INTERACTIONS BETWEEN LIVESTOCK AND LADAKH URIAL (*Ovis vignei vignei*)

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By

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Under the supervision of

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Wildlife Institute of India

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CERTIFICATE

This is to certify that Ms. Bindu Raghavan of the Wildlife Institute of India has carried out original research titled **"Interactions Between Livestock and Ladakh Urial (*Ovis vignei vignei*) "** towards the partial fulfillment of the Master of Science (Wildlife Science) degree from Saurashtra University, Rajkot, India. These investigations were carried out under our supervision from November 2002 to June 2003. We also certify that this research has not been submitted for any other degree to any university.

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SUMMARY

The Ladakh urial is a highly endangered and endemic subspecies of wild sheep. Past hunting pressures had decimated the population to extremely low levels. Recent estimates (1,000-1,500 individuals) suggest a marginal increase in numbers. The Ladakh urial occupies plateaus and gentle slopes along the lowermost elevations in the Indus and Shyok Valleys, areas that are easily accessible and heavily used by humans. This is also the most heavily populated area and due to geopolitical reasons, receives the highest developmental benefits. Due to such changes the Ladakh urial may be highly vulnerable to population decimation.

Pastoralism is a way of life in bulk of the Ladakh Trans-Himalaya; a region where wildlife including endangered species such as the urial and snow leopard are not restricted inside wildlife Protected Areas alone. Such species thus share their habitat with the over 3,00,000 livestock that occurs in the region. Recent studies from the Trans Himalaya have indicated competition with livestock as an important reason for the decimation of wild herbivore populations. This study thus aimed to investigate the interactions between the endangered Ladakh urial and livestock during the winter of 2002-03, a season of resource scarcity. We investigated the habitat selection of the Ladakh urial and its separation with livestock at the level of space, habitat variables and diet, to gather evidence for competition.

Four trails were walked 10 times each to obtain information on the habitat usage by the urial and livestock. Further information on livestock use was gathered from the herders using semi-structured interviews and resource maps. Diet of both urial and livestock was investigated by examining recently foraged sites using 10, 1mX1m quadrats at each such site. All sightings from the trails were plotted on a 1:50,000 SOI Toposheet. A 500mX500m grid was overlaid on these locations to obtain the grids used exclusively by the urial and livestock and by both together to calculate spatial separation.

Both, Ladakh urial and livestock primarily used the mid elevation zones (4,121-4,400m) with gentle to moderate inclination (<30°). However, along the elevation gradient there was some separation in that the urial used the uppermost elevations to a substantial degree (44%) even during the cold winter season, which livestock avoided. Even within the mid-elevation zones there may have been substantial spatial separation as the Sorensen's Index of overlap was low (C_s=0.3). Bulk of urial diet (*ca.* 75%) was constituted by just four species, two of which *Causinia thomsonii* and *Thermopsis* sp. primarily occurred at mid to low elevations. The overlap in the diets of urial and sheep and goat, the most numerous livestock, was also substantial (C_λ = 0.6).

The findings of this study thus show that the habitat and diet requirements of Ladakh urial and livestock sharing the range were similar during the winter season. The relatively high use of the sparsely vegetated uppermost elevations of the range by urial, where the cost of foraging is likely to be higher than the mid-elevations suggests that the urial were excluded from these areas by the livestock. We also reason that the relatively poor young:100 adult female ratio (31:100) may be a manifestation of the stress provided by such competition with livestock and survival in sub-optimal habitats.

1. INTRODUCTION

"Interactions" implies a 'relationship' between any two or more individuals, species, and other groups on a common dimension. Among animals, interspecific interactions would involve two dimensions - resource use and social interactions. Interactions on the resource use dimension may take the form of either facilitation or competition (Sinclair and Norton-Griffiths 1982, Van de Koppel and Prins 1998, Mishra 2001). Under conditions of high graminoid biomass (or pasture availability), the former would be the dominant form of interaction, as in the case of the African Savannas (Sinclair and Norton-Griffiths 1982, Jarman 1974, Jarman and Sinclair 1979). However, under low biomass conditions, the potential for competition is the greater (Van de Koppel and Prins 1998).

Competition between animals has been defined as the utilization of common resources, which may or may not be in short supply, in the process harming one another (Birch 1957, Wiens 1989, Prins 2000). This "harm" is reflected in the population as lowered birth rates, or increased death rates, or both, and in the individual as loss of body condition resulting in lowered reproductive success (Schoener 1977, Clutton-Brock *et al.* 1988).

Interspecific competition (Schoener 1983, Connell 1983) maybe of the following types:-

1. Interference or direct competition - where active or passive social interactions lead to one or both species avoiding each other (Vance 1984)

2. Exploitative or indirect competition (Gause 1934, Tilman 1982, Vance 1984, Begon *et al.* 1986, Johnson *et al.* 2000) - where competing species may:

a) partition these resources among themselves through niche differentiation (ecological separation) so that they can still co-exist together.

b) the superior competitor might take over the niche of the other species, competitively excluding them, or forcing them to settle for less optimal resources (reflecting in the other species' demography).

Resource partitioning may occur along two main resource dimensions: food and habitat (space) (Schoener 1974). Herbivores usually select for various topographical and vegetative features of the habitat (Gordon and Illius 1989, Putman 1996, Frank 1998), which also determines the utilization and selection of food resources. The understanding of patterns of habitat selection is then required to estimate the ecological effects and potential interactions between habitat and food (Johnson *et al.* 2000).

Over most of their range, wild herbivores share their habitat with both humans and a variety of domestic animal species from camels to goats and are thus, forced to interact with them. Increasing human and livestock populations have led to wide scale depletion of natural grasslands and pastures and consequently, increased the pressures on both wild fauna and flora. Such interactions may lead to the competitive exclusion of the wild species, described as the "pastoral road to extinction" by Prins (1992).

