement in the area. Mishra (1993) reported that the best habitat in terms of goral abundance was above 1600m in Majhatal Wildlife Sanctuary. Green (1985) reported that goral used altitudes up to 3600m, where as Sathyakumar (1994) reported 1900-2000m range as preferred habitat for goral in Kedarnath Wildlife Sanctuary. The preferred altitude range for goral in GHNP was higher than that reported earlier. This is because except Valley bottoms, most of the areas of GHNP falls above 2200m.

Goral sightings were mostly in the Southeast and Southern aspects. The south facing slopes provide warmer areas with open grassy slopes. Goral was never sighted in the Northeastern and Western aspects. Green (1985) reported that goral used South and Southwestern aspects more whereas Sathyakumar (1994) reported the preference of Eastern, Southeastern and Southern aspects at the lower altitudes and the avoidance of the same at the middle altitudes in Kedarnath Wildlife Sanctuary. Mishra (1993) and Mishra & Johnsingh (1997) has reported the use of Southeastern aspects more than expected by goral in Majhatal Wildlife Sanctuary. Pendarkar (1993) also reported the prefernce of Southeast and Southwest aspects in winter and summer respectively. However, in the present study there was a preference towards Southern aspects. Goral in GHNP preferred steep slopes and avoided gentle areas. The use of steep areas is an anti-predatory strategy. Mishra (1993) reported that goral in Majhatal Wildlife Sanctuary preferred the $>30^0$ slope categories and avoided the lower slope categories. Goral in Simbalbara Wildlife Sanctuary preferred $>51^0$ slope in Winter (Pendarkar 1993). Sathyakumar (1994) stated that 47% and 38% of the total goral sightings in Kedarnath Wildlife Sanctuaries were in $>60^0$ and $41\text{-}50^0$ slope categories respectively. The results of the present study agree the above results. Responses to slope steepness, altitude and aspect may be related to factors such as visibility, forage availability and proximity to escape terrain. Gionfriddo & Krausman (1986) reported similar observations in bighorn sheep (*Ovis canadensis*).

6.6.1.2. Use of tree cover, shrub cover, grass cover and rock & soil cover

Most of the goral sightings were in areas with low tree cover (<10%) and they preferred areas with 0% tree cover during winter. Green (1985) also reported that goral used 0% tree cover in Kedarnath Wildlife Sanctuary where as Sathyakumar (1994) the use of 1-25% tree cover in the same area. Goral used areas with low (<20%) shrub cover through out the year. Goral in the area avoided large shrub patches within open communities except for thermal cover. Studies on bighorn sheep have also shown similar avoidance of shrub-rich patches even if they were rich in forage (Dodd & Smith 1988). Similar observations were also reported by Mishra (1993), Pendarkar (1993) and Sathyakumar (1994), in various parts of Western Himalaya. The use of moderate grass cover and rock and soil cover were also similar to the observations made by Sathyakumar (1994) in Kedarnath Wildlife Sanctuary.

Goral, a primitive caprine, is expected to be a forest dwelling browser. However Green (1987) found that goral in Kedarnath Wildlife Sanctuary fed predominantly on grass and use more open areas. Mishra & Johnsigh (1997) also recorded similar results. The results of present study supports the above findings.

6.6.2. Himalayan musk deer

6.6.2.1. Use of altitude, aspect & slope

Himalayan musk deer always used higher altitudes, and were never sighted below 3200m. They preferred the altitude range between 3301 & 3500m. The analyses is limited to a total of 48 records and there is no evidence to suggest that animals move to lower altitudes during winter. Green (1985) and Sathyakumar (1994) also reported the use of higher altitudes by musk deer in Kedarnath Wildlife Sanctuary. Musk deer were mostly sighted in Eastern aspects. Green (1985) reported that musk deer used the Northwest, South, South-west and Western aspects more where as Sathyakumar (1994) had most of the musk deer sightings in South and South-western aspects. The result of the present study did not agree with the above findings. In GHNP, although majority of musk deer sightings were in Eastern aspects, they used the Eastern aspects in proportion to the availability. This is because majority of the identified musk deer habitats were in the Eastern aspects. They used moderate slope categories which is similar to the observations made by Green (1985) & Sathyakumar (1994) in Kedarnath Wildlife Sanctuary.

