

**HABITAT USE, GROUP SIZE AND
ACTIVITY PATTERN OF GORAL (Nemorhaedus goral)
IN SIMBALBARA SANCTUARY (HIMACHAL PRADESH)
AND DARPUR RESERVED FOREST (HARYANA) INDIA**

**DISSERTATION SUBMITTED TO SAURASHTRA UNIVERSITY,
RAJKOT, IN PARTIAL FULFILMENT OF MASTER'S DEGREE
IN WILDLIFE SCIENCE (1993)**

**BY
ANAND PENDHARKAR**

WII L&DC
Acc. No.: WF3410



WILDLIFE
INSTITUTE
OF INDIA

**SUPERVISOR
Dr. S.P. GOYAL
SCIENTIST-SD, FACULTY OF WILDLIFE BIOLOGY
WILDLIFE INSTITUTE OF INDIA, DEHRADUN.**

CONTENTS

CERTIFICATE	
ACKNOWLEDGEMENTS.....	(i)
SUMMARY.....	(iii)
CHAPTER 1 : INTRODUCTION.....	1
1.1 General Introduction.....	1
PLATE NO.1 and 2.....(facing)	2
1.2 Literature Review.....	3
1.3 Objectives.....	8
CHAPTER 2 : STUDY AREA.....	9
2.1 Administrative and General.....	10
2.2 Physical Features.....	11
PLATE NO.3 and 4.....(facing)	11
2.3 Climate.....	12
2.4 Vegetation	13
2.5 Fauna.....	14
2.6 Human Interference.....	15
PLATE NO.5.....(facing)	15
CHAPTER 3 : METHODS.....	18
3.1 Introduction.....	18
3.2 Climate.....	18
3.3 Vegetation and Phenology.....	19
3.4 Habitat Availability-Utilization.....	21
3.5 Group Size and Structure.....	22
3.6 Activity Pattern.....	22
3.7 Analyses of Data.....	23
CHAPTER 4 : RESULTS.....	24
4.1 Vegetation Studies.....	24
4.2 Availability-Utilization Analysis.....	29
4.3 Group Size.....	31
4.4 Activity Pattern.....	32
CHAPTER 5 : DISCUSSION.....	34
5.1 Habitat Use.....	34
5.2 Group Size.....	37
5.3 Activity Pattern.....	39
5.4 Conclusions.....	41
5.5 Limitations of the Study and Suggestions for a future Study	42
5.6 Conservation Implications.....	42
LITERATURE CITED	44
FIGURES AND TABLES.....	51
APPENDICES	



CERTIFICATE

This is to certify that Mr. Anand Pendharkar of the Wildlife Institute of India has carried out an original piece of research work entitled "Habitat use, group size and activity pattern of goral (*Nemorhaedus goral*) in Simbalbara Sanctuary (Himachal Pradesh) and Darpur Reserved Forest (Haryana) India" in partial fulfilment of M.Sc. (Wildlife Science) degree of Saurashtra University. These investigations were carried out under my supervision at the Wildlife Institute of India from November 1992 to June 1993. I also certify that this work has not been submitted for any other degree of any university.

DATE:

PLACE: DEHRADUN

S.P. GOYAL

SCIENTIST-SD

ACKNOWLEDGEMENTS

Six months of fieldwork in Simbalbara and Darpur were like a 'dream-come-true' for me. The fantastic experiences and memories of the jungle-life would occupy a special place in my life. The help and co-operation extended to me by various individuals and institutions require a special mention here. I thank the Chief Wildlife Wardens of Himachal Pradesh and Haryana Forest Departments and Mr.H.S. Panwar (Director WII) for granting me permission and funds to work on this Project. I am indebted to Mrs. Vijayalaxmi Tiwari (DCF-WL, Shimla) and Mr. D.D. Agarwal (R.O. Simbalbara) and their staff for providing logistic support and other help as and when necessary. The company of Mr & Mrs. Agarwal and their 2 sons was always a pleasure for me. Mr. Mansingh (B.O.Darpur) and Mahima Singh (Forester, Darpur) helped me select suitable study sites and provided accommodation in Darpur, I am grateful to both of them. I am highly indebted to Mr.M.S. Malik (ACF Haryana Forest Dept.), who suggested Darpur RF to be a good study site and for arranging for permissions and other logistic details. Most important was my field assistant, 'BUNDU KHAN' who was my plant taxonomist-cum-field assistant-cum-cook and a great story teller! - without whom my work would have been a disaster. Thanks to him, his family and all the gujjars of Piloudi village for their affection, help and lots of 'sweet tea'.

Dr. S.P. Goyal, my supervisor, took great pains to help me through my work and completion of this Dissertation in time. Drs. A.J.T. Johnsingh, Ajith Kumar, Y. Jhala, G.S. Rawat and R.S. Chundawat helped me a great deal at various stages of my project from formulation to completion. Drs. Ajith, Qamar Qureshi and Jhala provided critical comments and guidance during analysis and draft writing. Dr.Ravi Chellam receives a special thanks, for taking great pains in correcting the pathetic language in my drafts and for the timely warnings about method of writing and presentation. Messrs. Thapa, Sukumar, Lekh Nath, Manoj and Navneet (Computer Cell, WII), Ranaji, Vermaji (Library) and administrative staff were of great help from the initiation phase to analysis, and dissertation writing.

Back home at WII, Shomita, Nita, Pranav, Bhat, Pandav, Bhupathy 'Saar', Mrs. Ratna Singh, Aradhana, Wesley, Partho, Raghu

Tata and Dhaval have been great pals and general morale boosters whenever required. Shomita has helped me a great deal, in preparing Tables, graphs and draft-reading, I thank her for that.

Nima, Prachi, Yashveer, Parul, Gauri, Vipul, Suhel, Sangita, Hemali, Capt. Sandeep Karki, Prema, Pranav, Pandav, Aparajita ('Abu'), Bhat, Aswini, and Charu wrote to me regularly and provided news from over the globe. Nima, Yashveer and Prachi were really considerate and they send a lot of useful comments regarding my work and analysis of data. Thanks a Ton! for your best wishes.

My parents and my sister, Heena and all my relatives were extremely supportive. They found time from their busy schedules in Bombay and visited me during my stay at Simbalbara. They gave a lot of reassurance and monetary backing whenever required. This was most unexpected and I appreciate it. Messrs. Ashish Rawat, Gogi, Ambade, Sahai, Yadav, Joshi and Malik (IFS)- Diploma Course trainees were great companions at WII and gave me the pleasure of their company by visiting me in field too. Mr. Tom Jenner, from Scotland, who was studying the behaviour of RedJungle fowl in Simbalbara, was an excellent Ornithologist and he taught me to identify lots of *Phylloscopus* leaf warblers and Raptors. I would always miss those evenings we spent discussing about birds and animal behaviour. I am thankful to him for being a great companion in field. Arun, Vijay, Justus and Sathya stayed with me in field at Simbalbara and shared a lot of news from the 'so-called Civilized' world. Anish is thanked for his backing during the initial phases of my study and for not increasing my work-load of replying to his letters.

Last but not the least Thanks are due to all the GORAL in my study area for turning up along my search paths and making my study possible.

SUMMARY

A study on the habitat use, group size and activity patterns of goral (*Nemorhaedus goral*) was undertaken from November 1992 to May 1993 in Simbalbara Sanctuary (Himachal Pradesh) and Darpur Reserved Forest (Haryana). Data on availability of habitat types, vegetation types, slope, aspect and cover and their corresponding use (N=230 sightings), were collected along six search paths. Group size and activity pattern data were collected by walking along search paths and using instantaneous scan sampling.

The broad habitat types identified were:

Valley slope, Grassy slope, Ridge top flat, Nala slope, Valley bottom flat, Ridge top slope and Valley ridge slope.

The vegetation types identified in the study area were:

Sal forest (SF), mixed forest (MF), mixed forest grassy slope (MFGS), mixed forest riverine (MFR), sal forest riverine (SFR), pine-mixed woodland (PMW) and mixed forests with khair plantation (MFKP).

The characteristic features of habitat and vegetation types and seasonal variations in them are discussed.

The major findings of availability-utilization analysis were :

Goral showed preferential use of grassy slopes in summer. Valley bottom flat was used less in both the seasons.

Mixed Forest was preferred in both seasons, whereas Mixed Forest Grassy Slopes were preferred only in summer. Sal Forest, Sal Forest Riverine and Mixed Forest with Khair Plantations were used less in both the seasons.

A preferential use of the steep slopes was observed in winter. In summer there seemed to be no selection for terrain type. South facing slopes were preferred in both the seasons.

Extremely low shrub cover and medium grass cover were selectively used by goral.

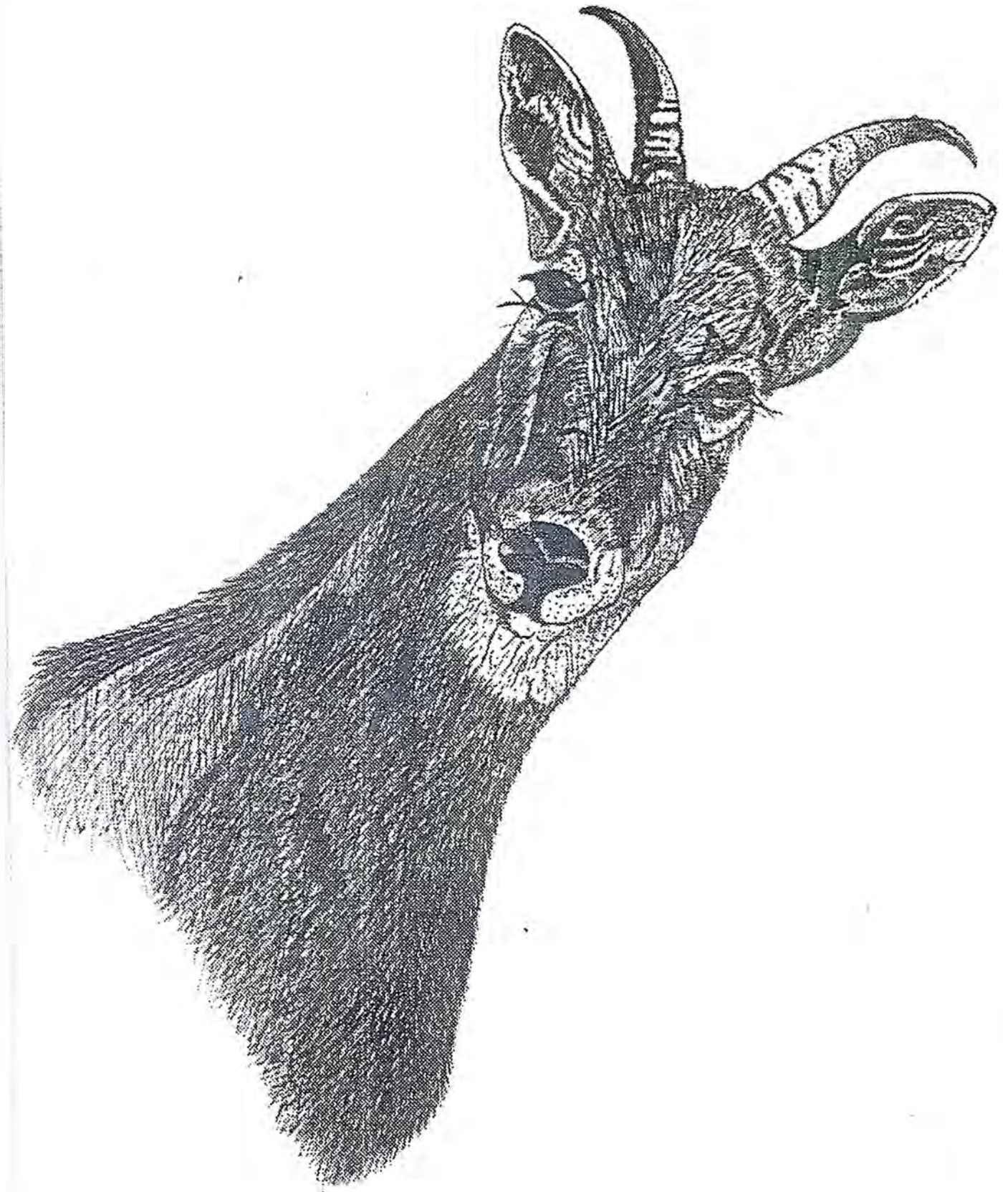
Major features of goral group size and activity pattern were:

Goral was predominantly a solitary species forming loose aggregations of upto eleven individuals.

Average group size of goral did not vary significantly (N=230, $d.f.=3$, $p=0.05$, $\chi^2 = 0.98$) between seasons, but during late evening hours, comparatively larger groups were observed in winter (N=127, $d.f.=4$, $p<0.02$, $\chi^2 = 12.42$). Group sizes were comparatively larger in disturbed areas (N=230, $d.f.=3$,

$p < 0.01$, $\chi^2 = 12.75$).

A significant difference in proportion of time spent in different activities was observed ($N=416$, $d.f.=8$, $p < 0.001$, $\chi^2 = 37.59$), between winter and summer. Nevertheless, activities and proportions of active and inactive individuals varied significantly over different hours of the day ($N=192$, $d.f.=2$, $p < 0.01$, $\chi^2 = 10.43$).



GREY GORAL (*Nemorhaedus goral bedfordi*)

CHAPTER 1: INTRODUCTION

1.1 General Introduction:

Habitat is a specific set of physical, biological and chemical conditions that surround an individual, a species or a community (Clements and Shelford 1939). Macro and micro habitat selection is a reflection of the evolutionary position, body size and the correlated feeding strategy of the species (Geist 1974a). Primitive species, with small body size have higher calorific requirements and defend resource territories. As against this, the typical Pleistocene 'grotesque giants' of the cold-temperate and periglacial climates are most capable and abundant in these extreme environments (Soma 1987). The habitat occupied governs the size and composition of social groups and the activity pattern of a species (Geist 1974a; Elsner-Schack 1985). Geist (1974b) and Jarman (1974) observed that the distribution of food resources in a habitat, the feeding behaviour and group size of the species, were interrelated. Jarman (1974) indicated that grazers which are largely unselective feeders, may be present in large groups as grass is abundantly available and grasslands can sustain high levels of grazing. Whereas, browsers which are much more selective feeders, live in smaller groups or are solitary.

Ungulates modify their activity pattern in response to habitat differences, seasons and disturbance factors (Owen-Smith 1979), and their behaviour could be a sensitive indicator of habitat quality (Owen-Smith 1979; Pachlatko and Nievergelt 1985). Therefore, knowledge of the habitat requirements of a species and their use are essential to enhance effective management of the species (Eisenberg and Seidensticker 1976; Riney 1982).



PLATE NO.1: The grey goral (*Nemorhaedus goral bedfordi*) in Delhi Zoo. The individual on the left is a female and the one in the centre (feeding) is a subadult male. Note the white throat-patch and thinner horn-base in the female as compared to the male.

PLATE NO.2: A goral as seen in its habitat. Note the steep slope (60-70°) besides the ridgetop slope.



The grey goral (*Nemorhaedus goral bedfordi* Hardwicke) is a small, primitive rupicaprid (Plate 1,2 and sketch) which is widely distributed throughout the Himalayas and Shiwaliks in India. It occurs at altitudes between 300-4000m above msl. Rupicaprids are essentially forest animals although some species spend much of their time in open terrain. Due to paucity of information on goral (Refer Section 1.2), its habitat requirements were identified based on the requirements of related mountain ungulates such as chamois (*Rupicapra rupicapra*) (Elsner-Schack 1985; Pachlatko and Nievergelt 1985), serow (*Capricornis sumatraensis*) (Soma 1987) and other caprids (Geist 1971; Schaller 1977; Nievergelt 1981; Etchberger *et al.* 1989), which have been studied in greater detail. The basic requirements of most mountain ungulates were identified as food, thermal cover, escape terrain or escape cover, water, areas for giving birth to young (Geist 1971; Etchberger *et al.* 1989).

Though goral is a relatively common animal throughout its wide distributional range in India, few quantitative studies have been conducted on its ecology and behaviour. It is still abundant in several areas and is not a 'Schedule-I' species according to the Indian Wildlife (Protection) Act (Anon. 1972). Goral is cherished by local hunters as a favoured-meat and in consequence has been reduced in numbers in many parts of the Himalayas and Shiwaliks. In many areas they are reported to be locally threatened; viz- Lippa Asrang, Ratchham Chitkul and Tundah Sanctuary, all in Himachal Pradesh (Singh *et al.* 1990). To understand the ecology of goral, knowledge of its habitat use, group size and activity pattern would be essential. Simbalbara Sanctuary (Himachal Pradesh) and Darpur Reserved Forest (Haryana) were selected as study areas. Ecological information gathered from this study aims to provide a basis for

the improved management of goral in India.