This is especially true for habitats where the livestock pressures and hence, their 'potentially' competitive interaction with wild herbivores, are relatively higher. Habitats provided by mountainous regions form one such example. With resources becoming scarcer due to habitat destruction and degradation, due to land use changes including livestock grazing, competition for these resources becomes an important limiting factor in determining the status, and indeed presence or absence (through competitive exclusion) of wild animal populations (Mishra 2001). Effective management of such areas of low productivity requires a sound understanding of the interaction between livestock husbandry and both pastures dynamics and wild animal species (Fox 1996).

In the arid and impoverished habitat provided by the Trans-Himalaya, where food and other resources are scarce and available mainly in the short growth season in summer (Jun-Sep), wild animals face strong competition from livestock, which have the advantage of supplementary stall feeding (Mishra 2001). In case of the Ladakh urial (*Ovis vignei vignei*; Family: Bovidae, Sub-family: Caprinae, Tribe: Caprini), as with many other mountain ungulates, this seems to be one of the most important factors affecting present population numbers and status all over its range in Ladakh (IUCN Red List 2000, Chundawat and Qureshi 1999, Shackleton 1997).

The Ladakh urial (see Appendix 1 for brief outline about the urial) is a highly endangered species listed in the IUCN Red List 2000, Appendix A of CITES and in the Schedule I of the Wildlife Protection Act of India. It is only now recovering from high hunting pressures, though the trend is still a declining one (IUCN Red List 2000, Chundawat and Qureshi 1999).

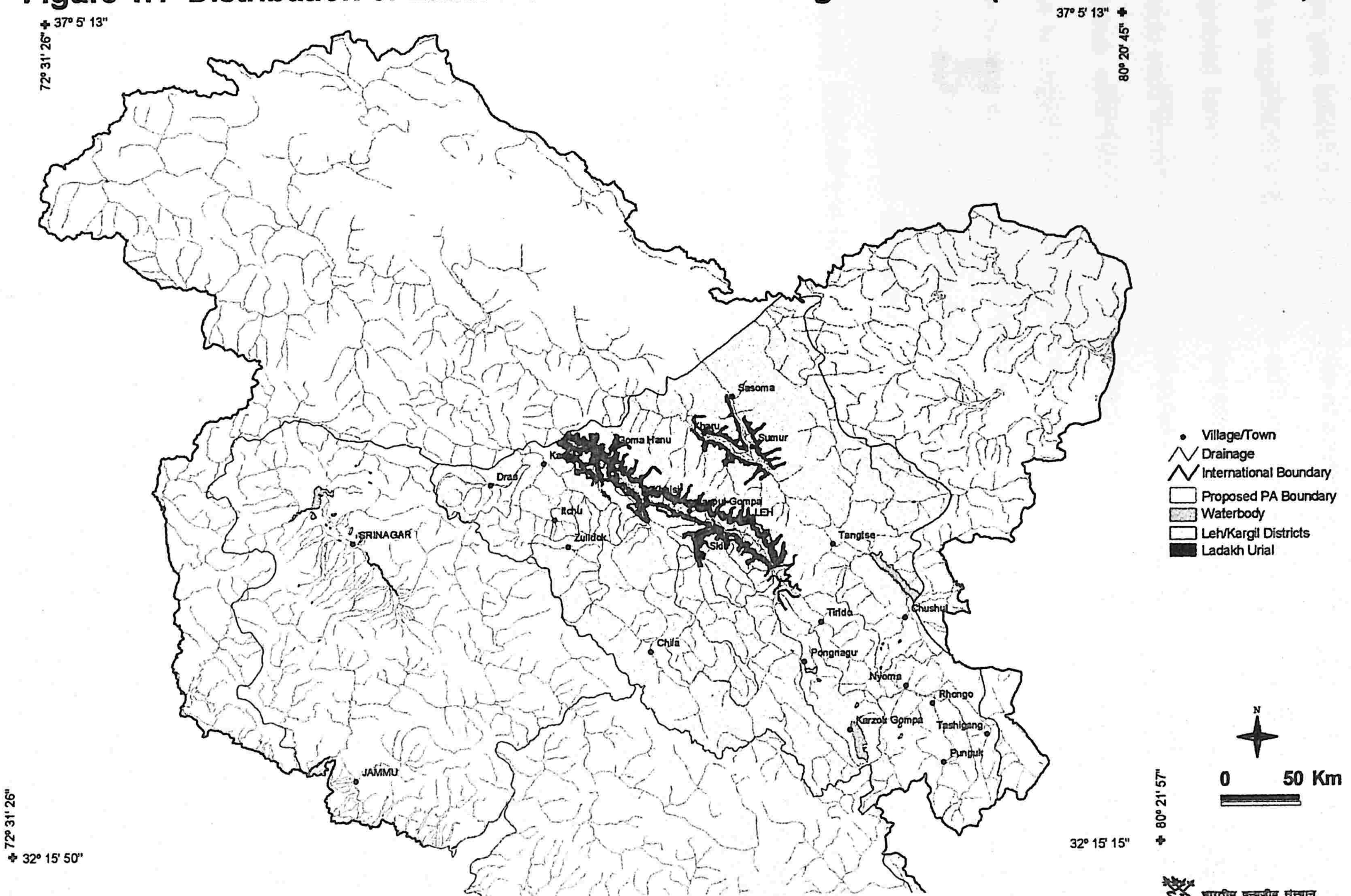
The Ladakh urial occurs in a narrow distribution zone of approximately 2700 Km^2, along the Indus and Shyok Rivers (Fig. 1.1) (Mallon 1983, Fox *et al.* 1991, Mallon 1991, Shackleton 1997, Chundawat and Qureshi 1999). Its numbers have been estimated to be around 1000-1500 individuals, occurring in scattered and small populations of not more than 150-200 individuals each (Mallon 1983, Fox *et al.* 1991, Mallon 1991, Shackleton 1997, Chundawat and Qureshi 1999).