6.6.2.2. Use of tree cover, shrub cover, grass cover and rock & soil cover

Musk deer were mostly encountered in areas with low tree cover, high shrub cover and moderate grass cover and rock & soil cover. The use of cover categories by musk deer are similar to the observations made by Green (1985) and Sathyakumar (1994) in Kedarnath Wildlife Sanctuary. The cover afforded by shrubs especially *Rhododendron companulatum* was important for musk deer. Native predators of Himalayan musk deer known to inhabit the area include snow leopard, common leopard and red fox. However the greatest need for escape cover in the area was to avoid domestic dogs (*Canis familiaris*) that are associated with graziers and shrub collectors. Dogs chasing musk deer was also reported by Harris & Guiquan (1993) in Tibet-Qinghai Plateau.

6.6.3. Himalayan Tahr

6.6.3.1. Use of altitude, aspect and slope

Himalayan tahr used a wide range of altitude ranging from 2800-3800m in GHNP. Schaller (1973) reported that tahr used 2500-4000m ranges in Bhota Kosi, Nepal. Green (1978) reported the use of 2700-5000m altitudes by tahr in Langtang National park, Nepal. Sathyakumar (1994) reported that tahr in Kedarnath Wildlife Sanctuary, used altitudes ranging from 2200-4300m. The present observations also agrees with these reports. The analyses is limited to a total of 84 records and there is no data to prove that altitudinal migration of tahrs from higher to lower altitudes in winter. However, segregation of all adult males to higher altitudes were observed in the area as reported by Green (1978).

Himalayan tahr sightings were mostly in Southeastern and Southern aspects and there was a preference towards Southern aspects. The Southern and Southeast facing slopes are more warmer and steeper in the area and hence they were preferred by the animal. The present result did not agree with Sathyakumar (1994), who reported more tahr sightings in the Eastern and Southeastern aspects. No tahr sightings were occurred below 40^0 and they preferred steeper areas ($61\text{-}70^0$). The use of steeper areas is an anti-predatory strategy. Similar observations were made by Schallar(1973) and Sathyakumar (1994).

6.6.3.2. Use of tree cover, shrub cover, grass cover and rock & soil cover

Himalayan tahr preferred areas without tree cover and avoided all areas having more than 10% tree cover. Most of the sightings were in areas having low shrub cover, moderate grass cover and rock & soil cover. The use of cover categories were similar to that reported by Sathyakumar (1994) in Kedarnath Wildlife Sanctuary.

6.6.4. Ecological separation

The differential use of altitudes by ungulates in GHNP is a major reason for their ecological separation. Goral in the area usually avoided altitudes above 2900m whereas musk deer and Himalayan tahr were never sighted below 2900 and 3200m respectively (Fig. 6.5. and Fig. 6.6.). There was an overlap in the use of altitude by goral and Himalyan tahr but they were never sighted together. Goral and Himalayan tahr showed a preference for steep open habitats in the Southerly aspects with low tree and shrub covers, but were ecologically separated by their preferences for different altitudinal zones. Musk deer with its altitudinal range was sympatric with Himalayan tahr. But they were ecologically separated by their differential use of aspect, slope and cover categories. Musk deer showed a preference towards Eastern aspects with high shrub cover whereas Himalayan tahr in the area always preferred Southern aspects with low shrub cover. Similar observations were reported by Green (1985) and Sathyakumar (1994). With limited data on the use of habitat by these ungulates, inter-specific associations were observed between goral and Himalayan tahr, and musk deer and Himalayan tahr.