1.2 Literature Review:

1.2.1 General - The gorals (*Nemorhaedus sps*) and serows (*Capricornis sps*) are classified under the tribe Rupicaprini (Family Bovidae, SubFamily Caprinae). They seem to have evolved in the Oriental region in the early Pliocene period (Thenius and Hofer 1960). Recently, both genera have been grouped under one genus *Nemorhaedus* (Groves and Grubb 1985). Goral are widely distributed in the Himalayas and Shiwaliks (Kashmir to Arunachal Pradesh) in India and extralimitally in Afghanistan, north east Pakistan, Nepal, Bhutan, China (Southern Tibet), Soviet far east, Burma and Thailand; occurring at altitudes ranging from sea level to 4000m above msl (Mead 1989). In the Ussuri area of Russia, goral is found at sea level and in Nepal they are known to inhabit areas near the timberline (around 4000m) (Schaller 1977). Three species and 8 subspecies of goral occur in this range. In India, 2 species with 3 subspecies are recognized, *N.g.bedfordi* ('goral') occurring in the Western Himalayas and Shiwaliks, *N.g.goral* ('hodgsoni') in Eastern Himalayas and *N. baileyi cranbrookii* in Assam (Groves and Grubb 1985).

The goral's choice of habitat is liberal as long as steep and rocky terrain and cover is available (Schaller 1977). In India, it occupies a variety of habitats between Himalayan temperate forests and the alpine pastures (upto 3600m) (Green 1987); the tropical moist deciduous and subtropical pine forests in the Shiwaliks; montane wet temperate and evergreen forests in its north eastern distributional range (Prater 1965; Dang 1968; Schaller 1977; Gaston *et al.* 1981;1983).

Information on goral is anecdotal mostly dealing with natural history and morphology (Jerdon 1874; Pocock 1908;1914; Hayman 1961; Roberts 1977; Schaller 1977; Green 1981; Soma 1987; Heptner *et al.* 1989; Mead 1989). Among a few quantitative studies on its ecology and behaviour, Green (1985;1987) studied ecological separation between Himalayan musk deer (*Moschus chrysogaster*), goral, serow (*Capricornis' sumatraensis*) and sambar (*Cervus unicolor*) in Kedarnath Sanctuary, Uttar Pradesh. Lovari and Apollonio (in press) conducted a comparative study on habitat use, group size and structure and activity rhythms of *N.g.bedfordi* in Majathal Harsang Wildlife Sanctuary in Himachal Pradesh, India and *N. caudatus evansi* in Om-Koi Wildlife Sanctuary in Chiang Mai Province, Thailand. No comprehensive survey investigating the status and distribution of goral has been conducted in India (IUCN 1987), though few ecological surveys were undertaken in Himachal Pradesh (Gaston 1986; Gaston *et al.* 1981;1983; Cavallini 1992).

1.2.2 Habitat Use - Quantitative information on habitat use by goral is scanty. There is general acceptance that goral are habitat generalists but food specialists (Lovari 1985; Green 1987; Cavallini 1992; Lovari and Apollonio in press) and they inhabit a variety of vegetation types (Refer Section 1.2.1). Based on its habitat requirements, studies on habitat use by goral can be reviewed under the following headings:

FOOD: The grey goral is a concentrate feeder with broad feeding habits (Schaller 1977, Soma 1987). Goral are largely believed to be grazers (Green 1987) though they are an intermediate species ie. a grazer/browser, depending on the availability of browse (Schaller 1977, Lovari and Apollonio in press).

In Kedarnath Sanctuary, Green (1987) determined the diet of

goral based on analysis of pellets and found them to be feeding largely on grass and bamboo, in all seasons. In spring and summer, grass and bamboo together constituted upto 80% of the food intake of goral, with much of fern and moss. The composition of woody oak, *Gaultheria*, and miscellaneous species along with ferns and forbs constituted to around 30% of the food intake in winter and autumn. On analysing goral pellets, he found the chemical composition of the faeces to vary according to the seasonal variations in forage quality. During the summer growth, between May and June, the level of cellulose in faeces was lowest, whereas the crude protein content of the faeces was highest. The diet of *N. caudatus* is reported to be varied consisting of graze and browse species; the proportions of which vary seasonally (Bromlei 1956, Valova 1978, Schaulskaya 1980; quoted from Mead 1989). In Pakistan, goral feed predominantly on the tussocks of grasses like *Aristida*, *Apluda* and *Themeda* (Roberts 1977). *N. bailayi cranbrookii* are known to feed on open grassy slopes mainly on *Usnea* sps and other lichens and grasses (Zhang 1987). In Russia, goral are found to be tree and shrub browsers during winter, evergreen herbage, broadleaf trees and shrubs being the principal food (Nasimovith 1955 in Mead 1989).

Green (1987) and Lovari and Apollonio (in press) found a significant correlation in goral's altitudinal variations with time. Higher altitudes were frequented around dawn. This coincides with their crepuscular or nocturnal feeding behaviour in high altitude alpine meadows (Green 1987). Avoidance of the higher altitudes and migration to lower altitudes in winter was to cope up with the short supply of resources in the snow bound areas. This and few other climatic constraints may be the crucial factors governing the seasonal habitat use of goral.

THERMAL COVER: Temperature is a very important factor regulating the habitat use and activity pattern of goral (Lovari and Apollonio in press). Goral are found in forests in winter and summer but never in spring or autumn (Green 1987). They are associated with tree cover in winter, due to deep snow on alpine meadows, which increases their vulnerability to predation. Increased use of tree cover in summer and in mid-day hours, coincides with a sharp rise in temperature. Nevertheless, factors like rain and cover for parturition would also bring about use of higher tree and shrub cover. Rocky ledges and cliff hollows are also used as thermal cover (Green 1987, Lovari and Apollonio in press).

ESCAPE TERRAIN: Goral is considered a typical cliff dweller (Heptner *et al.* 1989, Mead 1989) occupying precipitous terrain. Schaller (1977), Green (1987), Cavallini (1992) and Lovari and Apollonio (in press) report 30-60° to be the preferred slope category. Goral use crypticism as a strategy to elude predators, taking flight when the intruder/predator is close at hand. They take advantage of both, steep terrain as well as shrub or grass cover by running down steep cliffs and entering a nearby thicket. Therefore, selection of aspect not only governs the feeding strategy and activity, but also the escape strategy (Green 1987).

WATER: Goral are believed to have a strong dependency on water and they may travel a few kilometres to drink (Schaller 1977).

EFFECTS OF DISTURBANCE: Goral is supposed to be largely associated with disturbed areas with a long history of fire and hunting (Gaston *et al.* 1981). The effects of this have not been documented in literature. Nevertheless, in such areas, goral supplement diurnal feeding with more nocturnal feeding habits (Roberts 1977). It is felt that increased interference in terms of grazing, lopping

and poaching would deplete the habitat and have adverse effects on ungulate populations (Saharia 1982; Rodgers *et al.* 1986).

1.2.3 Group Size - Goral are not particularly social, though they tend to live in small groups throughout their geographic range. Males largely lead a solitary life, interacting with females only during the rut. On the contrary, females are more often associated in mixed groups (Roberts 1977; Schaller 1977; Green 1987; Mead 1989; Cavallini 1992; Lovari & Apollonio *in press*). The group sizes seen in different areas were highly variable (12:Engelmann 1938; 10:Heptner *et al.* 1961; 6:Green 1981; 3:Green 1987; 9:Cavallini 1992). Mean group size recorded at Kedarnath Sanctuary, Langtang National park and Majathal Harsang Sanctuary were 1.3 (Green 1987), 2.2 (Green 1981) and 1.9 (Lovari & Apollonio *in press*).

1.2.4 Activity Pattern - Goral are active both during the day and at night (Green 1987). The diurnal activity is variable seasonally and the time of retreating into cover depends on the temperature. Lovari and Apollonio (*in press*) observed, feeding in the morning hours to constitute more than 50% of the activity, followed by standing (17%) and moving (10%). Resting increased in mid-day followed by bouts of feeding in the evening. A 295-minute continuous observation of a female and her yearling, in Kedarnath Sanctuary, proved nocturnal feeding. Feeding was interspersed by resting, through the night. Resting seemed more pronounced around midnight (Green 1987). Social interactions increase as the day progresses and reduces by mid-day with a repetition of social events in late evenings (1500-1800 hours). Rut occurs around October-November in India and young are born after a gestation period of 180 days, in the month of April or May (Mead 1989). There is a strong bonding between mother and kid. A low 'hiss-like' alarm

call is uttered when surprised by an intruder. Few other activities identified were drinking, suckling, grooming, ruminating and vigilant (Schaller 1977, Soma 1987).

1.2.5 Selection of Methodology - The necessity to determine preference or avoidance of a specific habitat type or habitat parameter in terms of its availability has long been established (Glading *et al.* 1940; Bellrose and Anderson 1943; both quoted from Neu *et al.* 1974). Friedman (1937), Johnson (1980), Neu *et al.* (1974), Quade (1979) and many others suggested techniques for analysing availability-utilization data. All 4 methods compare habitat use to the availability of the corresponding habitat type. However, the Neu *et al.* (1974) method in combination with the non-mapping technique (Marcum and Loftsgaarden 1980) were considered suitable for this study.

1.3 Objectives:

Based on the aforementioned information, the study was designed to fulfil the following 3 objectives:

1. to determine the patterns of habitat use by goral between seasons, with reference to habitat type, vegetation type, slope, aspect, shrub cover and grass cover.

2. to assess whether disturbance, seasons and time of the day influence the group size and composition in goral.

3. to study diurnal and seasonal variations in the activity pattern of goral.

) The two hypotheses (H_0) to be tested were: Goral use the above mentioned habitat components in proportion to their availability. There is no diurnal, local or seasonal variation in group size and activity pattern of goral in relation to climatic factors and disturbance.

CHAPTER 2: STUDY AREA

Most of the anecdotal records and scientific studies on goral were from disturbed areas (Refer Section 1.3). More quantitative information on the ecology of goral in comparatively less disturbed areas was required (Schaller 1977, Cavallini 1992). Simbalbara Sanctuary and Darpur Reserved Forest were selected as the study areas for the following three reasons:-

(1) Absence of a resident human population inside the Sanctuary and a low incidence of cattle grazing and lopping (which is illegal) made Simbalbara Sanctuary an ideal undisturbed study site. Darpur Reserved Forest (RF), on the other hand, had all the disturbance factors like grass cutting, livestock grazing, lopping and occasional poaching (M.S.Malik, pers.comm). These factors were used to quantify effect of disturbance on goral.

(2) Discussions with several biologists and wildlife managers indicated the presence of a good population of goral in Simbalbara, Darpur and their environs (A.J.T Johnsingh, S.P Goyal, S. Pandey, M.S Jain, M.S Malik, pers.comm). This was supported by the study conducted by Cavallini in 1989 (Cavallini 1992) and H.P. Forest Dept. census figures. I conducted two preliminary surveys in Simbalbara Sanctuary on the 19-20th July, 1992 and on the 22nd August, 1992. On these occasions, I could see and observe 25 goral (in 15 sightings) and 8 goral (in 6 sightings), respectively. This confirmed the suitability of the site for such a study.

(3) The study area had an altitudinal range of 350-700m and is the lower altitudinal limit of goral distribution in India. Owing to their perennial accessibility, the Lower Shiwalik ranges are getting populous. Large chunks of prime goral habitat are being

fast depleted and lost to urbanization. This study would generate baseline information necessary to understand the ecology of the species and for its long-term survival in the Shiwaliks.

2.1 Administrative and General:

The study area encompasses the areas of Simbalbara Sanctuary ($30^{\circ} 24'21''$ to $30^{\circ} 28'13''$ N lat. and $77^{\circ} 27'18''$ to $77^{\circ} 31'26''$ E long.) in Sirmour District, Himachal Pradesh and Darpur Reserved Forest (DRF) ($30^{\circ} 24'$ to $30^{\circ} 23'$ N lat. and $77^{\circ} 26'$ to $77^{\circ} 30'$ E long.) in Chachchrouli District, Haryana, covering an area of ca.27.5 sq.kms (Fig 1). Darpur RF is contiguous and bordering Simbalbara Sanctuary along its south and south west periphery. Simbalbara Sanctuary, prior to its notification as a Sanctuary in 1958, was a hunting preserve of the former Maharajah of Sirmour. Historical records indicate presence of elephant in this area. It is believed that the Hydell Channel at Yamuna barrage cut off their migratory routes (Singh et al. 1990). The study area is representative of the lower Shiwalik region and lies in the confluence of the peninsular plains and the main Shiwalik System. The flora, fauna and physical features show affinities to Western Himalaya, Punjab Plains and Upper Gangetic Plains (Biogeographic Zones 2B,4A & 7A respectively) (Rodgers and Panwar 1988a,b), though it is present in the biogeographic province 4A.

The intensive study area (ISA), is divided into two satellite areas, situated along the border of the states of Himachal Pradesh and Haryana. The south west periphery of Simbalbara, including parts of Kaludeo, Madusidh and Danda Sukhchainpur blocks, were comparatively less disturbed. Effects of disturbance on the ecology of goral were studied in Block Nos. 2 and 5 of Darpur RF.

The physical and biotic features of ISA are elaborated below.

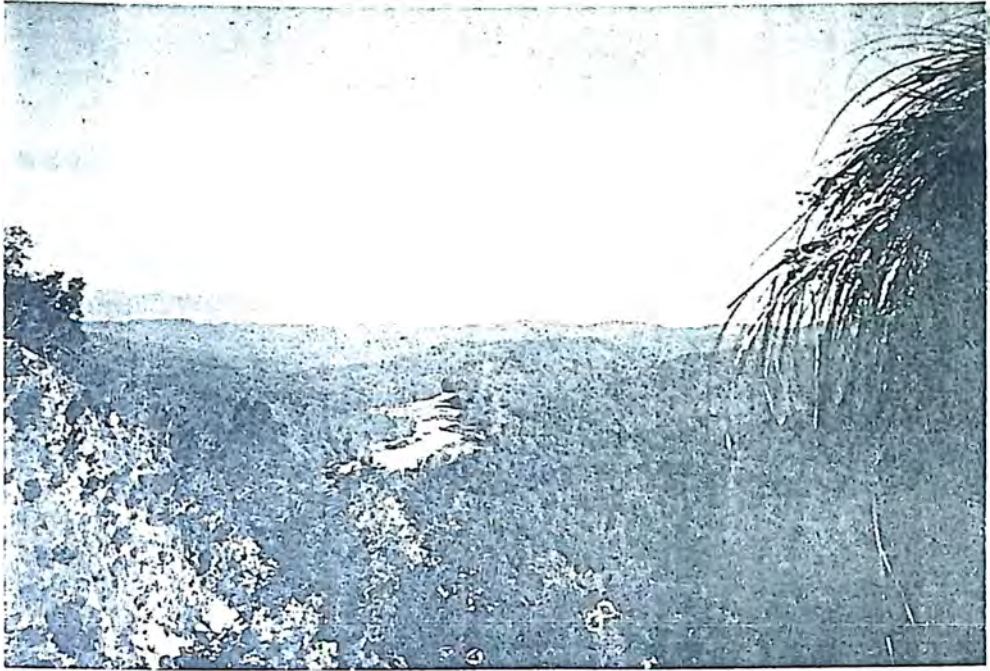
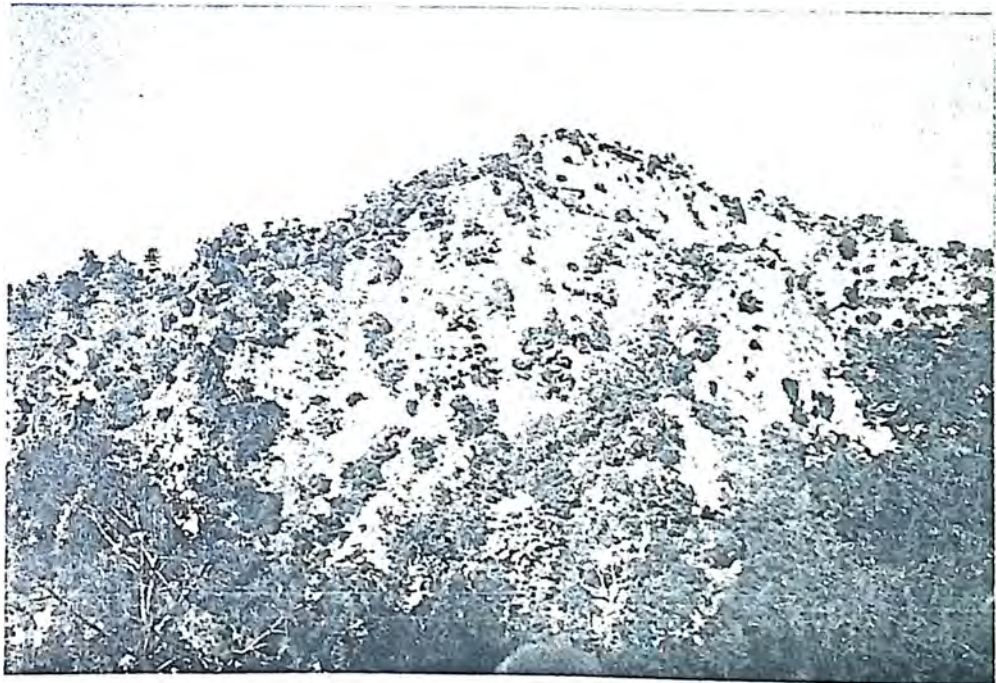


PLATE NO.3: Thick Sal forests in the valleys and Mixed forests on the ridgetops and hill slopes as seen in Simbalbara Sanctuary. Note the Himalayas in the background parallel to the higher ridges of Shiwaliks.