Most of these populations occur outside the protected area network, especially in areas with high human densities. The only populations occurring inside a protected area (Hemis National Park) number less than 50 individuals (Chundawat and Qureshi 1999). Such a localized distribution has made it more vulnerable to man-induced pressures and stochastic events (Mallon 1983, Fox *et al.* 1991, Mallon 1991, Chundawat and Qureshi 1999).

Since the Ladakh urial's range is also the 'hotspot' of development in Ladakh (it being along the area of maximum human habitation and the state highway), it would be neither be possible nor desirable to bring the entire range under a protected area network. It thus, becomes important to try and conserve it through the involvement of the local communities and various government departments, especially in view of the potential for conflict with humans and livestock (Mallon 1983, Fox *et al.* 1991, Mallon 1991, Shackleton 1997, Chundawat and Qureshi 1999, Raghavan and Bhatnagar unpublished).

Little is known about the species, especially in terms of population status, structure and resource utilization, except that it prefers lower elevations along the alluvial flats of the river valleys (Mallon 1983, Mallon 1991, Chundawat and Qureshi 1999). This is also the region highly suitable and preferred for agricultural and developmental activities (Lydekker and Dollman 1985, Chundawat and Qureshi 1999, Raghavan and Bhatnagar unpublished).

Figure 1.1 Distribution of Ladakh Urial in Leh and Kargil Districts (Jammu and Kashmir)



(Chundawat & Qureshi, 1999)

Mere presence of livestock in an area with wild ungulates may not always reflect a competitive situation. This was suggested by Bhatnagar *et al.* (2000), where they surmised that the herding practices and small holdings restricted resident livestock in Pin Valley National Park to a narrow zone close to habitation, while ibex (*Capra ibex*) used a much vaster area during summer- both clearly separating along an altitudinal gradient. Bagchi *et al.* (2002) further showed that the large migratory herds of sheep and goat pose a major threat to the ibex and that these also had a major overlap with ibex diet. Similar dietary overlap was found in another part of Spiti, the Kibber Wildlife Sanctuary, between bharal (*Pseudois nayaur*) and livestock (Mishra 2001).

It was also suggested that most pastures in the region were overstocked and that this led to a poor young: adult female ratio (Mishra 2001). Based on extensive surveys in eastern Ladakh, Bhatnagar and Wangchuk (2001) have suggested that increased threat from livestock competition is driving the endangered Tibetan gazelle (*Procapra picticaudata*) to the verge of extinction in Ladakh.

There is thus, an urgent need to study the resource utilization by the Ladakh urial in order to identify the areas most suitable for its conservation and where all management activities should be concentrated.

1.1. Objectives

Keeping the endangered status of the Ladakh urial and the threats posed by livestock and humans, this study was designed to examine the interactions between the urial and the livestock, and whether potential competition with the latter plays a role in shaping the population numbers and structure of the urial.

Earlier studies and a preliminary survey (Raghavan and Bhatnagar unpublished) have shown that urial shares its entire range with livestock. Two situations could arise out of this scenario. One that livestock and urial, though utilizing similar resources, are separated by space at a level that renders any competition null. However, if there was no clear spatial separation between them, the potential for competition is present, especially if livestock were limiting the availability of the resources for urial. Such 'competition' would either lead to co-existence between the two through resource partitioning or to exploitative competition where either livestock or urial would exclude the other species from the resource. The present study aims to find evidences for the above processes.

Thus, the following objectives were framed to investigate the resource use and ecological separation between the urial and livestock:

1. To study the resource (habitat and diet) utilization and selection by both the Ladakh urial and livestock
2. To evaluate the overlap or separation between the Ladakh urial and livestock at the level of space, habitat variables and diet.

2. STUDY AREA

2.1. Region

Ladakh is a cold desert in the state of Jammu and Kashmir in India. The Trans-Himalayan region (Biogeographic zone 1) in India covers an area of approximately 1,84,000 Km^2, much of which lies within Ladakh and the Lahul and Spiti district in Himachal Pradesh (Rodgers and Panwar 1988).

Being in the rain-shadow of the Himalaya, the Trans-Himalayan region comprises a cold and arid, high altitude desert, characterized by low rainfall and sparse, xerophytic vegetation. Temperatures are extremely low (- 20 °C to - 30 °C in winter) and so is both summer and winter precipitation (average snowfall in winter is about 1-2 feet) (Fox *et al.* 1994), resulting in its characteristic fauna and flora, which are uniquely adapted to these extreme conditions, albeit occurring at low densities (Schaller 1977, Rodgers *et al.* 2002).

Ladakh is characterized not only by its 'cold deserts', but also by its unique terrain. There are rugged mountains in the west classified under biogeographic province 1A and a rolling high altitude plateau in the east (contiguous with the Tibetan plateau), known as the Changthang, classified under province 1B (Rodgers and Panwar 1988). There are 3 main mountain ranges traversing Ladakh from the west to the east. The Karakorum range forms the northernmost boundary, while the Zanskar range, an offshoot of the Greater Himalaya, forms the southernmost boundary, of Ladakh. The Ladakh range, on the north of the Indus, lies between these two ranges. The elevation ranges from 2,200 m at Kargil to over 7,600 m in the Karakoram. The primary rivers flowing through Ladakh are the Indus and its tributaries- the Shyok in the north and the Zanskar to the south. It is along the Indus that much of the habitation of Ladakh is found. Three brackish water lakes are also found in the region- the Pangong tso, Tso kar, and Tso moriri, which along with numerous other small lakes and marshes, form important wetland and waterbird habitats.

The vegetation of the region is classified as Dry Alpine Scrub (Champion and Seth, 1968), characterized by genera such as *Caragana*, *Eurotia*, *Lonicera*, *Potentilla*, *Artemisia* and others, that are highly adapted to the arid and cold conditions prevailing here (Champion and Seth, 1968). The main vegetation types include: - dry alpine steppe, alpine scrub, alpine stony deserts and high altitude cold desert (Chundawat and Rawat 1999). There are patches of moist scrub (*Myricaria*, *Salix* and others) along the streams and water (Chundawat and Qureshi 1999).