Map

Map

7.0 CONSERVATION AND MANAGEMENT

7.1. INTRODUCTION

What are the optimum/achievable densities of ungulates in various habitats of GHNP is one of the most frequent questions asked during the study. Although GHNP covers a substantial area of prime wildlife habitat, the larger animal densities are relatively low (Gaston and Garson 1992). Data describing the long-term changes in the habitats and populations are not available for the area. The ever-increasing human population around the area and resulting biotic activities in the park could be a major reason for the low densities. Although natural disturbances such as landslides, fire and avalanches are normal events in the mountain ecosystem, there is a growing interest in anthropogenic disturbance. There is a growing conflict between development and conservation in the area (Gaston and Garson 1992). Park authority is not in a position to argue for conservation due to the lack of scientific knowledge of the area. In order to help the Park management, an assessment of various conservation issues related to goral, musk deer and Himalayan tahr populations of GHNP was carried out during January 1996 to November 1998.

7.2. CONSERVATION THREATS

7.2.1. Goral

The results of present study shows that goral in the area are sensitive to various anthropogenic activities. The abundance estimates and group sizes of gorals were low in more disturbed areas throughout the year. Following factors are identified as potential threats to goral in the study area.

7.2.1.1. Non-Wood Forest Produce (NWFP) collection

Gucchii or morel mushroom (*Morchella esculenta*) is one of the main NWFPs collected from the area. In GHNP, goral mainly inhabits the steep south facing slopes between 2000 and 3000 m, which is also rich in gucchii. Every year hundreds of square kilometres of its habitat are used by local people for gucchii collection. The collectors traverse every inch of the habitat in search of gucchii, which is highly priced in the local market (ca. Rs. 2500-3000/kg dry weight). During the study period ca. 1500-1700 people/year entered the intensive study area along with 300-350 domestic dogs for collecting gucchii (See Table 7.1.). The collection period coincides with the birth season of goral. The domestic dogs accompanying the collectors chase the animal frequently (Vinod 1997). The more dangerous impact are due to the fire which the collectors set every year to get more gucchii in the following years.

Table 7.1. The intensity of gucchii collection in the study area (1996-1998).

Month	Mean no. of gucchii collectors/day ± SE			Mean no of domestic dogs/day ± SE
	Male	Female	Overall	
March	8.1±1.8	8.9±1.7	17.0±3.2	3.4±0.6
April	9.5±1.1	10.6±1.9	20.1±1.6	3.8±0.6
May	8.3±2.5	9.3±1.3	17.6±3.1	3.6±0.5
Mean	8.6±1.0	9.6±1.0	18.3±1.6	3.6±0.3

Other NWFP collected includes fodder grasses, bamboo, nuts and fruits. There is no record for fodder extraction in the area. However, at least 10 families from villages very close to the park, such as Kharongcha, Dhara and Lapah, cut fodder in the study area. They extract ca. 10-15 kg of grass/family/day during the summer to feed their cattle, while each family extracts ca. 40-60 kg of grass daily in September and October to store for winter. Fodder cutting was observed mainly on the south facing grassy slopes, which also forms the preferred habitat for goral in the area. Thus fodder extraction might adversely affect the goral population in the area especially during winter months.

7.2.1.2. Disease transmission and grazing by local livestock

Livestock belonging to the villagers in and around the Park enter the study area throughout the year except for winter months. Many people interviewed around the area reported finding goral dead or dying from disease in the 70's. The last recorded epidemic, which occurred in 1979 substantially, reduced the goral population in Tirthan valley (Garson & Gaston 1985). However, there is no direct evidence of what the disease may have been, but secondary sources suggested that the goral were affected by Foot & mouth disease and another unknown disease causes blindness (Gaston, A.J. pers.comm.).