PLATE NO.4: Scattered *A. latifolia* and *P. roxburghii* trees in the Northern Dry Mixed Deciduous forest type in Darpur Reserved Forest.



Simbalbara and Darpur RF are dealt separately in most of the following sections owing to the subtle, yet crucial differences in these two areas.

2.2 PHYSICAL FEATURES:

The study area lies in the Lower Shiwalik region and has an altitudinal range from 350m to 700m above msl. The Shiwalik ridges run from a south easterly to a north westerly direction and at places are almost parallel to the Himalayas (Plate 3). Darpur lies completely in Lower Shiwaliks and immediately gives way to the Peninsular Plains, at their foothills. Whereas, the part of the ISA in Simbalbara lies in the Lower Shiwaliks and merges into Middle Shiwaliks and Upper Shiwaliks.

There is a great difference in the geology between Simbalbara and Darpur. In Simbalbara, the hills are largely composed of unconsolidated sandstone and conglomerate that are extremely prone to erosion. Whereas, in Darpur, the soil is composed of gravels, pebbles, boulders, sandy silt, shale, soft and friable sandstones, silty clay and slabs of hard and indurated sandstones. Such a habitat is totally absent in Simbalbara, presenting a comparatively rigid substratum on the slopes in Darpur RF (Anon. 1986).

The gradient on either sides of the ridges is controlled by regional dip. The dip-slope sides (north east and south east facing slopes) of the ridges form a gently sloping ground and have thicker forest. In comparison, steep scarps develop on the opposite side (south west and north west facing slopes). Several escarpments are rocky overhangs (Anon. 1986). Consequentially, they have sparse vegetation. Such steep slopes are used by goral as escape-terrain and even as resting sites.

The soil is extremely porous and has poor water-retention potential and thus, high drainage. However, at many low-lying areas springs emerge and create moist and cool patches of riverine species. The ISA has seven perennial (artificial) waterholes, 3 perennial streams and many seasonal springs and pools spread over the whole area. Darpur RF has a large reservoir which is supposed to be a crucial drinking-place for wildlife and domestic ungulates (M.S.Malik pers.comm). These factors of the physical geography of the ISA when considered along with the climatic factors, would affect the presence of plants (Champion and Seth 1968) and movement of many large and small species of animals. Such influences of site characters on wildlife are however, poorly documented.

2.3 CLIMATE:

The climate in the Shiwalik region is influenced by its proximity to the Himalayas though it retains the typical Continental Monsoonal Climate characterized by having three distinct seasons-viz: Monsoon- July to September (Oct), Winter- (Oct) November to February (Mar) and Summer-(Mar) April to June (the months in brackets indicate the transitional periods) (Rodgers *et al.* in press). The proximity of the Shiwaliks to the Himalayas and its relief leads to significant spatio-temporal variations in the climate and also the microclimate (Rodgers *et al.* in press). Temperatures in the study area vary seasonally with a maximum of 46°C in May (monthly max. average 45°C) to a minimum of -3°C in January (monthly min. average 4.4°C). Usually, winter rains and frost occur in the months of November to February due to the 'Westerly Disturbance' (Anon. 1986). However, during the study period, rains commenced on the 22nd of December 1992 and were

regular only from the 1st of January, 1993 and continued till 8th of May 1993. The average annual rainfall is highly variable throughout the Shiwalik Range from a low of 1,005mm at Ranipur to 2,464mm recorded at Thano. Simbalbara Sanctuary and its adjacent areas receive a Mean Annual Rainfall of about 1260mm (Singh *et al.* 1990). Whereas, Darpur RF records an average annual rainfall of about 1363mm (Anon. 1986). The frequently occurring frost is known not only to influence the fauna (esp. reptiles), but also vegetation of the study area (Champion and Seth 1968, Rodgers *et al.* in press). Relative humidity also varies from 100% on winter nights and monsoonal days to 26% in Summer afternoons.

Records of minimum and maximum temperatures and relative humidity were maintained during the study period and have been presented in Tables 1 and 2 respectively. The number of rainy days were also recorded (N=42) though the amount of rainfall received was not measured.

2.4 VEGETATION:

By and large, Simbalbara Sanctuary is covered by Moist Sal-bearing forest (Plate 3), categorized as 3C/C₂ (Champion and Seth 1968), and is considered to be the westernmost-limit of sal distribution in India (Singh *et al.* 1990). Darpur RF harbours the Northern Dry Mixed Deciduous forest type (Plate No.4), categorized as 5B/C₂ (Champion and Seth 1968). However, as mentioned in Section 2.2 and 2.3, the microclimatic conditions of temperature, rainfall, moisture and physical features such as altitude and terrain determine different vegetation types likely to be present in any area (Champion and Seth 1968).

Based on the initial surveys and subsequent quantification,

following 7 Vegetation types were identified in the study area:

- 1) Sal Forest (SF)
- 2) Mixed Forest (MF)
- 3) Mixed Forest-Grassy Slopes (MFGS)
- 4) Mixed Forest Riverine (MFR)
- 5) Sal Forest Riverine (SFR)
- 6) Pine-Mixed Woodland (PMW)
- 7) Mixed Forest-Khair Plantations (MFKP)

Local variations in species-composition and associations in these vegetation types were observed between the two ISAs. A detailed description and floristics of all the 7 vegetation types is presented in Chapter 4, and supplemented in Appendix I.

2.5 FAUNA:

The study area is a home for many species of mammals, birds, amphibians and reptiles. Most of the mammals present in the study area have a wide geographical distribution and are not unique to the study area. A few representatives are goral, sambar, barking Deer (*Muntiacus muntjac*), wild pig (*Sus scrofa*), hanuman langur (*Presbytis entellus*) and rhesus macaque (*Maccaca mulatta*), jackal (*Canis aureus*) and porcupine (*Hystrix indica*). Cheetal (*Cervus axis*) are known to migrate in the summer months between the plains of Darpur and Kalesar Sanctuary, Haryana and to the water holes in Simbalbara. Tiger (*Panthera tigris*), leopard (*Panthera pardus*), jungle cat (*Felis chaus*), leopard cat (*Felis bengalensis*) and pangolin (*Manis crassicaudata*) are the rare inhabitants. The occurrence of mammals such as goral, pangolin, Himalayan palm civet (*Paguma larvata*), Himalayan yellow-throated marten (*Martes flavigula*) and birds such as khaleej pheasant (*Lophura leucomelana*)



PLATE NO.5: At any given time more than 80-100 cattle are grazing on the slopes and they are usually accompanied by 2-3 persons.

and red billed blue magpie (*Cissa erythrorhyncha*) in the study area is indicative of the Himalayan influence on the fauna of Simbalbara. Similarly, presence of grey partridge (*Francolinus pondicerianus*), black partridge (*Francolinus francolinus*), saker falcon (*Falco biarmicus cherrug*) and imperial eagle (*Aquila heliaca*) is indicative of the influence of Peninsular India's plains on Darpur region. A total of 220 species of birds and 3 species of amphibians and 7 species of reptiles were recorded during the study period.

2.6 HUMAN INTERFERENCE:

The part of ISA in Simbalbara is comparatively less disturbed, due to absence of a resident human population inside the Sanctuary. The surrounding area has 35 villages with a population of 2444 (Anon. 1987), but all rights of these villagers to the forest have been settled before declaration of the Sanctuary and no collection or extraction is allowed. However, the villagers hold rights to the ISA to visit the Kaludeo Temple. About 50-100 pilgrims visit the temple every month. Illegal cattle grazing, lopping of *Ougeinia ougeinensis* and *Terminalia alata* and occasional poaching incidences are reported from the adjoining villages and Kalesar Forest of Haryana. The Simbalbara-Puruwala road is regularly used by gujjars and other migratory glaziers and this, is one of the major source of disturbance. The use of this Sanctuary by tourists is very low and less than 50 people visit the ISA throughout the year. A record of visitors is not maintained.

In contrast, the ISA in Darpur RF has a well-defined tract allotted for the exercise of the rights of the villagers. The inhabitants of Darpur village can avail the following rights by

preventing forest offenses and by helping in extinguishing forest fires. The rights are as follows: (Quoted from Working Plan, Anon. 1986)

(i) Free grazing of livestock except sheep, goat and camel.

(ii) To remove grasses, *Eulaliopsis binata*, *Bauhinia vahlii* leaves for personal use only.

(iii) Lopping of *Shorea robusta*, *Terminalia chebula*, *Terminalia belerica*, *Acacia catechu*, *Terminalia alata* and *Dalbergia sissoo* is not allowed.

(iv) Free use of *S. robusta*, *A. auriculiformis*, *O. ougeinesis* and *T. belerica* etc. for bonafide domestic use with permission of the concerned Forest Officer.

(v) Removal of dry fallen fuelwood from the forest. In case of extra demand of fuelwood, for marriage and funeral, the same can be given with the permission of the Forest Officer.

(vi) *Zizyphus mauritiana* and *Carissa spinarum* for fencing of agricultural fields.

(vii) Miscellaneous and small wood for agricultural implements, charcoal and for repair of the implements.

Although grazing of goats and lopping was not permitted, illegal use was very high and at any given time between 80-100 goat and cattle were seen grazing (Plate No.5). *Anogeissus latifolia*, *A. catechu* and *O. ougeinesis* were the most severely lopped. Other forms of disturbances included poaching and trench digging and pre-plantation clearing operations. Every year, a contract is given to a paper-pulp mill to cut bhabar and other grasses. For the collection of the required grass, the mill employs local gujjars who cut and collect the grass in the area and deposit it with the contractor. This disturbs the fauna by physical displacement,

destruction of habitat and reduction in food availability. The effects of disturbance would reflect on the distribution, movement pattern, group size and structure and anti-predatory behaviour displayed by goral. These are discussed in Chapter 4.

✓ 3.1 Introduction:

The Neu *et al.* method (1974) analyzes availability-utilization data based on the accurate proportions of each and every habitat parameter available ('mapping technique') (Alldredge and Ratti 1992). This was not feasible in the rugged areas of the ISA. Habitat parameters like categories of slope, slope position, elevation, habitat types, highly heterogeneous vegetation and areas of disturbance are difficult to map. Hence, the 'non-mapping technique', which is a modification of the 'mapping technique', was adopted for estimating the proportions of categories of several habitat parameters. This technique was developed by Marcum and Loftsgaarden (1980).

Data were collected on the following major aspects:

- (1) Climate,
- (2) Vegetation and Phenology,
- (3) Habitat Availability-Utilization,
- (4) Group Size and Structure,
- (5) Activity Pattern.

The methods of data collection were same in both the ISA's.

3.2 Climate:

I hypothesized that climatic factors such as seasons, temperature, rainfall and relative humidity would affect the habitat use, activity pattern, group size and group-structure of goral (Refer Section 1.1 and 1.2). Data on these parameters were collected as follows:

3.2.1 Seasons - The study covered 2 seasons viz.

- ✓(1) Winter- from 16th November 1992 to 14th March 1993,
(2) Summer- 15th March 1993 to 8th May 1993.

Seasons were differentiated based on rainfall and mean temperature for each month (Table 1). The month of March was transitional with frequent rains and high noon temperatures and low early morning, late evening and night temperatures. ✓

3.2.2 Rainfall and (Relative Humidity)- Only presence or absence of rain was recorded on a daily basis throughout the study period. Relative humidity was recorded daily at every 3 hourly intervals from 6am to 6pm (Table 2), using a dial hygrometer.

3.2.3 (Temperature) - Temperature was measured at the base camp with a mercury maximum-minimum thermometer. The number of days in a month on which records were made varied from 8 to 21 days. Maximum and minimum temperatures were recorded on every data-collection day. The mean maximum and minimum temperatures for each month are presented in Table 1. Temperature was also recorded at every goral location.

3.3 Vegetation and Phenology:

Vegetation studies were conducted at two levels viz. (i) Surveying and stratification, and (ii) Sampling.

3.3.1 Surveying and Stratification - The initial period of the study, from 16th November to 1st December, was spent in surveying the study areas to locate suitable study sites and collecting plants for identification. After surveying, certain areas which indicated presence of goral were identified and study paths or search paths were randomly laid in these areas. (Search paths (SPs) were laid to study habitat use by goral and to quantify the vegetation on the SPs.) Six SPs were selected and points were marked

at every 100m, to divide them into 100m segments in which to conduct vegetation studies. Owing to the complex terrain, the SPs were not straight and varied in altitude. Out of the six SPs- 3 were in comparatively undisturbed areas, 1 was in slightly disturbed and 2 in highly disturbed areas (Table 3). Seven broad vegetation types were recognized along the SPs. Broad stratification, followed by quantification for studying availability of vegetation types to goral, was attempted.

3.3.2 Sampling - Quantification was conducted using the circular plot method (Mueller-Dombois and Ellenberg 1974) at the beginning of both the seasons. Data on trees was collected at every 100m on the SPs in a 10m diameter plot. Similarly, data on shrubs and grasses were collected at every 50m on the SPs using 2m diameter plots for shrubs and two 1m diameter plots for grasses.

To quantify the level of disturbance, other information on vegetation was collected in the form of lopping of trees and shrubs, and cutting of grasses. In many plots, presence/absence of wild and domestic ungulate pellets was noted. Important food and cover species of trees, shrubs and grasses were identified (Appendix I, Table 4).

1. The broad vegetation type was recorded in each plot.
2. All tree species >20 cm girth at breast height (gbh) were recorded and their phenology noted as flush leaves, green leaves, drying leaves (yellow), dry leaves, leafless, flowering and fruiting. The corresponding canopy cover was visually estimated at the centre of the plot at a 5-point scale as- 0=0%, 1=1-25%, 2=25-50%, 3=51-75%, 4=>75%. Tree species composition, phenology and canopy cover was recorded as it was expected to have a strong impact on the shrub and grass species present and their

corresponding cover values.

3. In each of the plots, shrub species were enumerated and shrub cover was estimated on a 5-point scale (as for trees). All tree species with gbh <20cm were included as shrubs and enumerated. Phenology was recorded in a manner similar to trees. Since, the cover and food value provided by a single shrub and that by large clumps of shrubs is different, the number of branches arising from the base of the shrub were enumerated separately. The corresponding density is referred to as 'shrub clump density' (Table 4).

4. The percent grass cover was visually estimated on a 5-point scale in the 2 plots placed on either sides of the SP. In these plots, grass species and their phenology and whether cut was noted. The average height of each species was also recorded.

3.4 Habitat Availability-Utilization:

Quantification along SPs was conducted as it would provide data on availability of habitat variables and subsequently, data on utilization of these parameters could be obtained on the search paths. This data is thus comparable. Vegetation plots were used to collect availability data and utilization data was recorded on the points where goral were sighted on the SPs.

3.4.1 Availability Quantification - The variables quantified for availability were:

1. Slope was measured using a clinometer and gauged in 10^0 units from 0^0 (flat) to 90^0 .
2. Aspect was visually determined on an 8-point scale as E, W, N, S, NE, NW, SE and SW and was checked using a magnetic compass.
3. Seven habitat types (HTs) were identified in the study area as Valley slope (VS), Grassy slope (GS), Ridge top flat (RTF), Nulla

slope (NS), Valley bottom flat (VBF), Ridge top slope (RTS) and Valley ridge slope (VRS). The habitat type for each plots was recorded, and Vegetation-data collected as discussed in Section 3.3.2.

3.4.2 Habitat Utilization - Data on habitat utilization by goral was collected along the 6 SPs. All the 6 SPs were walked at least 13 times during the study period (Table 3). On every walk, the following data were collected where goral were sighted.

1. Sighting time and ambient temperature.
2. Vegetation type and Habitat type.
3. Aspect.
4. Slope.
5. Shrub cover and Grass cover.
6. Circular plots were laid to quantify other vegetation parameters on accessible sighting points.