The faunal diversity of Ladakh is influenced by the Palaearctic, Mediterranean and Oriental elements (Das 1966). The animals have developed various physiological adaptations like thick fur, large nasal cavity, winter hibernation, and seasonal and local migrations.

Mammals of the area include 10 species of ungulates (especially wild sheep and goat, of which the region has a high diversity) represented by the Yak (*Bos grunniens grunniens*), Asiatic Ibex (*Capra ibex siberica*), Bharal or Blue sheep (*Pseudois nayaur*), Tibetan Argali (*Ovis ammon hodgsoni*), Ladakh urial (*Ovis vignei vignei*), Tibetan gazelle (*Procapra picticaudata*) and others. There are 13 species of carnivores including the flagship species of the area-the Snow leopard (*Uncia uncia*) apart from the Tibetan wolf (*Canis *lupus chanku*) and the Himalayan lynx (*Felis lynx*). Eighteen species of small mammals are also found including the Tibetan woolly hare (*Lepus oistolus*), Pika (*Ochotona* spp.), Himalayan Marmot (*Marmota* spp.) (Chundawat and Qureshi 1999).

The bird diversity includes about 225 species and the communities are characterized by many migratory birds that come here from the plains for breeding, including several species of migratory waterfowl like Bar-headed Geese, and the endangered Black-necked Crane (Singh and Jayapal 2001). Several species of amphibians, reptiles and invertebrates are also found here (Chundawat and Qureshi 1999, Vijayakumar *et al.* 2001).

The people of Ladakh are predominantly Buddhists practicing a settled agro-pastoral lifestyle. In the eastern parts of Ladakh however, nomadic pastoralism is the main occupation.

There is usually only one crop between April and September, with the main crop grown being barley or wheat, along with several kinds of vegetables. Other major produce from the region is apricots, walnuts, apples and even mulberry. The main species of livestock reared in Ladakh include sheep, goats, cows, yaks, demos, zhos, zhomos, donkeys and a few horses. Most livestock are taken to pastures at high altitudes (4,500-5,000 m) in summer, and brought down to lower pastures around the villages in winter. During winter, agricultural residue and forage collected from pastures are also used to stall feed the animals. Yaks, however, are seldom brought down, even in winter.

The social system consists of a large joint family system with some remnants of the traditional polyandrous system. However, opening up of new opportunities in terms of jobs, education and development has resulted in an increase in the number of smaller, nuclear family units. The people cultivate crops in the short growing season between April and October. Social, cultural and religious activities take place in the remaining months (November to March), which coincide with the harsh winter season.

2.2. Intensive Study Area

The Intensive study area, Chipskianchan-Potorche-Fotu la, covering ca. 40 Km^2 (Fig. 2.1) lies between 76° 45' E and 76° 37' W latitudes and 34° 23' N and 34° 16' S longitudes. The area was observed to have a good population of Urial, high livestock density and was also logistically viable (Raghavan and Bhatnagar unpublished).

This area falls mostly under the Khalse block of district Leh and partly under the Kargil district. Elevation ranges from 3,800 to 5,500 m, with average elevation being 4,400 m. Minimum temperature ranged from - 7 to –10°C in early winter to -15 to -20°C in peak winter (*pers. obs.*). Average snow accumulation during the study period was about 3 feet (*pers. obs.*).

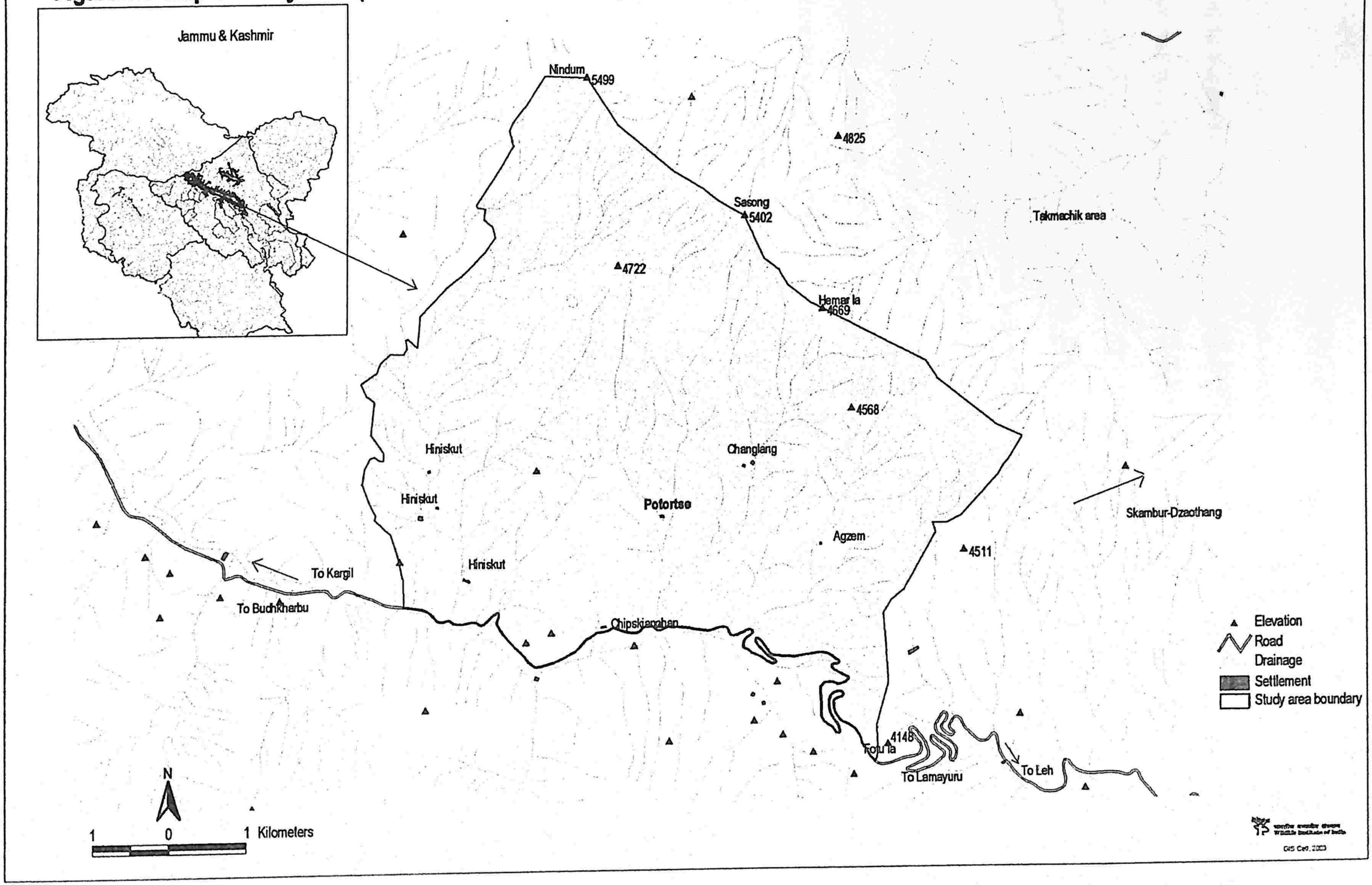
The area comprised of two main 'villages', Fotu la lok, under village Lamayuru, of Leh district, and Hiniskut under Kargil district. Fotu la lok comprises of four hamlets, each consisting of 2-4 households. These households also have landholdings and homes in the adjacent village of Lamayuru (also their administrative centre), which they visit during the growing season to cultivate the land. Hiniskut comprises of 30 households spread in 3 clusters.