7.2.1.3. Poaching

Traditionally, local people hunted wild animals such as goral, Himalayan tahr and serow for their meat and for their skins and horns. Hunting of certain species (Schedule I species) became illegal after the Wildlife (Protection) Act, 1972 was enacted. A complete ban on hunting was imposed in Himachal Pradesh between 1982-84. Hunting of all the animals in the Park has been illegal after the first notification in 1984. Many local people in the area have access to guns and unfortunately the existing regulations are seldom enforced and had a major impact on the species. The use of firearms were common during winter months (n=14), whereas snares were commonly used in other seasons. During 1997, a combined search by the Park staff and the research team of Wildlife Institute has removed ca. 300 snares from the goral habitat of the study area.

7.2.2. Himalayan Musk Deer

The major concerns for Himalayan musk deer in the area are identified as poaching and habitat degradation.

7.2.2.1. Poaching

Poaching of Himalayan musk deer is a serious problem in the region because of the high price of 'musk' in the international market. The main capture methods in the area are snaring and use of firearms. Atleast eight musk deer kills were encountered during the study period. Table 7.2. shows the intensity of snaring in the six identified Himalayan musk deer habitat of the study area.

7.2.2.2. Habitat degradation

In GHNP, Himalayan musk deer mainly inhabits the birch-rhododendron forest and krummholz zone between 3000 and 4000 m. In the intensive study area, the presence of musk deer has been confirmed only on six fragmented patches, of which graziers and herb collectors also used all patches. The present study indicates that shrubs are extremely important to Himalayan musk deer both as a refuge from predators and as a source of food. Extensive removal of the forest understorey has affected the density of Himalayan musk deer in the area (See Table 7.3.). Grazing also increases the growth of specific species such as *Rumex* and *Girardina*. Studies on the impact of grazing on forests elsewhere in HP have shown that grazing hinders regeneration of naturally dominant tree species and lead to significant changes in the structure and composition of shrub and herb communities on the forest floor (Gaston and Garson 1985).

Table 7.2. Intensity of snaring in the critical Himalayan musk deer habitats in the study area (1996-1998).

Area	No. of counts	Musk deer density (No/km^2)	Snare density (No/km^2)
Gumthrao	6	3.3	6.8 (2)*
Dhela	6	0.7	3.8 (3)*
Jatholi	2	3.3	8.3
Majhoni	2	1.7	4.2
Asurbagh	2	2.9	8.6
Nara	2	0.8	3.3
Overall	-	2.1	5.8

* Parenthesis shows # of kills encountered.

Table 7.3. Mean annual fuelwood consumption (kg) by various groups of people in the critical Himalayan musk deer habitats of the study area (1996-1998).

Area	Herb collectors	Graziers	Tourist	Staff	Religious ceremonies	Total (kg)
Gumtharao	2240 (8*7)	720 (1*18)	320 (4*4)	600 (8*3)	0	3880
Dhela	3840 (8*12)	2800 (2*35)	720 (9*4)	400 (4*4)	240 (4*2)	8000
Jatholi	1680 (6*7)	1120 (2*14)	160 (2*4)	200 (2*4)	0	3160
Majhoni	2880 (6*12)	1120 (2*14)	360 (9*2)	300 (6*2)	360 (6*2)	5020
Asurbagh	960 (4*6)	840 (1*21)	240 (3*4)	150 (2*3)	0	2190
Nara	1920 (4*12)	1120 (2*14)	480 (12*2)	450 (9*2)	720 (12*2)	4690
Overall	13520	7720	2280	2100	1320	26940

Parenthesis shows the no. of groups and duration of stay (days) by each group

7.2.3. Himalayan Tahr

7.2.3.1. Poaching

Poaching of Himalayan tahr is a considerable problem throughout the Park. Himalayan tahrs are frequently killed probably because their meat is highly regarded by the local people. Many time the herb collectors and graziers turn to become opportunistic poachers. The main capture method is use of snares. With the help of frontline staff ca. 200 snares were detected and removed from the tahr habitats of the intensive study area during 1997.

7.3. CONSERVATION MEASURES

The first and foremost thing to conserve the area was the settlement of rights and final notification of the Park. The final notification of the Park was issued during June 1999. But as far as settlements of rights are concerned, confusion is still prevailing among the villagers. The following are some of the major conservation measures needed for the protection of ungulates and other mammals in the area.