3.5 Group Size and Structure:

Search paths and scan-points were used to locate goral and collect data on their numbers, age-class and sex (whenever possible). Changes in group size and structure were recorded between seasons and between areas of less disturbance (SP 2,3,4) and higher disturbance (SP 1,5,6).

3.6 Activity Pattern:

Data on diurnal activities of goral were collected from instantaneous scan samples (Altmann 1974) while scanning the ISA from certain pre-decided vantage points. Similarly, whenever a goral was sighted on a SP (while studying habitat use), its activity at the moment and all subsequent activities were noted

with reference to time and temperature of sighting. Activities were classified as feeding, moving, resting, standing and others which includes grooming, rutting, suckling, sparring and ruminating.

3.7 Analyses of Data:

Availability-Utilization analysis was based on Neu *et al.* (1974) and Marcum and Loftsgaarden (1980). The null hypothesis (H_0) to be tested was, all habitat parameters are used in proportion to their availability. The data was subjected to G-Test to check for significant differences between available and used habitat parameters. On rejecting of H_0 , Bonferroni's confidence intervals (CI) were calculated. Categories of habitat parameters were merged if the number of sightings in the category were low, for statistical analysis (Siegel 1956). Data on group size was pooled into 4 categories as 1,2,3 and ≥ 4 individuals for comparing between disturbed and undisturbed areas. Whereas, 3 categories of 1, 2 and ≥ 3 were made, to compare group sizes between time periods of day. Chi-square tests were used to compare differences in group sizes between disturbed-undisturbed and time periods of the day. Differences in activity between hours of the day and between activity and inactivity was compared using Chi-square test. For the latter analysis, moving and feeding animals were categorized as active and standing, resting and others as inactive.

CHAPTER 4: RESULTS

4.1 Vegetation Studies:

The species composition and density of trees, shrubs and grasses and proportions of their distribution in the study area are presented in Table 4.

The ISA is largely covered by the moist sal-bearing forests and the northern dry mixed deciduous forests. Based on physiognomy, seven vegetation types (VTs) were identified. The detailed floristics of each of these VTs is presented below.

4.1.1 Mixed Forests (MF) - This is the most widespread vegetation type of the ISA and covers almost 31% of the sampled area. The dominant trees amongst them were *Anogeissus latifolia* (26.61%), *Acacia catechu* (16.97%), *Ougeinia ougeinensis* (13.76%), *Diospyros melanoxylon* (11.01%) and *Boswellia serrata* (8.26%).

The primary shrub species were *Nyctanthes arbor-tristis* (29.03%), *Woodfordia fruticosa* (19.54%), *A. latifolia* (14.7%), *Carissa spinarum* (14.58%), *Indigofera pulchellum* (3.56%) and *D. melanoxylon* (2.42%). All these shrubs were also observed to be the main browse species for goral.

Chrysopogon fulvus (36.06%) was the dominant grass species in MF, followed by Bhabar *Eulaliopsis binata* (32.78%) and *Heteropogon contortus* (18.03%). These three grass species were palatable and used by goral.

4.1.2 Mixed Forest Riverine (MFR) - In MFR, the dominant tree species were *A. latifolia* (27.64%), *O. ougeinensis* (17.88%), *Acacia catechu* (13.82%), *D. melanoxylon* (8.13%) and *Terminalia alata* (6.5%). The climber, *Bauhinia vahlii* was a prominent feature (8.13%) in the canopy layer. The important shrub species out of the

46 recorded species were - *Nyctanthes arbor-tristis* (20.62%), *A. latifolia* (12.26%), *B. vahlii* (7.42%), *C. spinarum* (7.04%), *D. melanoxyton* (6.66%), *W. fruticosa* (6.03%), *I. pulchellum* (5.03%), *Hamiltonia suaveolens* (4.78%), *Colebrookia oppositifolia* (4.53%) and *T. alata* (4.27%).

Chrysopogon fulvus (30.86%), *Eulaliopsis binata* (27.16%), *Heteropogon contortus* (16.05%), *Apluda mutica* (8.64%), *Phragmites karka* (6.17%) and *Carex sp.* (3.7%) were the dominant species of grasses.

4.1.3 Sal Forests (SF) - SFs were largely present at lower altitudes and in flat valleys. Sal *Shorea robusta* (60.29%) was most dominant of the 14 recorded tree species. The other associated and common tree species with *S. robusta* were *O. ougeinensis* (11.76%), *Buchanania lanzan* (4.41%), *D. melanoxyton* (4.41%) and *Elaeodendron glaucum* (4.41%).

The shrub species recorded in SF were predominantly *I. pulchellum* (34.08%), *Mallotus philippinensis* (16.71%), *Inula cappa* (6.64%), *S. robusta* (5.72%), *Xeromphis spinosa* (5.44%), *Blainvilia rhomboides* (5.12%) and *C. spinarum* (3.48%). The climbers, *Millettia extensa* (2.83%) and *B. vahlii* (2.78%) were quite prominent in the shrub layer of SFs. The shrub density was highest in sal forests.

Eleven grass species were identified, dominant among them were *C. fulvus* (22.5%), *E. binata* (15%), *A. mutica* (12.5%), *P. karka* (12.5%). *Saccharum sps.* were present along the raus (dry river beds).

4.1.4 Sal Forest Riverine (SFR) - SFRs are the most heterogeneous of all the VTs in the ISA. They covered about 14.93% of the sampled area and 22 trees, 68 shrub & herb and 11 grass species were recorded. The tree density was highest with 335.84 trees/ha. *S.*

robusta (44.83%) was the dominant tree species and had associates like *O. ougeinensis* (14.65%), *M. philipinensis* (4.31%), and *T. alata* (4.31%). *B. vahlii* (7.76%) spread over the canopy and in consequence, many areas with this VT had canopy cover >80-90%.

The forest floor in SFR was dominated a weedy herb *Ageratum conyzoides* (13.21%). But, many other associated species had comparatively higher food and cover value. The associated shrubs were *C. spinarum* (11.11%), *M. philipinensis* (10.43%), *C. oppositifolia* (10.27%), *I. pulchellum* (9.17%), *S. robusta* (4.55%), *D. pulchellum* (3.41%), *B. rhomboides* (3.3%) and *I. cappa* (2.83%). *Ichnocarpus frutescens* (4.56%), *M. extensa* (2.94%) and *B. vahlii* (2.79%) were the dominant lianas in the lower canopy of the SFR.

The major grass species recorded were *C. fulvus* (18.18%), *O. compositus* (18.18%), *A. mutica* (15.91%), *Carex* sps. (9.09%), *Eulaliopsis binata* (9.09%), *Heteropogon contortus* (9.09%).

4.1.5 Mixed Forest Grassy Slopes (MFGS) - Although, this VT had the lowest species richness, it had the highest value for goral in terms of food and cover (Table 4). Tree density was low (Table 4) with many areas having no canopy cover.

A. latifolia (28.13%), *B. serrata* (21.88%), *O. ougeinensis* (12.5%) and *D. melanoxyton* (9.38%) were the dominant tree species. Major shrubs were *N. arbor-tristis* (27.12%), *W. fruticosa* (16.95%), *A. latifolia* (13.28%), *I. cappa* (10.45%), *O. ougeinensis* (5.08%), *D. melanoxyton* (4.8%) and *Tephrosia candida* (4.66%). The dominant graminoids were *E. binata* (30.61%), *C. fulvus* (26.53%), *H. contortus* (22.45%), *Eragrostiella nardooides* (14.29%), *Carex* sp. (4.08%) and *Eriophorum cosmosum* (2.04%). Most grasses were either cut (in disturbed areas) or >50cms long and coarse in winter and were largely unavailable to goral. Flush grass (sprouting) was

available in MFGS during spring (March) and summer (April and May). Grass cutting in the disturbed areas ceased after 31st March 1993 and thus, flush grass was available for goral in summer.

4.1.6 Pine-Mixed Woodland (PMW) - This VT was present only in the disturbed areas (SP 5 and SP 6) and was subjected to regular grass-cutting till 31st March 1992. After this date, the contract for grass cutting terminated. *Boswellia serrata* (20.83%), Pine *Pinus roxburghii* (16.66%), *A. catechu* (12.5%), *A. latifolia* (12.5%), *O. ougeinensis* (12.5%) and *T. alata* (8.33%) were the dominant trees. This is the confluence zone for sal, pine and mixed forest species. 16.64% of this VT was composed of sal (4.16%) and sal-associates. The higher proportions of *B. serrata* and *A. catechu* and presence of pine at an altitude of about 500m, is indicative of the aridity of the soil in this area.

The shrubs present in PMW were: *N. arbor-tristis* (16.92%), *H. suaveolens* (16.41%), *C. oppositifolia* (14.36%), *A. latifolia* (12.05%), *T. candida* (8.21%), *O. ougeinensis* (5.89%) and *T. alata* (5.64%). Although, *H. suaveolens* constituted a great proportion of the shrub numbers and was supposed to be a palatable species, it was leafless during most part of the study period and was thus, unavailable to goral.

Grass species recorded in this VT were: Bhabar (23.68%), *C. fulvus* (18.42%), *H. contortus* (18.42%), *Eragrostiella nardoides* (7.69%) and *A. mutica* (5.13%). Most grasses were cut in winter and dry in spring. Flush grass was available only in the summer months (end of April and May).

4.1.7 Mixed Forest with Khair Plantations (MFKP) - This was the least represented VT in the ISA (Table 4). Almost 40% of this VT was dominated by a single species ie. *A. catechu*. The rest was

represented by *T. alata* (20%), *A. latifolia* (12%), *D. melanoxylon* (10%) and other mixed forest species (in all 9 species). Khair trees were heavily lopped during late winter and the villagers herded their livestock below the trees before lopping. The tree canopy was totally destroyed in these trees. These activities disturbed goral movement and affected their distribution.

Nyctanthes arbor-tristis (31.86%), *A. latifolia* (15.58%), *C. spinarum* (9.77%), *W. fruticosa* (8.5%), *D. melanoxylon* (6.98%) and *H. suaveolens* (5.81%) contributed to the shrub layer. The climber *Celastrus paniculata* (7.21%) was quite widespread in this VT. Due to grass cutting and livestock grazing, most of the grass in the VT was cut and dry. Flush grass started to appear in summer. The major grass species were *E. binata* (25.81%), *H. contortus* (19.35%), *C. fulvus* (16.13%), *Eragrostiella nardoides* (9.68%) and *Cynodon dactylon* (9.68%).

Throughout the ISA, *A. latifolia* and *B. serrata* had shed leaves in late winter and were leafless till end of the study. *S. robusta*, *T. alata* and *O. ougeinensis* shed leaves (partially) in late winter. Similarly, *Nyctanthes arbor-tristis* and *I. pulchellum*, which were the dominant cover species, had shed leaves in early spring. Flush leaves appeared on some bushes in the month of May. *Carissa spinarum* and *Diospyros melanoxylon* produced flush leaves in April and May and most shrubs showed signs of feeding by ungulates. Woodfordia fruticosa was one of the major food species of goral and a dominant cover species in mixed forest categories (MF, MFR, MFGS and MFKP). It had shed most of its leaves in early April and was seen to be flowering from February to April.

4.2 Availability-Utilization Analysis:

Data on the selection of different habitat parameters was analyzed separately for winter and summer. The results are presented as follows:

4.2.1 Habitat Type Use - On analysing data on overall use of the broad habitat types, it was observed that H_0 is rejected in both seasons. In winter, Valley bottom flats were used less than expected and all other HTs were used proportionately ($N=127$, $d.f.=6$, $p=0.01$, $G=16.81$, Table 5a). In summer, there was greater use of the grassy slope HT than expected, but VBF and VRS did not show any use ($N=103$, $d.f.=6$, $p<0.001$, $G=52.52$, Table 5b).

4.2.2 Selection of Vegetation types - H_0 was rejected in both seasons. In winter, mixed forests (MF) were used more than expected and sal forests (SF) and sal forest riverine (SFR) were used less than expected ($N=127$, $d.f.=6$, $p<0.001$, $G=47.84$, Table 6a). No use of mixed forests with khair plantations (MFKP) was observed in winter. All other VTs were used according to their availability. In summer, MF and mixed forests grassy slopes (MFGS) were used more than expected and SF, SFR and MFKP were used less than expected ($N=103$, $d.f.=6$, $p<0.001$, $G=46.73$, Table 6b). Mixed forest riverine (MFR) and pine-mixed woodland (PMW) were used in proportion to their availability.

4.2.3 Slope-Use - Analysis of winter data shows that steep slopes ($>50^\circ$) have been used more than expected (Categories $51-75^\circ$ and $>75^\circ$ were merged). The medium slope category ($31-50^\circ$) was used less than expected ($N=127$, $d.f.=3$, $p<0.001$, $G=17.57$, Table 7a). $0-10^\circ$ and $11-30^\circ$ slope categories were used in accordance to their availability. As against the results in winter, H_0 was accepted in summer ($N=103$, $d.f.=3$, $p=0.05$, $G=3.16$, Table 7b) . Hence, during summer, all the

slope categories were used in proportion to availability and there was no selection for the type of terrain occupied by goral.

4.2.4 Aspect-Use - H_0 was rejected in both seasons. During winter, south east facing aspects were used more than expected, whereas north west facing aspects were used less than expected ($N=127, d.f.=7, p<0.001, G=32.68$, Table 8a). All other aspects were used proportionately. In summer, H_0 was rejected and the south west facing aspects were selected for and used more than expected ($N=103, d.f.=7, p<0.01, G=23.72$, Table 8b). Contrary to this, west facing aspects were not used at all. All other aspects were used in proportion to their availability.

4.2.5 Shrub Cover Use - H_0 was rejected in both the seasons. In winter, 0% shrub cover was used less than expected and 1-25% category was used more than expected ($N=113, d.f.=4, p<0.001, G=28.75$, Table 9a). The higher shrub cover categories (26-50%, 51-75% and >75%) were used proportionately. In summer, there was a highly significant difference in the use of shrub cover ($N=98, d.f.=4, p<0.001, G=176.41$, Table 9b). There was more use of open ground cover type (0% shrub cover) in summer, than was expected. The low to medium shrub cover category (1-25%) was used less than expected. The higher shrub cover categories were used proportionately, as in winter.

4.2.6 Grass Cover Use - Grass cover use was significantly different in both seasons. In winter, the medium grass cover category (26-50%) was used less than expected and all other categories (0%, 1-25%, 51-75% and >75%) were used in proportion ($N=112, d.f.=4, p<0.05, G=11.38$, Table 10a). In summer, there was a reversal of selection and the 1-25% grass cover category was used less than expected and the 26-50% category was selected for and used more

than expected ($N=96$, $d.f.=4$, $p<0.01$, $G=15.5$, Table 10b). No grass cover (0%), 51-75% and >75% grass covers were used proportionately.

4.3 Group Size:

Data on group size was compared between seasons, time periods of the day and between disturbed and undisturbed areas.

4.3.1 General - Distribution of group size was skewed due to the preponderance of sightings of single individuals in both the seasons (59.84% in winter and 61.17% in summer, Fig 3). No significant difference was observed in the size of groups formed between winter and summer ($N=230$, $d.f.=3$, $p=0.05$, $\chi^2=0.98$; Fig 3). The mean group size for winter and summer was 1.75 and 1.6, respectively. Due to the skewed distribution, the mean group size, after excluding observations of single individuals, was calculated. The means were 2.86 ± 1.3 (S.D) in winter and 2.55 ± 0.9 (S.D) in summer. Median group size for both seasons was 1.

4.3.2 Group size over parts of the day - Due to a low frequency of the higher group sizes (>3), sightings were pooled into 3 categories as 1,2 and > or =3 individuals. On comparing for difference in group size between parts of the day, a significant result was obtained in winter ($N=127$, $d.f.=4$, $p<0.02$, $\chi^2=12.42$, Table 11). The group sizes were comparatively larger during winter evenings (1500-1900 hrs). Though, groups were observed to be comparatively larger on summer evenings, a significant result was not obtained ($N=103$, $d.f.=4$, $p=0.05$, $\chi^2=1.47$, Table 11). The clumped data of winter and summer shows significant difference in group size between parts of the day, with larger groups predominant during evening hours (1500-1900 hrs) ($N=230$, $d.f.=4$, $p<0.05$, $\chi^2=11.32$, Table 11).

4.3.3 Effects of Disturbance on group size - The group size varies between disturbed and undisturbed areas during both the seasons, but it is significant only in winter (N=127, d.f.=3, $p < 0.05$, $\chi^2 = 8.01$, Table 12). Significant difference in group size between disturbed and undisturbed areas was obtained when data was pooled for the whole study period (N=230, d.f.=3, $p < 0.01$, $\chi^2 = 12.75$).