All households share the same general pasture and although there are areas demarcated for use by each village or hamlet, the boundaries are not strict. The pastures lie on the southern slopes of the Nindum and Sasong peaks (see Fig 2.1). The area is naturally bounded on the east and west by two ridges coming down from the main ridge (comprised by the above peaks). The southern boundary of the study area is formed by the Leh-Kargil highway. The ridgeline on the east meets the highway at a motorable pass known as Fotu la (13,400 ft), after which the village is named.

The base camp was situated in one of the hamlets of Fotu la lok, known as Potortse, comprising of 4 households, on the lower slopes of the above peaks, *ca.* 2 kms uphill from the highway. The other hamlets included Chipskianchan (2 households), Changlang (2 households) and Sumshen (6 households). Fotu la lok was represented in the Village panchayat (local governing body) of Lamayuru by a "Panch", hailing from Changlang. The people practice settled agriculture and also tend livestock to some extent.

The entire study area lies in the western part of Ladakh. The area is bounded by the Ladakh range in the north and the Zanskar range in the south. The region is drained mainly by the Indus River and its tributaries and is characterized by great expanses of alluvial fans at lower elevations, which form the ideal habitat for the Ladakh urial. It is characterized by the following habitat types and their associated vegetation communities: - Moist slopes, Riverine areas, Field borders and valley bottoms, Rubble slopes and screes and Snowline (Chundawat and Qureshi 1999).

Figure 2.1 Map of Study Area (Nindum Wildlife Sanctuary - Proposed) Showing major drainage, peaks, road and settlements



3. METHODS

3.1. General Field Methods

A preliminary reconnaissance of the study area was carried out at the beginning of the study (22 November to 6 December, 2002) to determine the best method (vantage points or monitoring trails) of sampling, period of sampling, effort required to reach each point and identification of areas covered by map grids on the landscape.

As line transect assumptions (Burnham *et al.* 1980) cannot be satisfied under the terrain and weather conditions prevalent in the region, vantage points or monitoring trails would have been the best sampling method (Nievergelt 1981, Bhatnagar 1997, Johnsingh *et al.* 1999). As the area was too undulating to ensure uniform coverage of the entire study area using vantage points, regular monitoring from trails (Jackson and Hunter 1996) was decided as the main sampling method for observations on the Ladakh urial and livestock species.

Four monitoring trails (each approximately 3-4 kms long) were selected such that almost the entire area was uniformly sampled. Each trail was walked 10 times over a period of five months to give a total of 40 trail walks. The area visible from each trail was mapped on a 1:50,000 toposheet to estimate the area for calculating densities. Though there was substantial overlap in the areas visible from each trail, some areas could be covered only from specific trails. Also, there was no other option logistically (access from base camp). Hence, all four trails were retained.

The reconnaissance period was also used to sample the entire area for availability of non-mappable habitat features (Section 3.2.1.b.)

Ad libitum sampling to estimate periods of maximum visibility and urial activity was also conducted. Based on this, the time period between 0830 to 1700 hrs was found to be best for monitoring the animals, except when poor weather reduced visibility. In that case, the trail was monitored an hour later. In early and peak winter, day length was shorter and optimum visibility was found to coincide with the above mentioned time interval.

The trails were walked at a uniform pace (as far as is possible in undulating terrain) and area on both sides of the trail was first scanned by naked eye and then using 7x40 binoculars. Once animals were sighted (whether urial or livestock), the place was observed using 16-40x spotting scope for further classification. Each observation was treated as one group or sighting, irrespective of number of individuals seen. For each sighting, the following information was then noted in an area of approximately 30m radius and at the point of the highest aggregation of the group: -

1. Date and time of observation
2. Species of animal (urial, sheep-goat, yak, donkey or horse)
3. Group size and type (group types identified were all male, female with young and mixed groups)
4. Age and sex classification (wherever possible)
5. Activity (*e.g.* feeding, foraging, resting, others)
6. Slope angle
7. Aspect
8. Terrain type (*e.g.* scree slopes, rocky outcrops, escarpments, valley bottoms, smooth slopes)
9. Vegetation type

10. Distance to ridgeline

11. Distance to cliff

12. Bearing from trail (wherever possible)

13. GPS location of the point on the trail from where animals were sighted (wherever possible) and any other remarks.

14. The location of each group (taken at the centre of the group) was then plotted on a 1:50,000 toposheet of the area.

15. These locations were then used to extract information on elevation at which the animals were seen.

Table 3.1 gives the descriptions of the various habitat variables mentioned above and their categories. Table 3.2. gives the age-sex classification, while Table 3.3. gives the description of activity types.