7.3.1. Control of Poaching

Poaching in the area should be strictly controlled by regularly policing the area and confiscation of weapons. Enforce anti-poaching laws and caution the local villagers on the consequences of poaching protected animals like Himalayan musk deer. Quick and decisive action against offenders, which is seldom happened in the area, is direly necessary to mitigate against reckless poaching. For this, the Park management needs to be strengthened by providing better infrastructure and increase in staff. The monitoring network of the park should be strengthened, with the involvement of educated local people as guards and members of anti-poaching squads. There should be more frequent patrolling and better communications through the provision of an improved wireless network. A thorough follow-up of cases through the legal system would act as a deterrent. The entire area needs to be thoroughly combed at least once every year to identify and remove the snares. Local people should be given incentives for all their support and their long-term participation should be ensured for further protection.

7.3.2. Regulation of Biotic Activities

With the recent final notification of the park, all biotic activities inside the Park would be illegal. However, the heavy demand for gucchii and medicinal herbs and the precious financial support it affords to the local people that makes the ban not only unrealistic, but also impracticable. So there should be a strict regulation in gucchii and medicinal herb collection in the area. Domestic dogs should not be allowed to enter the Park. All livestock entering the area should be examined for diseases and tagged. The grazing route needs to be diverted from the confirmed critical Himalayan musk deer habitats such as Gumtharao, Dhela and Jatholi. The graziers should be thoroughly checked at the entry points for carrying of illegal arms and the dogs accompanying each herd need to be limited to two. All the activities of the graziers and gucchii and medicinal herb collectors should be monitored regularly.

7.3.3. Conservation Education/Awareness of Local People

Both local and outside hunters have played a major role in the decline of ungulates in the area. Despite legal protection, there is little awareness or concern for the status of these animals. There is an urgent need to increase the awareness among the local people. These could include distributing pamphlets and posters on Himalayan musk deer and other animals concerned, encouraging local NGO’s like SAVE to undertake publicity expeditions to the villages. Certainly no realistic attempt to conserve the animals of GHNP can or should be made without the involvement of the local people. GHNP and its animals could be saved by means of contractual agreement with local people, who would receive revenues generated by the Park (through the FREEP Project and other sources) in exchange of withdrawing their livestock, ceasing to hunt and collect NWTP, and acting as tourist guides, watchers, hosts and protectors. It is critical that such a solution be implemented immediately.

7.4. FUTURE DIRECTIONS

7.4.1. Long Term Monitoring

Based on the present study three ungulate species viz. goral, Himalayan musk deer and Himalayan tahr was proposed for long term monitoring. These species are distributed in various habitats covering different altitudinal zones and are associated with many other fauna and flora. The Forest Department should take the monitoring of these ungulates population in the area on annual basis. Winter (especially during February) is the best season for monitoring of gorals. Himalayan musk deer and Himalayan tahr can be monitored during late spring (mid May to mid June) and /or autumn (October-November). Earlier morning is the best time to monitor these animals. In Tirthan Valley, Rolla-Basu, Rolla-Shilt, and Chalocha-Nara trails are ideal for monitoring gorals. Vantage points at Kharongcha, Rolla and Chidor are suitable for monitoring goral where as Chidor, Nara, Pardi and Gumtharao areas are good for monitoring Himalayan tahr populations. Himalayan musk deer could be monitored in Dhela and Gumtharao areas. A combination of encounter rate based on direct sightings and scanning would be appropriate for monitoring goral populations in the area. Himalayan musk deer and Himalayan tahr can be monitored in the area only by silent drive counts and scanning respectively.

7.4.2. Research

Further research inputs are required in the area. The home range and movement patterns of these ungulates, especially Himalayan tahr, need to be studied. An augmentation project should be planned in case Himalayan musk deer population in the area fails to improve with enhanced habitat protection.

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