4.3.4 Group Structure and composition - The group composition of all groups could not be exactly identified owing to the secretive nature of goral and due to monomorphism in the species. (Sex whenever identified was based on horn-base thickness, males have slightly thicker hornbases, and looking at the genitals). The closest association observed was between a mother and her kid (for winter 63.33%, N=19 and 56%, N=14 for summer) and this was of a strict nature. The kid or yearling young rarely strayed more than 10-15m from its mother. Groups of 3 or more individuals were usually composed of one or more adult females, her kids or yearlings and an associated subadult female. They were thus, female family units. Mixed herds essentially had a single adult male, few adult females, her young and one or more subadult females. In most cases, there were one or more individuals whose sex could not be identified. Adult and subadult males were usually solitary unless associated with a family unit. An adult female accompanied by 2 yearlings or kids was a common sight in the ISA and they were assumed to be twins.

4.4 Activity Pattern:

The major activities of goral that were observed during the study were standing, moving, feeding and resting, in that order of frequency (Fig 3a & 3b). Other activities like autogrooming,

rutting, suckling, sparring and ruminating contributed to only 3.37% of the total observations (N=416) and were clumped into the 'other activities' category. Events like alarm-call, urinating, defecating, vigilant or running (flushing) were not incorporated in the analysis. Observations of goral drinking water could be obtained only on 2 occasions and were not included in the analysis.

On subjecting the five major activities to a Chi-square Test for testing difference in activities over parts of the day, significant results were obtained during both the seasons (Winter- N=224, *d.f.*=8, $p < 0.01$, $\chi^2 = 22.53$, Fig 3a and Summer- N=192, *d.f.*=8, $p < 0.001$, $\chi^2 = 34.74$, Fig 3b). On testing activities for significant differences between 3 parts of the day for the study period (clumped), the null hypothesis of there being no difference in activity between the hours in a day was rejected (N=416, *d.f.*=8, $p < 0.001$, $\chi^2 = 37.59$).

On testing for significance between the numbers of active and inactive animals, in different parts of the day, a significant difference was obtained only in summer (N=192, *d.f.*=2, $p < 0.01$, $\chi^2 = 10.43$). The number of active individuals in the different parts of the day was significantly different between winter and summer (N=149, *d.f.*=2, $p < 0.001$, $\chi^2 = 16.68$, Fig 4a & 4b).

CHAPTER 5: DISCUSSION

Habitat selection by a species is the result of the intrinsic characteristics of the species and the inherent features of the habitat, supplemented by environmental constraints like topography, climate and geology (Elsner-Schack 1985). Distribution of food, cover and aspects of security (escape terrain or cover) in the habitat would therefore bear overriding importance. To cope up with these environmental constraints, a species forms an 'adaptive syndrome'. Goral being a small-sized rupicaprid depends on 'resource-defence' to sustain its ecological needs (Soma 1987). This strategy can occur only when an animal or species selects a very productive habitat in which a small territory can cater to its life requirements, year round. Greater habitat interspersion results in habitat heterogeneity. This in turn results in higher species diversity and forage availability. This is favourable for most ungulates (Leopold 1961, Karanth 1988, Soma 1987). Goral, due to their selective requirements inhabit habitats which would provide them sufficient forage and cover within a narrow radius around a safe site (Soma 1987). The habitat selection and adaptive strategies of goral in Simbalbara and Darpur RF are discussed hereafter.

5.1 Habitat Use:

The preference of mixed forests in both the seasons and MFGS in summer can be considered in relation to the basic requirements of goral (Refer Section 1.2.2). *Nyctanthes*, *Woodfordia* and *Anogeissus*, which are the dominant shrub species in both the preferred vegetation types, are also the principal food and cover

species for goral in the study area. A new flush of *Carissa* and *Diospyros* leaves attract goral to the MFs in summer. Tussocks of grass appear in summer, coinciding with the end of contract grass-cutting (March end) and goral show a preference for the GS habitat type and MFGS in summer.

In winter, browsing is more frequent and goral are rarely seen grazing upon the long, coarse and flowering grass. Hence, selection of MF is in relation to the higher use of medium shrub cover and less use of open areas (0% cover). In summer, low shrub cover and open areas were preferred in combination with preference of MF and MFGS. All other shrub cover categories are used opportunistically. Medium grass cover is used more, in relation to grazing kind of food habits and the avoidance of low (1-25%) grass cover emphasizes selection for grazing.

MF, MFR, MFGS and PMW occur on valley slopes and higher up on the ridges. Thus, they hold areas with steep terrain which goral can take refuge on, when threatened (Mead 1989). Visibility in MF categories is higher and predator detection is not hindered. Sal forests (SF), sal forest riverine (SFR) and mixed forest with khair plantations (MFKP) occur in low altitude, valley areas, ie. VBF and VRS- habitat types, which due to their low or gradual slopes are easily accessible to people for lopping, grazing their livestock and for hunting. In SF, SFR and MFKP, the number of palatable species (Table 4) and areas with escape terrain/cover were few. Tree density, shrub density (Table 4) and grass height is very high, reducing visibility. Reduced visibility in these VTs dilutes the anti-predatory strategy of goral, rendering them unsuitable.

Steep slopes ($>50^{\circ}$) are essential as escape terrain for goral (Schaller 1977, Heptner *et al.* 1989, Mead 1989, Lovari and

Apollonio in press). They are preferred in winter and show greater use than the medium slope category (31-50°). Owing to goral's dependency on water (Schaller 1977), they need to visit valley bottoms or nullas regularly and the lower slope categories show proportionate use. In summer, water is present in extremely restricted areas and the even distribution of grass, requires goral to move over larger areas to satisfy its requirements of food and water (Green 1987). Feeding on grassy slopes, resting in nalas and ridgetops and occasional drinking in the valleys would require goral to use various degrees of slope in summer, without any preference, a fact corroborated by my findings. The absence of sightings on search paths in MFKP and VBF and VRS habitat types is probably due to a combination of low visibility and very low use by goral. On few occasions in summer, while quantifying vegetation, scanning or while returning from SPs, goral were sighted in valley bottoms and SFs and areas with MFKP. To maintain comparability of data, such observations could not be included in analysis. This proves use of these areas though it was negligible. A similar limitation of sightings was encountered in use of western aspects in summer months.

SE aspects were used more in winter and SW more in summer. I observed that on overcast and rainy days in winter, goral moved onto SE facing slopes to stand or lie basking. However, as soon as the sun emerged from the clouds and the temperature rose above 20°C, they moved towards the thickly vegetated NE slopes. Differential use of aspects could result in selection of suitable temperature for activity or resting. Less use of NW facing slopes was probably a result of three interdependent factors, viz: steep nature of slopes with few suitable areas for resting, poor cover

value and direct impact of the sun. In summer, SW aspects were cooler in the mornings and noons due to oblique rays of the sun, as compared to the West facing slopes which received direct solar radiation. Correspondingly, more use of SW aspects and less use of West facing aspects was observed. These observations are in agreement with other studies. Schaller (1977) and Green (1987) observed that northern aspects are usually more forested and warmer during the nights. However, south-facing slopes were warmer during the days due to the opener canopy layer.

5.2 Group Size:

A small body size and selective browsing/grazing would essentially require goral to lead a solitary life (Roberts 1977, Schaller 1977, Green 1987, Soma 1987, Mead 1989, Cavallini 1992). I observed a similar trend and almost 60% of the goral encountered during the study were solitary, majority of these sightings were dominated by males. Groups were usually composed of females associated with their kids or yearlings and subadult females of the previous year. Groups were essentially spatial aggregations without a strict social organization. The closest association was seen to be present between a female and her kids.

The overall group size did not vary between seasons as breaking up of maternal groups was compensated by new births in April and May. Largest group size observed in the study was 11. Group sizes in disturbed areas were larger in both the seasons, though a significant result was obtained only in winter. Stoppage of grass cutting reduced disturbance and flush of grass, *Diospyros* and other shrubs in summer, increased forage availability. This could have allowed goral to restrict themselves closer to the

shrubs and in smaller groups. However, shedding of leaves by cover plants, widespread presence of grass, which is in open areas and socialization of kids would require an anti-predatory strategy of gregariousness (Elsner-Schack 1985).

In Kedarnath Sanctuary (Green 1987) and Majathal Harsang Sanctuary (Lovari and Apollonio in press), maximum group sizes observed were 3 and 11, respectively. In Kedarnath, they were known to occupy forests during winters and open slopes during summers and in the night. However, in Majathal, they largely inhabit open grassy slopes using shrubs and forests only as escape or thermal cover. In Majathal, grass cutting and poaching is extensive (C. Mishra pers.comm). I also observed that comparatively larger groups were seen in disturbed areas (Table 12). These group sizes seem to be a reflection of the disturbance and invasion of open habitats and formation of 'selfish herds' as an anti-predatory strategy (Soma 1987, Lovari and Apollonio in press). This has also been observed in solitary species such as roe deer (*Capreolus capreolus*) which when occupying open habitats, often group together in herds (Geist 1974b).

Significantly larger groups were observed in evening hours during the study period (Table 11). Resting and feeding aggregations were seen in the evenings. In disturbed areas (SP 1,5,6), tree lopping and herding of livestock below these trees, displaced goral and damaged vegetation due to trampling and led to soil compaction. However, during late evening hours, after the people and their livestock returned, goral were seen to be feeding on the remaining lopped vegetation. On many occasions, goral were poached on such sites (pers.comm. with locals and forest guards). Nocturnal feeding would require higher vigilance due to poor

visibility and open grazing (Green 1987). Thus, dependence of group size on disturbance and open habitat grazing, as an anti-predatory strategy, seems overriding than for any social need. There could be more than strictly social or environmental factors influencing the group size of goral. It would be interesting to study the densities of populations of goral within the same habitat and their survivorship to determine whether goral distribution is density dependent.

5.3 Activity Pattern :

Low temperatures in winter accompanied by rain and high temperatures in summer and disturbance seemed to affect the time activity budget of goral. In winters, goral were seen basking till around 0830, after which they fed for a few hours before retreating to the NE aspects to rest. Similarly, they returned to feed early in the evenings (around 1500 hours), when the temperature was around 17°C. Feeding continued even after dusk, as was also observed by Roberts (1977). Similarly, activity coincided with sunrise and goral were found grazing as early as 0515. Corresponding to this, animals retreated into cover around 9am, to move again around 1330, to the NE or SE facing aspects. During noon hours, goral usually rested with their head close to the ground and ruminated. Out of the 8 bedding sites observed during the study, 4 were NE facing and on/close to 60-90° ridges. Two bedding sites were on SW aspects in mixed forests, 1 on a SE and 1 on a north facing slope.

Resting increased significantly from winter to summer and was the dominant activity during late morning and noon hours (11-15 hours), for both the seasons (Fig 3a & Fig 3b). Thus, it is observed

that there is a significant difference in activities over the day and between seasons. Statistical significance, between number of active and inactive animals observed over time periods of the days, was seen in summer (Fig 4b) In winter however, goral activity was more uniform throughout the day due to equable climatic conditions (Fig 4a). Schaller (1977) and S.P. Goyal (pers.comm.) mention that goral are seen feeding throughout the day on cloudy or rainy days.

On two occasions when goral were seen drinking, temperature was around 40-45⁰C. On approaching the water hole, they thoroughly scanned the area and moved very cautiously. Feeding and basking activities were also interrupted to scan for predators. In case of the group with 11 animals, the only adult male was standing (vigilant) and feeding alternatively. Out of the 4 adult females, 3 were resting and one was standing. The 6 yearlings were either resting or standing and autogrooming. The adult male, which was dominant in the group, probably compensated for the time spent in vigilance, by feeding in noon hours. Similarly, the adult female, acting guard over the group was one of the first to locate me and give an alarm call along with another resting female who also had sighted me. In this case, gregariousness seems to provide a chance for each of the individuals to take advantage of the other by either feeding, resting or grooming. Similar observations of animals in groups performing different activities were observed (Winter N=21, Summer N=15).

It seems probable from the above discussed observations that all activities of goral are dependant on the climatic conditions, habitat parameter selection, disturbance and the structure and composition of goral groups observed in the study area.

used less by goral in both seasons. This indicates avoidance of disturbed areas. Broad habitat use of goral have been summarized in Table 13.

5.5 Limitations of the Study and Suggestions for a future Study:

Habitat parameters such as water, saltlicks and level of disturbance though quantified, could not be analyzed due to the paucity of sightings. Similarly, detailed quantification on vegetation parameters was done, but analysis was conducted on a coarse level. This was due to the difficulty in visually identifying plant species fed by goral, especially in the case of grasses. Scan-Sampling is an inappropriate method to study activity pattern of goral in Shivaliks due to the higher density of vegetation and complexity of terrain (S.P. Goyal pers.comm; pers. observ.), whereby animals were always lost to cover or behind ridges on slight movement. Thus, continuous data could not be collected.

To infer about the factors mentioned hereabout, comparative studies in areas with and without these parameters are essential, though both areas should be ecologically similar. Conclusion on the effect of the parameters could be made after sampling both areas equally and then conducting a statistical analysis.

Another problem observed was of habitats which showed null use on search paths, but *ad libitum* records indicate use. All such areas should be scanned and data collected incorporated in the main study as it helps explain many otherwise inexplicable questions.

5.6 Conservation Implications:

Simbalbara Sanctuary is a unique protected area, not only in

Himachal Pradesh but also throughout India, due to absence of a resident human population in the Sanctuary. Secondly, it is contiguous with Kalesar Sanctuary, Darpur, Majra and Nagli RFs in Haryana and Himachal Pradesh. These areas hold a substantial population of goral. Goral being the typical, primitive ungulate of the Shiwaliks and Middle Himalayas, this stretch of forest is vital for their long term conservation. Therefore, a large Protected Area (PA) covering these Sanctuaries and Reserved Forests would ensure better conservation prospects for this 'Mountain Monarch'.

I observed that goral are displaced by disturbances like grass cutting, lopping and livestock grazing. These factors may deplete the habitat and affect goral indirectly. However, poaching with rifles would soon lead to their extermination in these areas. Goral feed largely on shrubs during winter and grasses during summer. Cutting of grasses during winter, and mid-winter burning would provide new leaves on shrubs and trees and a flush of grass, for goral. However, a control over the level of shrub and grass collection for domestic consumption by locals would be required. Control over fire and livestock grazing and poaching would improve the habitat and the population densities in these areas. A total closure of the area for graziers and grass-cutters should be maintained during April and May, when the kids are born. This would be reflected on the average survivorship of young and hence, on the overall population of goral in this region.

Goral was just the representative species for this study, however, other groups of animals would also have been affected by these disturbances. Thus, by extending protection to the habitat of this typical ungulate, we would protect the fragile ecosystem of the Shiwaliks, in general.

LITERATURE CITED

- Anon. 1972. The Indian Wildlife (Protection) Act, 1972. Natraj Publishers. Dehra Dun. pp.86.
- Anon. (Working Plan) 1986. The Working Plan for Kalesar and Kalsia ranges, District Ambala, Government of Haryana.
- Anon. (Management Plan) 1987. Department of Forest Farming and Conservation, Wildlife Wing: 'Management Plan of Simbalbara Wildlife Sanctuary, District Sirmur', Government of Himachal Pradesh, June 1987.
- Allredge, J.R and J.T. Ratti 1992. Further comparison of some statistical techniques for analysis of resource selection. *J.Wild.Manage.* 56(1): 1-9.
- Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49: 227-267.
- Bellrose, F.C. and H.G. Anderson 1943*. Preferential ratings of duck food plants. *Illinois Nat. Hist. Surv. Bull.* 22(5):417-433.
- Bromlei, G.E. 1956*. Goral (*Nemorhaedus caudatus raddeanus* Heude, 1894). *Zool. Zhurnal.* 35:1305-1405.
- Cavallini, P. 1992. Survey of the goral *Nemorhaedus goral* (Hardwicke) in Himachal Pradesh *J. Bombay. Nat. Hist. Soc.* 89:302-307.
- Champion, H.G and S.K. Seth 1968. The Revised Survey of Forest Types of India. Manager of Publications, Government of India, Delhi. 404pp.
- Clements, F.E and V.E. Shelford 1939*. Bio-ecology. New York. John E. Wiley & Sons.
- Dang, H. 1968. The goral of Benog. *The Cheeta*. 11:47-58.