Studies on mountain ungulates have shown the importance of slope angle, aspect, elevation, terrain type, distance to ridge and distance to cliff to be important variables determining habitat use by them (Schaller 1977, Chundawat 1992, Bhatnagar 1997). The urial being a wild sheep would seem to prefer open, gentle slopes with high visibility in order to detect predators. Since their "escape strategy" involves running away to put maximum distance between themselves and the predators, and the use of ridgelines for better view of the area to locate predators (Schaller 1977, Roberts 1977), these variables were selected for quantifying habitat use.

In case the animals were seen to be feeding, the location of the feeding site was identified and the site was visited and sampled as explained in Section 3.2.1.b., either on the same or the next day (Nievergelt 1981).

Table 3.1. Habitat variables and their categories used in quantifying habitat utilization by Ladakh urial and livestock in the study area (Nindum Wildlife Sanctuary- Proposed)

Habitat Variables	Categories	Description
Slope Angle (measured in 5° intervals)	0-10°	Very gentle slopes
	11-20°	Gentle slopes
	21-30°	Intermediate slope
	>30°	Steep slopes
Elevation	Lower elevation	3800-4120m
	Middle elevation	4120-4400m
	Higher elevation	4400-5400m
Distance to ridgeline		Measured at 10m intervals; includes the crests of various slopes and not just major ridgelines
Distance to cliff		Measured at 10m intervals; includes cliffs and rocky area inaccessible to urial and livestock
Aspect	N	Includes following aspects- N (338° - 23°), NE (24° - 68°) and NW (294° - 337°)
	S	Includes following aspects- S (159°-203°), SW (204° - 248°) and SE (114° - 158°)
	E	(69° - 113°)
	W	(249° - 293°)
Terrain types	Smooth	Usually very gentle to gentle slopes with rock or stone cover < 20% and maximum vegetation
	Broken	Usually gentle to steep slopes with rock or stone cover >20% but <30 %, and relatively lesser vegetation cover than smooth terrain (includes scree slopes)
	Rocky	Usually Intermediate to steep slopes with large rocks, cliffs or boulders, rock cover > 30% and very little vegetation cover
	Snow covered	Areas which were snow covered irrespective of the underlying terrain type
Vegetation	Dominance ranks between 1-5	Plant species occurring within 30m radius, ranked according to increasing order of dominance with respect to biomass as 1,2,3,4,5 and 0 if the ground was bare.

Table 3.2. Criteria used for age and sex classification of the urial in the study area (Nindum Wildlife Sanctuary- Proposed) (Classification derived from personal observations)

Age class	Sex class	Description			
		Age	Body size	Horn size/curvature	Coat color
Lamb	Lamb	< 1 yr	Small	Very small and stubby	Pale rust
Yearling or sub-adult	Male	1-3 yrs	Medium	Small and pointed like female's but curving out and down	Rusty brown to grayish brown; black marking on throat as a line (sometimes)
	Female	1-2 yrs	Medium-Small	Smaller than adult female, pointed and curved backward but not downwards	Rusty brown, sometimes dark brownish
Adult	Female	> 2 yrs	Medium	Small and pointed backwards but not downwards	
	Male – class 1	3-4 yrs	Larger than sub-adult	Base broader; tips blunt, pointing out and down upto just above angle of base of horn	Dark to light rust; black line on throat and just behind the elbow, on the "saddle"
	Male – class 2	4-6 yrs	Large	Base broader; tips blunt, pointing out and down upto angle of eye; not describing a complete semi-circle;	Dark to light rust; black ruff on throat upto dewlap; black marking on the borders of the "saddle"; saddle may have indistinct grayish coloring
	Male – class 3	> 6 yrs	Largest	Base broader, tips blunt and pointing out and down upto below angle of eye, describing a complete semi-circle or more	Dark to light rust; black, thick ruff upto knee level; distinct black marking on the borders of the "saddle"; saddle with distinct pale grey coloring

Table 3.3. Types of activity shown by Ladakh urial in the study area (Nindum Wildlife Sanctuary- Proposed)

Activity	Description
Feeding	Head down towards ground, eating or searching for food
Moving	Forward motion with head held at shoulder level or higher
Standing	Motionless stand with held above shoulders
Resting	Sitting or sleeping

3.2. Specific Field Methods

3.2.1. *Resource Utilization by Ladakh Urial and Livestock*

a. Spatial Overlap Between Ladakh Urial and Livestock– Locations of both Ladakh urial and livestock were plotted on a 1:50,000 Survey of India (SOI) toposheet of the intensive study area. This toposheet was later overlaid with grids of 1 x 1 cm (500 x 500 m) to compare the spatial overlap between the urial and livestock. The number of grids consisting only urial or livestock sightings and those containing both in the same grid, were compared to assess the spatial overlap between the two groups.

b. Habitat Selection and Utilization- To assess the pattern of habitat use and selection by urial and livestock species, data on habitat variables 'available' and 'used' was gathered and analyzed.

Availability of habitat features such as terrain type, distance to ridge, distance to cliff, slope angle and aspect, vegetation community types were estimated using a Non-Mapping Technique (Marcum and Loftsgarden 1980). A hundred and ninety grids of 1 x 1cm (500 x 500m on ground) size were overlaid on the toposheet of the entire study area and each grid was coded. Vantage points were chosen from where a particular part of the study area could be observed clearly. From the vantage point, the area corresponding to each grid centre was then identified on the field and observed using a spotting scope (Bhatnagar 1997). The habitat variables (Section 3.1, Table 3.1) available within a 30m radius around that point were noted for 117 grids. Since the time period for the study was limited not all the grids could be sampled. However, all the grids falling within the general area used or with potential for use have been sampled. Most unsampled grids fell within areas close to the villages or in the villages and fields. All the variables except slope angle and elevation were estimated visually. This was because measurements of these variables for information on use were also performed visually (Bhatnagar 1997). Slope angle was measured using a compass while elevation was obtained from the 1:50,000 SOI toposheet of the area.

The availability of vegetation community types (n=123) was estimated in early winter (end of November- early December) to estimate actual availability at the start of the season, and to avoid problems caused by possible snowfall later in the season. A few extra grids were sampled here as this sampling was performed earlier in the study when time and logistics were not so much a problem as later. The availability of topographical features was estimated in April, as this data was independent of time. Some areas, especially along the western boundary of the study area were found to be unused by any of the animal species considered in this study. Hence, such grids (6 in number) were dropped from the April sampling. The percent grids under different habitat variables were calculated to obtain estimates of overall availability for the entire study area.

To estimate the area under different cover types (barren, vegetation and dung) in the study area, Point Intercept Transects (Muller-Dumbois and Ellenberg 1974) were laid in a random manner, all over the study area, to estimate cover. The area was first divided into three elevation zones- upper (4,400 to 5,400m), middle (4,120 to 4,400m) and lower (3,800 to 4,120m), based on elevation values obtained from the map. Then Point Intercept Transects (53 m i.e. 53 points, 1m apart) were laid in the upper (n=15), middle (n=18) and lower (n=20) elevation zones respectively. The three zones could not be sampled equally as the transects were laid late in the season (April) when the area, especially mid and higher elevations, was still under snow. However, each zone has been sampled such that the entire area of the zone was covered equally.

The type of cover at each point (every 1m) was noted and the percent area under each cover category was calculated for each zone. The information on availability was then compared with the information (obtained through direct observations from monitoring trails) on use by all species.

c. Diet Selection and Overlap- Determination of plant species (and where possible, plant parts) available and eaten by both Ladakh urial and livestock was carried out using quadrat sampling (Manjrekar 1997).

Availability and use of various plant species and plant parts were quantified for the area where the animals were seen feeding with the help of vegetation sampling plots. When an animal species (urial or livestock) was seen feeding (during the monitoring trail walks) in an area, the location of the feeding site was carefully noted down and the area visited the same or the next day. A 5m radius circular feeding plot was then laid in the area. Within this, at least 10, 1 x 1m quadrats were sampled randomly (without replacement) to quantify plant species and plant parts available and eaten by urial and livestock.

In areas used by both urial and livestock, it would be difficult to distinguish between feeding signs (and hence, plant species and parts eaten) of the two. Therefore, efforts were made to sample such areas immediately.

When the area was snow covered, quadrat sampling of vegetation and feeding sites would be difficult. Crater sampling was then selected as the sampling method (Schaeffer and Messier 1995) for such periods. The assumption was that in case of snow cover on the ground, the animals would dig craters in the snow to gain access to the vegetation beneath. However, this was not seen to be the case in this area. The animals, including livestock and urial, fed only on the vegetation emergent over the snow layer. Hence, the previous method of sampling plots was retained with the modification that percentage snow cover, in each of the quadrats, was also recorded.

Herder information was also used to identify feeding sites, herding times and duration, plant species eaten and details of stall feeding. Information was gathered on time and duration of stall feeding, species that are stall fed, type (wild-collected fodder, concentrates, agricultural residues or others) and quantity of feed given to understand the role of feed supplementation in grazing patterns of livestock. It helped estimate the total pasture biomass removal for stall feeding, in a season.

For urial, focal and scan sampling was not possible due to large flight distances of the animals in this area. Hence, most of the information on feeding is based on data from feeding plots and ad libitum, opportunistic observations on feeding behaviour.

3.2.2. *Movement Pattern of the Study Population*

Due to a record snowfall (after 4-5 years) in Ladakh in the year of this study, the snow cover on the ground in the study area was deep enough (3-4 feet) to cover almost all vegetation. The study area lay on the south facing slope of the Nindum-Sasong ridge. Hence, the snow became compact and hard within 2-3 days of snowfall. This greatly hindered the ability of the urial as also livestock to dig "craters" in the snow, in order to access the vegetation underneath (Geist 1971). Under such conditions, most mountain ungulates and especially sheep tend to migrate to areas that are more open, have faster snow melt and more "exposed" vegetation. Since number of urial sightings reduced in the period immediately after heavy snowfall (late February to late March), it was theorized that the urial migrated to adjoining areas where snow melt was faster or the snow was not so compact, and where there was more exposed vegetation than in the study area.

On the basis of this theory, the possible areas the urial could have migrated to were listed and each one was surveyed for possible signs of the "missing" study population. Three main areas were identified for this purpose, based on contiguity with the study area. The area known as "Budhkharbu", west of the study area, was one of these. This is also the area where some of the animals migrate to in the summer season (as per local herders). The second area, represented by the Hemar lungpa and the villages of Takmachik (on the banks of Indus), Sumdo, and Champakuttu, lay on the northern face of the Nindum-Sasong ridgeline. The third area was the Lamayuru area adjoining the eastern boundary of the study area.

a. Survey for the Missing Animals in the Three Areas – Each of the three areas were visited separately and surveyed for signs of the missing study population. Vehicle monitoring was undertaken first, from the intensive study area to each new area. The slopes were scanned from a vehicle moving at a constant, slow pace and occasionally the slopes were scanned from vantage points on the road.

b. Interviews With Locals - On reaching the new site, the villagers and local herders were questioned regarding the whereabouts of urial in the area. Herders living at the highest zone of human habitations in each area were especially questioned. These included the village of Stakse-Brok in Budhkharbu, Sumdo and Champakuttu in Takmachik and Skambur in Lamayuru. Once urial presence was confirmed, efforts were made to establish if the locals had noticed an increase in the local population of urial. Two teams of two people each then went up on the slopes and covered as much area as possible through trail walk or vantage point sampling, scanning the slopes for the animals, their tracks on the snow, or other signs of urial presence.