- Eisenberg, J.F and J. Seidensticker 1976. Ungulates of Southern Asia: A consideration of biomass estimated for selected habitats. *Biol. Conserv.*, 10:293-307.
- Elsner-Schack, I.von 1985. Seasonal Changes in the size of Chamois Groups in the Ammergauer Mountains, Bavaria. pp.148-153. In. S,Lovari (ed.) *The Biology and Management of Mountain Ungulates*. Croom Helm, New Hampshire. pp.271.
- Engelmann, C. 1938*. Verber die Grossauger Szetschwan, Sikongs und Osttibet. *Z. Säugetierkunde* 13, Sonderheft, 76pp.
- Etchberger, R.C, P.R. Krausman and R. Mazaika 1989. Mountain Sheep Habitat characteristics in the Pusch Ridge Wilderness, Arizona. *J.Wild.Manage.* 53(4):902-907.
- Friedman, M. 1937*. The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *J.Am.Stat. Assoc.* 32:675-701.
- Gaston, A.J. 1986. West Himalayan Wildlife Survey. Report on the activities in 1985. Unpublished Report. 18pp.
- , P.J. Garson and M.L. Hunter.Jr. 1981. The wildlife of Himachal Pradesh Western Himalayas. *Univ. Maine Sch.For. Resources Tech. Notes* No.82:1-159.
- 1983. The status and conservation of forest wildlife in Himachal Pradesh, Western Himalayas. *Biol. Conserv.* 27:291-314.
- Geist, V. 1971. *Mountain Sheep: A Study in Behaviour and Evolution*. The University of Chicago Press. Chicago and London. 383pp.
- 1974a. On the Relationships of Ecology and Behaviour in the Evolution of Ungulates: Theoretical Considerations In. V,Geist & F,Walther (eds.) *The Behaviour of Ungulates*

and its Relation to Management, IUCN Pub., Gland. 235-246pp.

----- 1974b. On the relationship of social evolution ecology of Ungulates. *Am.Zool.* 14:205-220.

Glading, B., H.H. Biswell and C.F. Smith 1940. Studies on the food habits of the California quail in 1937. *J. Wildl. Manage.* 4(2):128-144.

Green, M.J.B. 1981. A checklist and some notes concerning the mammals of the Langtang National Park, Nepal. *J. Bombay Nat. Hist. Soc.*, 78:77-87.

----- 1985. Aspects of the ecology of the Himalayan musk deer. Ph.D. Thesis: University of Cambridge. UK. pp.280.

----- 1987. Ecological Separation in Himalayan ungulates. *J. Zool., Lond. (B)* 1,693-719.

Groves, C.P. and P. Grubb 1985. Reclassification of serow and goral. pp.45-50. In. S.Lovari (ed.), *The biology and Management of mountain ungulates*. Croom Helm, London, pp.271.

Hayman, R.W. 1961. The red goral of the north-east frontier region. *Proc.Zool.Soc.London.* 136:317-324.

Heptner, V.G, A.A. Nasimovic and A.G. Bannikov (Eds.) 1989. *Mammals of the Soviet Union*. Vol.1. Brill Publishers, London & New York. pp.939.

IUCN 1987. The conservation status of leopard, goral and serow in Bangladesh, Bhutan, northern India and southern Tibet. A report prepared by the IUCN Cons. Mon. Cent. for the US-FWS. Compiled by M.J.B. Green. pp.24.

Jarman, P. 1974. The social organization of antelope in relation to their ecology. *Behaviour.* 48:215-267.

- Jerdon, T. 1867*. The mammals of India: A Natural History of All the Animals known to Inhabit Continental India. Thomason College Press, Roorkee, India. pp.319.
- Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* 61:65-71.
- Karanth, U. 1988. Population structure, density and biomass of large herbivores in a south Indian tropical forest. M.S. Thesis. *University of Florida*, Florida. 91pp.
- Leopold, 1961. Game Management. IInd Edition. New York, Charles Scribner's Sons. 481pp.
- Lovari, S. (Ed.) 1985. *The Biology and Management of Mountain Ungulates*. Croom Helm, London, 271pp.
- and M. Apollonio (in press). Notes on the ecology of the goral *Nemorhaedus spp.* in two areas of South Asia. *Revue d'Ecologie*.
- Marcum, C.L and D.O. Loftsgaarden 1980. A Non-mapping technique for studying habitat preferences. *J.Wildl. Manage.* 44(4): 963-968.
- Mead, J.I. 1989. *Nemorhaedus goral*. Mammalian species. *The American Society of Mammalogists*. No.335, pp.1-5.
- Mueller-Dombois, D. and H. Ellenberg 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons. New York, London.
- Nasimovitch, A.A. 1955*. The role of the regime of snow cover in the life of ungulates in the Ussr. *Akad. Nauk. SSSR, Moskva (Transl. Canadian Wild. Serv., Ottawa)*. mimeographed. pp.371.
- Neu, C.W, C.R. Byers and J.M. Peck 1974. A technique for analysis of utilization-availability data. *J. Wild. Manage.* 38:

541-545.

- Nievergelt, B. 1981. *Ibex in an African environment*. Springer, Berlin, 189pp.
- Owen-Smith, N. 1979. Assessing the foraging efficiency of a large herbivore, the Kudu. *S. Afr. J. Wild. Res.* 9:102-110.
- Pachlatko, T. and B. Nievergelt 1985. Time budgeting, Range Use Pattern and Relationships with groups of individually marked Chamois. pp.93-101, In. S. Lovari (ed.) *The Biology and Management of Mountain Ungulates*. Croom Helm, New Hampshire. pp.271.
- Pocock, R.I. 1908*. Notes on some species and geographical races of serows (*Capricornis*) and gorals (*Naemorhedus*), based upon specimens exhibited in the society's gardens. *Proc. Zool. Soc. London.* 1908:173-202.
- 1914*. Description of a new species of goral (*Nemorhaedus*) shot by Capt. F.M. Bailey. *J. Bombay. Nat. Hist. Soc.*, 23:32-33.
- Prater, S.H. 1965. *The Book of Indian Animals*. Bombay Nat.Hist. Soc., Bombay, 323pp.
- Quade, D. 1979. Using weighted rankings in the analysis of complete blocks with additive block effects. *J. Am. Stat. Assoc.* 74:680-683.
- Riney, T. 1982. *Study and management of large mammals*. Chichester, John E. Wiley & Sons. 552pp.
- Roberts, T.J. 1977. *The mammals of Pakistan*. Ernest Benn, London. 361pp.
- Rodgers, W.A and H.S. Panwar 1988a. Planning a Wildlife Protected Area network in India. Vol I: *The report, Wildlife Institute of India, Dehra Dun.*

- 1988b. Planning a Wildlife Protected Area network in India. Vol II: State Summaries, Wildlife Institute of India, Dehra Dun.
- Rodgers, W.A, S.S.R. Bennet and V.B. Sawarkar 1986. Fire and Vegetation structure in sal forests, Dehra Dun, India. *Trop.Ecol.* 27:49-61.
- Rodgers, W.A, G.S. Rawat and J.L. Srivastava (in press): The Vegetation of Western Rajaji National Park: Floristic and Community Analysis. A Report . Wildlife Institute of India. Dehra Dun. pp.183.
- Saharia, V.B. (Ed.) 1982. Wildlife Institute of India. Natraj Publishers, Dehra Dun. 278pp.
- Schaller, G.B. 1977. Mountain Monarchs: Wild Sheep and Goats of the Himalaya. The University of Chicago Press. Chicago and London. 425pp.
- Schaulskaya, N.A. 1980. Seasonal changes in plant consumption by goral *Nemorhaedus goral* in the Sikhota-Alin Reservation Russian-SFSR USSR. *Rastitel Nye Resusry*, 16:177-186.
- Siegel, S. 1956. Non-parametric statistics for the Behavioural Sciences. Mac-Graw Hill, New York. pp.216.
- Singh.S, A. Kothari and P. Pande (eds.) 1990. Directory of National Parks and Sanctuaries in Himachal Pradesh: *Management Status and Profiles*. Indian Institute of Public Administration. 164pp.
- Soma, H. (ed.) 1989. The Biology and Management of *Capricornis* and Related Mountain Antelopes. Croom Helm, London, 391pp.
- Thenius, E. and H. Hofer 1960*. Stammesgeschichte der Säugetiere. Springer, Berlin, 322pp.
- Valova. Z.G. 1978*. Food plants of the long-tailed goral in the

TABLE 1: Temperature records (in °C) for Simbalbara Feild Station.
 Collected from 19th November 1992 to 8th May 1993.

MONTH	N	MAXIMUM			MINIMUM		
		MEAN	HIGH	LOW	MEAN	HIGH	LOW
NOVEMBER1992	10	23.80	32	20	9.9	14	8
DECEMBER1992	21	25.05	34	17	5.19	10	4
JANUARY1993	21	22.28	34	12	4.39	8	-3
FEBRUARY1993	16	22.85	36	15	6.94	10	1
MARCH1993	15	30.20	38	18	7.46	12	4
APRIL1993	18	41.12	46	34	14.12	21	9
MAY1993	8	45.00	46	43	20.50	23	19

TABLE 2: Average Relative Humidity (in %) for Simbalbara Feild Station.
 Collected from 19th November,1992 to 8th May, 1993.

MONTH	RECORDING TIME				
	6AM	9AM	12NOON	3PM	6PM
NOVEMBER1992	100.00	92.63	61.56	66.43	96.00
DECEMBER1992	100.00	67.57	50.60	68.33	96.76
JANUARY1993	97.94	91.00	62.66	66.50	85.16
FEBRUARY1993	93.00	73.50	28.38	47.77	70.09
MARCH1993	89.08	66.90	26.89	36.82	54.70
APRIL1993	82.89	47.00	26.00	31.33	37.40
MAY1993	72.80	49.75	37.75	37.66	39.00

TABLE 3: Description of Search Paths (SPs) used for Habitat-Use Studies. For location of Search Paths, refer Map of Study Area (Fig 1).

SP.NO	LENGTH	HAB. TYPES PRESENT	VEG. TYPES PRESENT	DIST.*
SP 1	0.75 Km	GS, NS, RTS, VBF, VRS, VS	MF, SF, MFR, SFR, MFGS	2
SP 2	0.90 Km	GS, RTF, VBF, VS	MF, SF, MFR, SFR, MFGS	1
SP 3	1.05 Km	GS, NS, RTF, RTS, VBF, VRS, VS	MF, SF, MFR, SFR, MFGS	1
SP 4	2.0 Km	GS, NS, RTF, RTS, VBF, VS	MF, SF, MFR, SFR, MFGS	1
SP 5	1.2 Km	GS, NS, RTS, VBF, VRS, VS	MF, MFR, MFGS, PMW, MFKP	3
SP 6	1.75 Km	GS, NS, RTF, RTS, VS	MF, MFR, MFGS, PMW, MFKP	3

Hab. types = Habitat types:

GS= Grassy slope, NS= Nala slope, RTF= Ridgetop flat, RTS= Ridgetop slope, VBF= Valley bottom flat, VRS= Valley ridge slope, VS= Valley slope.

Veg. types = Vegetation types:

MF= Mixed forest, SF= Sal forest, MFR= Mixed forest riverine, SFR= Sal forest riverine, MFGS= Mixed forest grassy slopes, PMW= Pine-Mixed Woodland, MFKP= Mixed forest with Khair plantations.

Dist.* = Disturbance level:

1= No or very low disturbance: occasional fire, lopping or grass cutting.

2= Low to medium disturbance: fire, grass cutting, livestock grazing, occasional lopping and goral poaching.

3= high level of disturbance: contract for grass cutting, lopping and fire-wood collection, trench digging for plantations and extensive poaching.

TABLE 4 : Description of vegetation types, observed in study area, in terms of species richness, palatability and density of trees, shrubs and grasses.

VEG. TYPES	% SA	TREE SPS.		TD T/H	SHRUB SPS.		SCD S/H	GRASS SPS.	
		TNS	NPS		TNS	NPS		TNS	NPS
MF	31	21	15	217	35	24	40741	8	4
MFR	20	16	9	196	46	24	54448	14	3
SF	9.5	14	8	240	55	15	99894	11	3
SFR	15	22	10	336	68	29	83218	11	3
MFGS	13	9	8	127	21	17	35191	6	5
PMW	5.5	10	7	153	26	19	36624	5	3
MFKP	5.2	9	7	318	27	18	38393	10	5

% SA = percent of sampled area ; TNS = total number of species ; NPS = number of palatable species ; TD = tree density ; T/H = trees per hectare ; SCD = shrub-clump density ; S/H = shrubs per hectare.

TABLE 5a : Utilisation-availability data for habitat types during winter season. Utilisation is based on 127 goral sightings on the six search paths.

HAB. TYPES	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
VS	22	0.2619	42	0.3307	0.218	0.443	*
GS	9	0.1071	18	0.1417	0.058	0.225	*
RTF	8	0.0952	14	0.1102	0.035	0.185	*
NS	21	0.2500	28	0.2204	0.121	0.319	*
VBF	9	0.1071	3	0.0236	-0.012	0.059	-
RTS	10	0.1190	16	0.1259	0.046	0.205	*
VRS	5	0.0595	6	0.0472	-0.003	0.098	*

N=84 N=127 (df=6, G=16.81, p=0.01)

* = used in proportion to availability
 - = used less than available.

TABLE 5b : Utilisation-availability data for habitat types during summer season. Utilisation is based on 103 goral sightings on the six search paths.

HAB. TYPES	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
VS	22	0.2619	38	0.3689	0.240	0.497	*
GS	9	0.1071	24	0.2330	0.120	0.345	+
RTF	8	0.0952	12	0.1165	0.031	0.201	*
NS	21	0.2500	20	0.1941	0.089	0.299	*
RTS	10	0.1190	9	0.0873	0.012	0.162	*

N=84 N=103 (df=6, G=52.52, p<0.001)

+ = used more than available
 (note : VBF and VSR showed no use in summer)

TABLE 6a : Utilisation-availability data for vegetation types during winter.
Utilisation is based on 127 sightings on six search paths.

VEG. TYPES	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
SF	15	0.0974	5	0.039	-0.007	0.085	-
MF	48	0.3116	61	0.480	0.360	0.60	+
MFGS	20	0.1298	20	0.157	0.070	0.244	*
MFR	31	0.2012	30	0.236	0.134	0.337	*
SFR	23	0.1493	4	0.031	-0.010	0.073	-
PMW	9	0.0584	7	0.055	0.0004	0.109	*

N=154 N=127 (df=6, G=47.84, p<0.001)

(note : use of MFKP was not observed during winter)

TABLE 6b : Utilisation-availability data for vegetation types during summer.
Utilisation is based on 103 sightings of goral on six search paths.

VEG. TYPES	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
SF	15	0.0974	1	0.009	-0.011	0.035	-
MF	48	0.3116	49	0.475	0.342	0.608	+
MFGS	20	0.1298	26	0.252	0.136	0.367	+
MFR	31	0.2012	16	0.155	0.059	0.251	*
SFR	23	0.1493	3	0.048	-0.008	0.105	-
PMW	9	0.0584	5	0.048	-0.008	0.105	*
MFKP	8	0.0519	1	0.009	-0.016	0.035	-

N=154 N=103 (df=6, G=46.73, p<0.001)

TABLE 7a : Utilisation-availability data for slope categories during winter.
Utilisation is based on 127 sightings of goral on six search paths.

SLOPE CAT.	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
0-10 ⁰	9	0.1071	19	0.149	0.070	0.228	*
11-30 ⁰	11	0.1309	16	0.125	0.052	0.199	*
31-50 ⁰	47	0.5595	50	0.393	0.285	0.502	-
>51 ⁰	17	0.2024	42	0.330	0.226	0.435	+

N=84 N=127 (df=3, G=17.57, p<0.001)

SLOPE CAT. = slope categories.

TABLE 7b : Utilisation-availability data for slope categories during summer.
Utilisation is based on 103 sightings of goral on six search paths.

SLOPE CAT.	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
0-10 ⁰	9	0.1071	13	0.126	-	-	*
11-30 ⁰	11	0.1309	8	0.077	-	-	*
31-50 ⁰	47	0.5595	61	0.592	-	-	*
>51 ⁰	17	0.2024	21	0.203	-	-	*

N=84 N=103 (df=3, G=3.16, p=0.05)

TABLE 8a : Utilisation-availability data for aspects during winter. Utilisation is based on 127 sightings of goral on six search paths.

ASPT.	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
E	4	0.0449	6	0.047	-0.003	0.098	*
W	2	0.0224	2	0.015	-0.014	0.045	*
N	2	0.0224	3	0.023	-0.012	0.060	*
S	2	0.022	2	0.015	-0.014	0.045	*
SE	15	0.168	40	0.314	0.203	0.426	+
SW	14	0.157	25	0.196	0.101	0.292	*
NE	25	0.280	35	0.275	0.168	0.382	*
NW	25	0.280	14	0.110	0.352	0.185	-

N=89 N=127 ($df=7, G=32.68, p<0.001$)

SPT = aspect; E = east; W = west; N = north; S = south; SE = south east; SW = south west; NE = north east; NW = north west.

TABLE 8b : Utilisation-availability data for aspects during summer. Utilisation is based on 103 sightings of goral on six search paths.

ASPT.	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
E	4	0.044	4	0.038	-0.012	0.090	*
N	2	0.022	2	0.019	-0.017	0.056	*
S	2	0.224	1	0.009	-0.016	0.035	*
SE	15	0.168	14	0.135	0.044	0.227	*
SW	14	0.157	33	0.320	0.196	0.444	+
NE	25	0.280	30	0.291	0.170	0.412	*
NW	25	0.280	19	0.184	0.081	0.287	*

N=89 N=103 ($df=7, G=23.72, p<0.01$)

Note : west facing aspects were not used during summer)

TABLE 9a : Utilisation-availability data of shrub cover during winter. Utilisation is based on 113 sightings of goral on six search paths.

SHRB. COVER	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
0%	125	0.525	32	0.283	0.174	0.392	-
1-25%	70	0.294	51	0.451	0.331	0.571	+
26-50%	32	0.134	18	0.159	0.070	0.247	*
51-75%	8	0.033	9	0.079	0.142	0.145	*
>75%	3	0.012	3	0.026	-0.01	0.065	*

N=238

N=113

(df=4, G=28.75, p<0.001)

SHRB = shrub.

TABLE 9b : Utilisation-availability data of shrub cover during summer. Utilisation is based on 98 sightings of goral on six search paths.

SHRB. COVER	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROPN	N	PROPN			
0%	4	0.025	40	0.408	0.280	0.535	+
1-25%	116	0.748	34	0.346	0.223	0.470	-
26-50%	26	0.167	18	0.183	0.083	0.284	*
51-75%	4	0.025	5	0.051	-0.006	0.108	*
>75%	5	0.032	1	0.010	-0.015	0.036	*

N=155

N=98

(df=4, G=176.41, p<0.001)

TABLE 10a : Utilisation-availability data of grass cover during winter. Utilisation is based on 112 sightings of goral on six search paths.

GRASS COVER	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROP	N	PROP			
0%	14	0.070	9	0.080	0.014	0.146	*
1-25%	74	0.371	42	0.375	0.257	0.492	*
26-50%	60	0.301	21	0.187	0.092	0.282	-
51-75%	39	0.195	29	0.259	0.152	0.365	*
>75%	12	0.060	11	0.098	0.026	0.170	*

N=199

N=112

(df=4, G=11.38, p<0.05)

TABLE 10b : Utilisation-availability data of grass cover during summer. Utilisation is based on 96 sightings of goral on six search paths.

GRASS COVER	AVAILABILITY		UTILISATION		LOWER LEVEL	UPPER LIMIT	SIG.
	N	PROP	N	PROP			
0%	22	0.075	3	0.031	-0.014	0.076	*
1-25%	183	0.624	47	0.489	0.358	0.620	-
26-50%	51	0.174	29	0.302	0.181	0.422	+
51-75%	34	0.116	16	0.166	0.068	0.264	*
>75%	3	0.010	1	0.010	-0.016	0.037	*

N=293

N=96

(df=4, G=15.5, p<0.01)

TABLE 11: A comparison of number of sightings of different group sizes, observed during the 3 time periods of the day.

TIME PERIOD	WINTER			SUMMER			CLUMPED-OVERALL		
	1	2	>=3	1	2	>=3	1	2	>=3
06:00-11:00	46	20	11	40	17	8	86	37	19
11:01-15:00	9	7	0	3	2	1	12	9	1
15:01-19:00	21	3	10	20	6	6	41	9	16
TOTAL	76	30	21	63	25	15	139	55	36

WINTER- $N=127$, $df=4$, $p<0.02$, $\chi^2= 12.42$

SUMMER- $N=103$, $df=4$, $p=0.05$, $\chi^2= 1.47$

CLUMPED- $N=230$, $df=4$, $p<0.05$, $\chi^2=11.31$

TABLE 12 : A comparison of number of sightings of different group sizes observed in disturbed and undisturbed areas.

GROUP SIZE	WINTER		SUMMER	
	DISTURBED	UNDISTURBED	DISTURBED	UNDISTURBED
1	27	49	26	37
2	9	21	6	19
3	8	3	7	3
> 4	2	8	3	2
TOTAL	46	81	42	61

WINTER : $N = 127$, $df = 3$, $\chi^2 = 8.01$, $p = 0.05$

SUMMER : $N = 103$, $df = 3$, $\chi^2 = 7.21$, $p = 0.1$

TABLE 13: Overall habitat selection by goral in Simbalbara Sanctuary and Darpur RF.

HABITAT PARAMETERS	WINTER	SUMMER
HABITAT TYPES		
VS	*	*
GS	*	(+)
RTF	*	*
NS	*	*
VBF	(-)	* (null)
RTS	*	*
VRS	*	* (null)
VEGETATION TYPES		
SP	(-)	(-)
MF	(+)	(+)
MFGS	*	(+)
MFR	*	*
SFR	(-)	(-)
PMW	*	*
MFKP	* (null)	(-)
SLOPE CATEGORIES		
0-10 ⁰	*	*
11-30 ⁰	*	*
31-50 ⁰	(-)	*
>51 ⁰	(+)	*
ASPECT-USE		
E	*	*
W	*	* (null)
N	*	*
S	*	*
SE	(+)	*
SW	*	(+)
NE	*	*
NW	(-)	*
SHRUB COVER-USE		
0%	(-)	(+)
1-25%	*	(-)
26-50%	*	*
51-75%	*	*
>75%	*	*
GRASS COVER-USE		
0%	*	*
1-25%	*	(-)
26-50%	(-)	(+)
51-75%	*	*
>75%	*	*

- Primorski-Krai. *Rastitel Nye Resursy*, 14:446-454.
- Zhang, C. 1987. *Nemorhaedus cranbrooki* Hayman. pp.213-223, In,
Soma, H.(ed.) The biology and management of *Capricornis*
and related mountain antelopes. Croom Helm, London.391pp.

[* = Cross References]

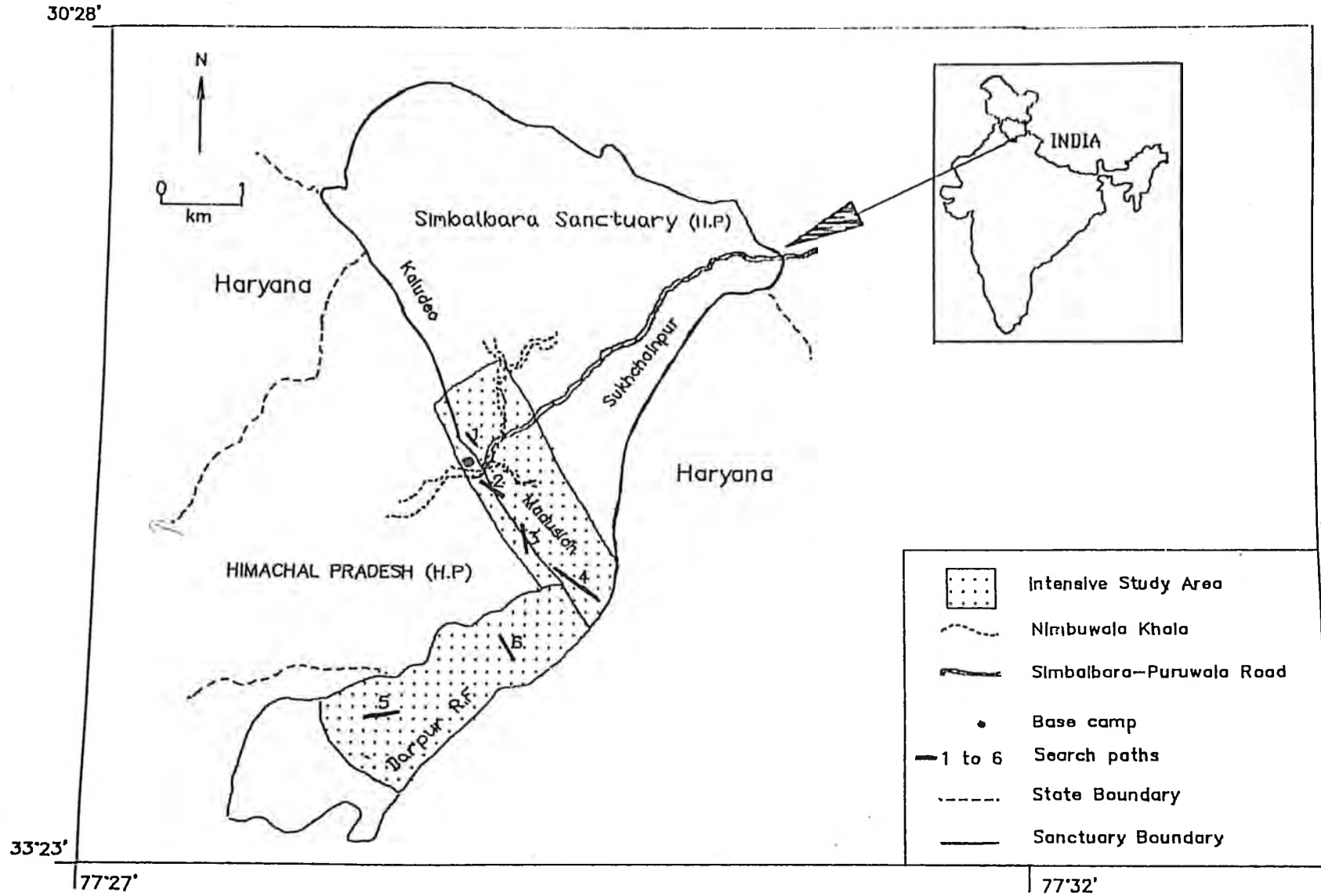


Fig.No.1: Map Of Study Area

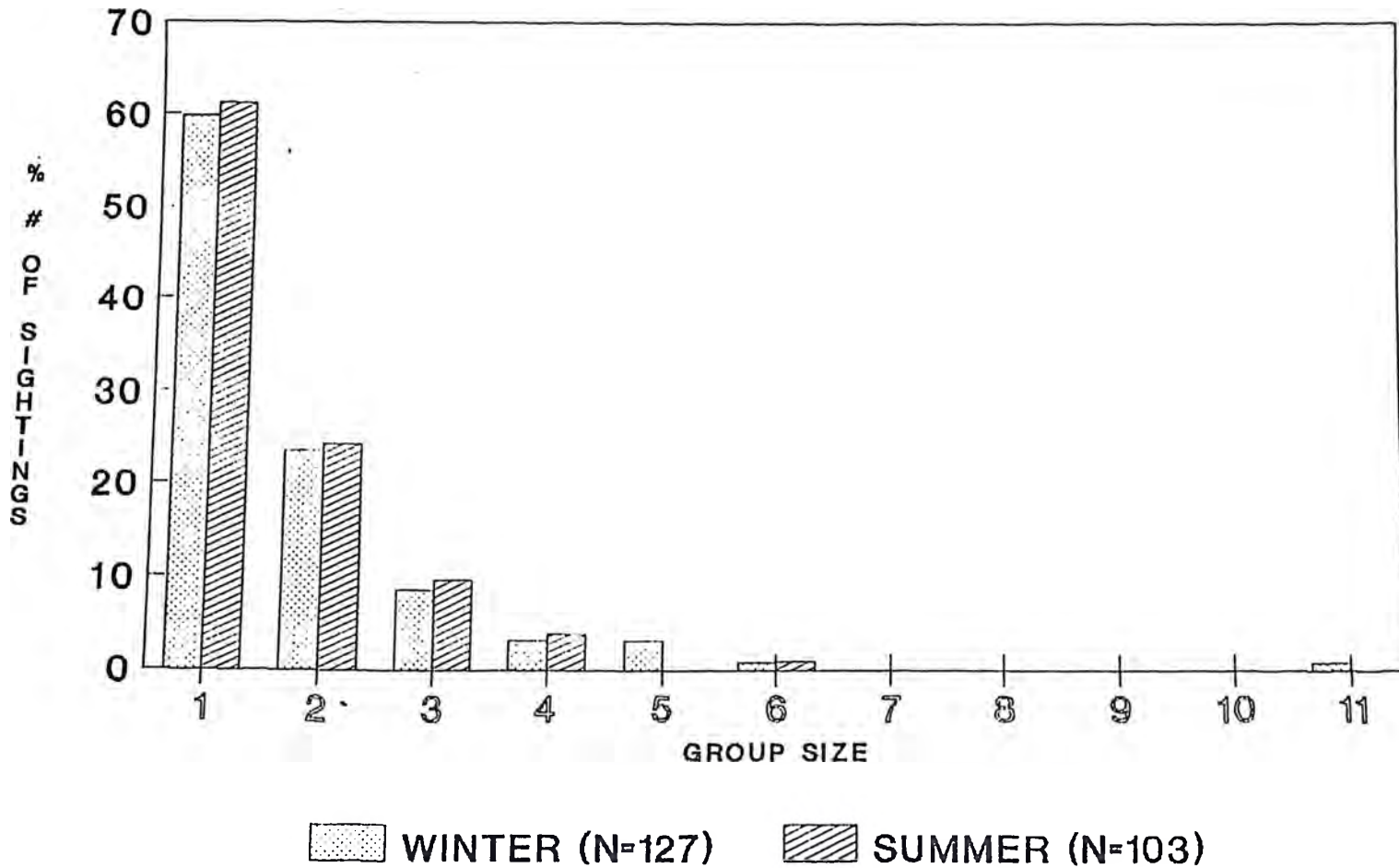


Fig 2. Seasonal variation in percent distribution of goral group sizes. (N=230, df=3, X²=0.98)

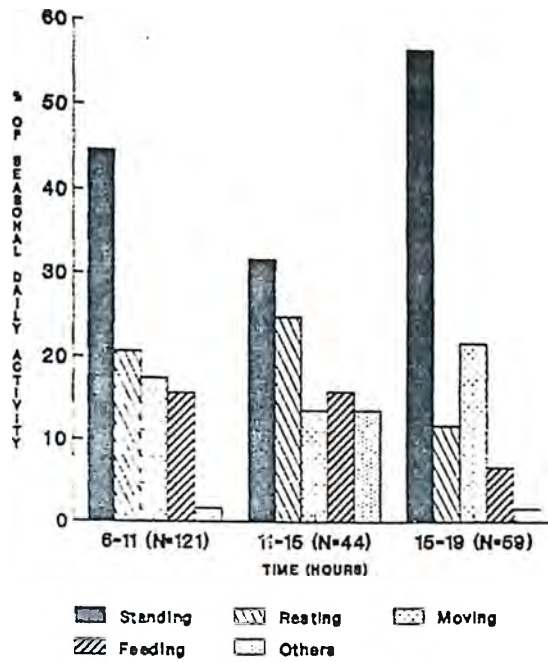


Fig 3a: Daily diurnal activity pattern of goral in winter

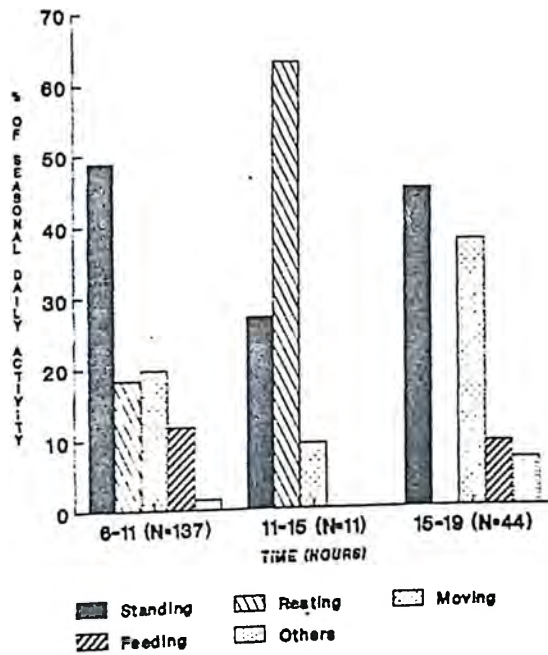


Fig 3b: Daily diurnal activity of goral in summer.

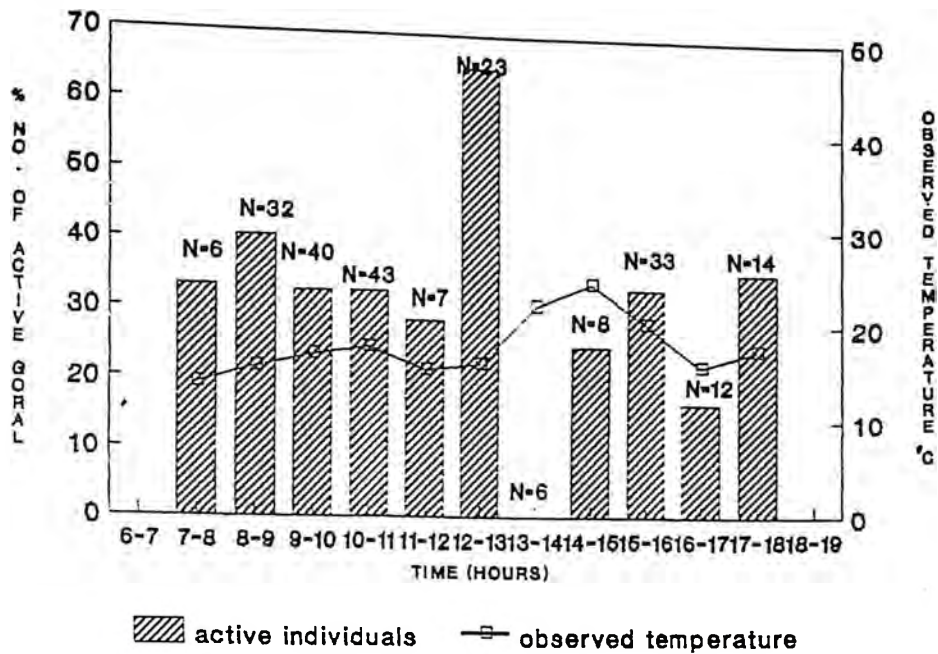


Fig 4a: Diurnal variations in winter activity with changes in temperature

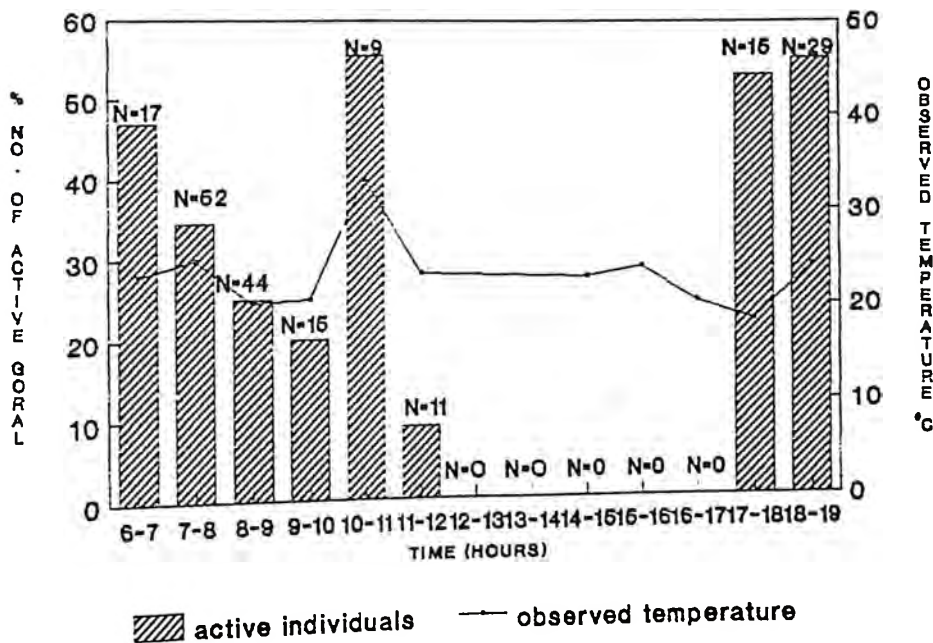


Fig 4b: Diurnal variation in summer activity with changes in temperature.

APPENDIX 1

LIST OF PLANTS RECORDED IN STUDY AREA
(NOTE: Palatability was decided either by pers. observ. or by Dr. G.S. Rawat, field assistant and locals)

SCIENTIFIC NAME	FAMILY	VERNACULAR NAME
TREE SPECIES:		
<i>Acacia catechu</i>	Legum-Mimoseae	Khair *
<i>Aegle marmelos</i>	Rutaceae	Beli
<i>Albizia lepbeck</i>	Legum-Mimoseae	Sirsi
<i>Anogeisus latifolia</i>	Combretaceae	Chal, Bankli*
<i>Azadirachta indica</i>	Meliaceae	Neem
<i>Bauhinia malabarica</i>	Legum-Caesalpinieae	Khatla
<i>Bauhinia racemosa</i>	Legum-Caesalpinieae	Kachnari
<i>Bauhinia variegata</i>	Legum-Caesalpinieae	Kachnar *
<i>Boswellia serrata</i>	Burseraceae	Sala *
<i>Bridelia retusa</i>	Euphorbiaceae	Gajra
<i>Buchanania lanzan</i>	Anacardiaceae	Chironji
<i>Butea monosperma</i>	Legum-Papilionaeae	Dhak
<i>Careya arborea</i>	Myrtaceae	Kumbhi
<i>Casearia elliptica</i>	Samydaceae	Chilla * @
<i>Casearia graveolens</i>	Samydaceae	Chilli * @
<i>Cassia fistula</i>	Legum-Caesalpinieae	Gulakdi
<i>Cordia myxa</i>	Boraginaceae	-
<i>Cordia vestita</i>	Boraginaceae	Kumbh
<i>Diospyros melanoxylon</i>	Ebenaceae	Tendu *
<i>Ehretia laevis</i>	Boraginaceae	Chamror
<i>Elaeodendron glaucum</i>	Celastraceae	Jangel, Jangela
<i>Emblica officinalis</i>	Euphorbiaceae	Amla
<i>Ficus bengalensis</i>	Urticaceae	Bar, Bargat
<i>Ficus cunia</i>	Urticaceae	Jarhphali
<i>Ficus racemosa</i>	Urticaceae	Gular
<i>Ficus religiosa</i>	Urticaceae	Pipal
<i>Flacourtia indica</i>	Bixaceae	Kandai, Kandeï *
<i>Flacourtia jangomas</i>	Bixaceae	Jamnua
<i>Gmelina arborea</i>	Verbenaceae	Kum (kumhar)
<i>Grewia elastica</i>	Tiliaceae	Dhaman *
<i>Grewia tilifolia</i>	Tiliaceae	Pagasi *
<i>Holarrhena antidysenterica</i>	Apocynaceae	Kura, Kurchi
<i>Kydia calycina</i>	Malvaceae	Pula
<i>Lanea coromandelica</i>	Anacardiaceae	Jhinghan
<i>Litsea glutinosa</i>	Lauraceae	Chandna
<i>Mallotus philippinensis</i>	Euphorbiaceae	Raini, Rohini @
<i>Mangifera indica</i>	Anacardiaceae	Aam
<i>Miliusa velutina</i>	Anonaceae	Dom sal
<i>Murraya paniculata</i>	Rutaceae	Ban Mirchi, Marchula.
<i>Naringi crenulata</i>	Rutaceae	Beli
<i>Ougeinia ougeinensis</i>	Legum-Papiloineae	Sandhan * @
<i>Phoenix acaulis</i>	Palmae	Khajur
<i>Pinus roxburghii</i>	Coniferae	Chir @

<i>Salix</i> sps.	Salicaceae	- (Planted)
<i>Semecarpus anacardium</i>	Anacardiaceae	Bhilawa, Dhobi Nut
<i>Shorea robusta</i>	Dipterocarpaceae	Sal * @
<i>Sterculia villosa</i>	Sterculiaceae	Godhada
<i>Stereospermum suaveolens</i>	Bignoniaceae	Padal *
<i>Syzygium cerasoides</i>	Myrtaceae	Thuti
<i>Syzygium cumini</i>	Myrtaceae	Jamun
<i>Syzygium operculata</i>	Myrtaceae	Thuti
<i>Terminalia alata</i>	Combretaceae	Sain * @
<i>Terminalia belerica</i>	Combretaceae	Behera
<i>Terminalia chebula</i>	Combretaceae	Harr
<i>Toona ciliata</i>	Meliaceae	Toon Tree
<i>Wendlandia exserta</i>	Rubiaceae	-
<i>Xeromphis spinosa</i>	Rubiaceae	Maindal, Maiphal * @
<i>Zizyphus muaritiana</i>	Rhamnaceae	Ber *

SHRUB SPECIES:

<i>Abutilon indicum</i>	Malvaceae	Kandhi
<i>Anisomelis ovata</i>	Labiataeae	enroute to T4
<i>Ardisia solanaceae</i>	Myrsinaceae	-
<i>Aruva scandens</i>	Amaranthaceae	like Cilosia
<i>Asparagus</i> sps.	Liliaceae	-
<i>Aspidopteris walichii</i>	Rutaceae	UA-2
<i>Blainvilia rhomboides</i>	Compositae	- *
<i>Baliospermum mantanum</i>	Euphorbiaceae	-
<i>Barleria cristata</i>	Acanthaceae	UA-5 *(?)
<i>Callicarpa macrophylla</i>	Verbenaceae	Daia *
<i>Callicarpa microphylla</i>	Verbenaceae	Dhauldandi *
<i>Capparis zeylanica</i>	Capparidaceae	Khalis *
<i>Carissa spinarum</i>	Apocynaceae	Karaunda * @
<i>Caryopteris grata</i>	Verbenaceae	-
<i>Catamixis baccharoides</i>	Compositae	-
<i>Colebrookia oppositifolia</i>	Labiatae	Dhaulphuli * @
<i>Crotolaria sericea</i>	Legum-Papilionaeae	Chunchunna
<i>Desmodium laxiflorum</i>	Legum-Papilionaeae	- *
<i>Desmodium pulchellum</i>	Legum-Papilionaeae	Chipku-1 *
<i>Desmodium gangeticum</i>	Legum-Papilionaeae	Chipku-2 *
<i>Eupatorium adinophorum</i>	Compositae	Unknown-T2
<i>Evolvulus alsinoides</i>	Convulvulaceae	UA-13 on T5
<i>Flemengia bracteata</i>	Legum-Papilionaeae	Butti
<i>Goldfussia dalhousiana</i>	Acanthaceae	-
<i>Grewia sapida</i>	Tiliaceae	Kangudana *
<i>Grewia tilifolia</i>	Tiliaceae	- *
<i>Hamiltonii suaveolens</i>	Rubiaceae	Chaura *
<i>Indigofera pulchella</i>	Legum-Papilionaeae	Nil, Lilabdi * @
<i>Inula cappa</i>	Compositae	Jibhphadu *
<i>Klarkela</i> sps.	Acanthaceae	UA-13 on T4
<i>Lantana camara</i>	Verbinaceae	- @
<i>Leucas aspera</i>	Rutaceae	Gandhela
<i>Murraya koenigii</i>	Oleaceae	Kuri * @
<i>Nyctanthes arbortristis</i>		

<i>Plectranthus rugosus</i>	Labiatae	-
<i>Reinwardtia indica</i>	Linaceae	Unknown
<i>Sida cordifolia</i>	Malvaceae	-
<i>Sida humilis</i>	Malvaceae	-
<i>Sida rhombifolia</i>	Malvaceae	Kharenti
<i>Tephrosia candida</i>	Legum-Papilionaceae	Kulthi *
<i>Trema orientalis</i>	Urticaceae	Charcoal Tree
<i>Urena lobata</i>	Malvaceae	Unga
<i>Woodfordia fruticosa</i>	Lythraceae	Dha * @
<i>Zizyphus xylopyra</i>	Rhamnaceae	Mandera, Bhandar * @

HERB SPECIES:

<i>Ageratum conyzoides</i>	Compositae	Pudina @
<i>Anapheles leutoalba</i>	Compositae	UA-16
<i>Antidesma diandrum</i>	Antidesmaceae	UA-11 on T4
<i>Bupleurum tenue</i>	Apiaceae	Wild Sarso
<i>Crotolaria alba</i>	Legum-Papilionaceae	UA-10
<i>Hemigraphis latifolia</i>	Acanthaceae	UA-1
<i>Vernonia cineria</i>	Compositae	UA-5 (not Barleria)

GRASS SPECIES:

<i>Apluda mutica</i>	Gramineae	Munmuna *
<i>Aristida setacea</i>	Gramineae	Dhubda *
<i>Capilipidium humilii</i>	Gramineae	-
<i>Carex</i> sps.	Cyperaceae	Dhil *(?)
<i>Chrysopogon fulvus</i>	Gramineae	Dhauloo * @
<i>Cymbopogon martini</i>	Gramineae	Banchari
<i>Eragrostella nardoides</i>	Gramineae	Bhabar-2 *
<i>Eriophorum cosmosum</i>	Cyperaceae	Cosmos @
<i>Eulaliopsis binata</i>	Gramineae	Bhabar * @
<i>Hemarthra compressa</i>	Gramineae	-
<i>Heteropogon contortus</i>	Gramineae	Laldu *
<i>Imperata cylindrica</i>	Gramineae	Siriyo
<i>Oplismens compositus</i>	Gramineae	Saukhaghas
<i>Phragmites karka</i>	Gramineae	Dhaulibansi
<i>Saccharum munja</i>	Gramineae	Munja @
<i>Saccharum spontaneum</i>	Gramineae	Kans @
<i>Saccharum</i> sps.	Gramineae	Baru
<i>Saccharum</i> sps.	Gramineae	Dhuwasa
<i>Thysanolaena agrostis</i>	Gramineae	Pirlu *

CLIMBER SPECIES:

<i>Abrus precatorius</i>	Legum-Papilionaceae	Ratti
<i>Aspidopteris wallichii</i>	Rutaceae	Dhauili Bel
<i>Bauhinia vahlii</i>	Legum-Caesalpinieae	Maljhan * @
<i>Celastrus panniculata</i>	Celastraceae	Malkangni * @
<i>Cissampelos pareira</i>	Menispermaceae	-

<i>Dioscoria deltoidea</i>	Dioscoreaceae	UA-Climber on T4
<i>Ichnocarpus frutescens</i>	Apocynaceae	Bakarbel
<i>Milletia extensa</i>	Legum-Papilionaeae	Gauj @
<i>Ventilago calyculata</i>	Rhamnaceae	Kalibel

OTHERS:

<i>Adiantum sps.</i>	Adiantaceae	Fern.
<i>Curculigo orculooides</i>	Hypoxidaceae	Kalimusli
<i>Equisetum ramosissimum</i>	Equisetaceae	Horse-tailed Fern
<i>Goodyera procera</i>	Orchidaceae	Ground Orchid
<i>Lygodium flexuosum</i>	Lygopodeaceae	Climbing Fern
<i>Pteris sps</i>	Pterideaceae	Fern

[* = food plants of goral].

[@ = plants with cover value for goral].

APPENDIX II.
A LIST OF MAMMALS OCCURRING IN SIMBALBARA SANCTUARY
(HIMACHAL PRADESH) AND DARPUR RESERVED FOREST (HARYANA).

The classification and nomenclature followed here is based on that of S.H.Prater (1971). The unconfirmed records(*) are based on pers. comm. with Park Officials and locals.

PRIMATES

<i>Macaca mulatta</i> Zimmermann	Rhesus Macaque
<i>Presbytis entellus</i> Dufresne	Hanuman Langur/Common Langur

CARNIVORA

<i>Panthera tigris</i> Linnaeus	Tiger
<i>Panthera pardus</i> Linnaeus	Leopard/ Panther
<i>Felis bengalensis</i> Kerr	Leopard Cat*
<i>Felis chaus</i> Guldenstaedt	Jungle Cat
<i>Paradoxurus hermaphroditus</i> Pallas	Common Palm Civet/ Toddy Cat
<i>Herpestes</i> sps	Mongoose
<i>Canis aureus</i> Linnaeus	Jackal
<i>Martes flavigula</i> Boddaert	Himalayan Yellowthroated Marten
<i>Paguma larvata</i> Hamilton-Smith	Himalayan Palm Civet

CHIROPTERA

<i>Pipistrellus pipistrellus</i>	Indian Pipistrelle
----------------------------------	--------------------

RODENTIA

<i>Funambulus pennanti</i> Wroughtc	5-Striped Palm Squirrel
<i>Tatera indica</i> Hardwicke	Indian Gerbille
<i>Hystrix indica</i> Kerr	Indian Porcupine

LAGOMORPHA

<i>Lepus nigricollis</i> F.Cuvier	Indian Hare (Rufous Tailed Hare)
-----------------------------------	----------------------------------

ARTIODACTYLA

<i>Bos (gaurus) sps.</i>	Mithun (introduced)
<i>Nemorhaedus goral</i> Hardwicke	Grey Goral
<i>Cervus unicolor</i> Kerr	Sambar
<i>Axis (Cervus) axis</i> Erxleben	Chital/ Spotted Deer(migratory)
<i>Muntiacus muntjak</i> Zimmermann	Barking Deer/ Muntjac
<i>Sus scrofa</i> Linnaeus	Indian Wild Pig

PHOLIDOTA

<i>Manis crassicaudatus</i>	Indian Pangolin
-----------------------------	-----------------