3.2.3. *Intensive Sampling of Skambur and Dzaothang, Lamayuru*

The "new" area, where the missing study population was expected to most likely be present, based on the surveys and interviews, was known as the Skambur-Dzaothang area of Lamayuru. This area had been identified by the local herders as the usual migration area for the urial population from the study area during times of snow. However, this migration had reduced to very few animals undertaking it over the past three to four years due to almost negligible snowfall in these years. During the period of this study however, Ladakh and the study area saw record snowfall and this had probably forced the urial population to undertake their movement.

Once it was confirmed that Skambur-Dzaothang was the area the animals could possibly have moved to, the area was sampled for overall cover types, snow cover and dung densities of urial, to compare with the values from the study area.

a. Snow Cover – The snow cover in the new area was estimated using a modification of the non-mapping technique (Marcum and Loftsgarden 1980). A vantage point was selected such that maximum of the area to be sampled would be visible. Imaginary points were then laid on the area visible, starting from the top right hand corner, i.e. the ridgeline, and coming down in a *zig-zag* manner, from right to left, then left to right and so on. The points corresponded to four imaginary points dividing the field of vision of a pair of 7 x 40 binoculars equally.

The presence or absence of snow cover and the extent of snow at each point was recorded under three categories (Table 3.4). The percent area under each category was estimated.

Snow cover was also estimated for the study area and compared with the snow cover for the Skambur-Dzaothang area.

b. Cover type – The type of cover in the Skambur-Dzaothang area was estimated using the Point-intercept technique as for the study area. The area was first divided into three elevation zones and 10 point-intercept transects (each with 52 points, 1m apart) were laid in each elevation zone. Percent area under different cover types was determined as for the intensive study area. This was then compared with the estimates for the study area.

3.2.4. *Resource Use by Agro-Pastoralists in Study Area*

The use of resources available in the urial habitat, such as plant biomass for fodder, fuel wood, and others by the local people has a bearing on the kind of pressures being exerted on the urial population in the study area. Hence, information on intensity of use of such resources was gathered from all the villages in the area.

There are two main villages in the study area (Chapter 2, Study Area). Fotu la lok has four hamlets consisting of 14 households. Representative members of each household were gathered in each hamlet and interviewed in an informal semi-structured format for information on their resource use. There are 30 households in Hiniskut scattered over three different, far flung areas.

To sample all the households would have been difficult in the limited time period of this study. Hence, information was obtained based on interviews with the village headman or "*goba*" and two to three other village elders.

For the present study, only information pertaining to biomass removal from the pastures in urial habitat and grazing and herding patterns of livestock were used for this study.

3.3. Analysis

3.3.1. *Urial Densities*

Urial density in the study area was calculated from information on number of groups and individuals seen from each trail. Densities were first calculated for each day and each trail using number of observations of urial in a day and the area visible from that trail (Nievergelt 1981). These densities were then used to calculate mean density (over all days) for each trail. Since area visible from trail 1 and 2 overlapped by about 90 %, the mean density for the two trails was clubbed together and a total mean density was calculated using these. This became the total mean density for trail 1 and trail 2. Trail 3 and trail 4 were treated in a similar manner. This was done to overcome any bias that may arise due to overlap in the area visible (Section 3.1) from each trail. The two total mean densities thus obtained were added to obtain the overall mean density for the entire study area.

3.3.2. *Urial Group Sizes and Composition*

The overall mean group sizes and that under different types of group of urial such as 'all-male', 'all-female', 'female with young', 'mixed herds', were calculated. The age and sex composition of the population (Table 3.2) was also expressed as ratio of adult males and young (yearlings and lambs) to every hundred females. Since the variation in the group sizes was found to be extremely large and mean group sizes do not capture this variation effectively, the typical group size was found to be a better estimate. The typical group size refers to the group that the average urial would find itself in (Jarman 1974).

3.3.3. *Use of Habitat Variables*

The proportional use of various habitat variables by both livestock and urial was calculated in order to identify the principle habitat categories used. were Habitat preferences were estimated using Simultaneous Bonferroni confidence intervals on the difference between proportion used and proportion available Marcum and Loftsgarden (1980). For habitat variables 90 % confidence intervals were generated.

In order to test for the differences in utilization of habitat variables by livestock species and urial, Kruskal Wallis test was performed. Multivariate analysis using Principal Component Analysis (Norussis 1997, Madhusudan and Johnsingh 1998) was performed to examine these differences.

A Non-metric Multidimensional Scaling (NMDS) was performed to assess the separation between all the species on the basis of their differential use of the habitat features (Bagchi *et al.* 2002).

3.3.4. *Principal and Preferred Diets*

Information obtained from the feeding plots laid for both urial and livestock was used to calculate proportional use and availability and the principal diet. The Kruskal Wallis test for independent samples was used to test for selection processes in the use of various plant species by the urial.

To assess the similarity in the diet on a quantitative basis, Sorenson's Quantitative Index (C_n) was used on the proportional use of various plant species by the urial and livestock. The Morista's index (C_λ) of overlap (Magurran 1988) was used to quantify dietary overlap between pairs of species (Harris and Miller 1995). The value of the index ranges from 0 to 1 with 0 implying complete difference or separation and 1 implying complete similarity or overlap.

Note: - Due to small sample sizes for donkey (n=9) and horse (n=6), these two species were dropped from all further analysis.

3.3.5. *Spatial Separation between Urial and Livestock*

Sorenson's Qualitative Index (C_s) (Magurran 1988) was used to test for similarity between grids used by urial and livestock.

3.3.6. *Comparison of Study Area with Skambur-Dzaothang Area*

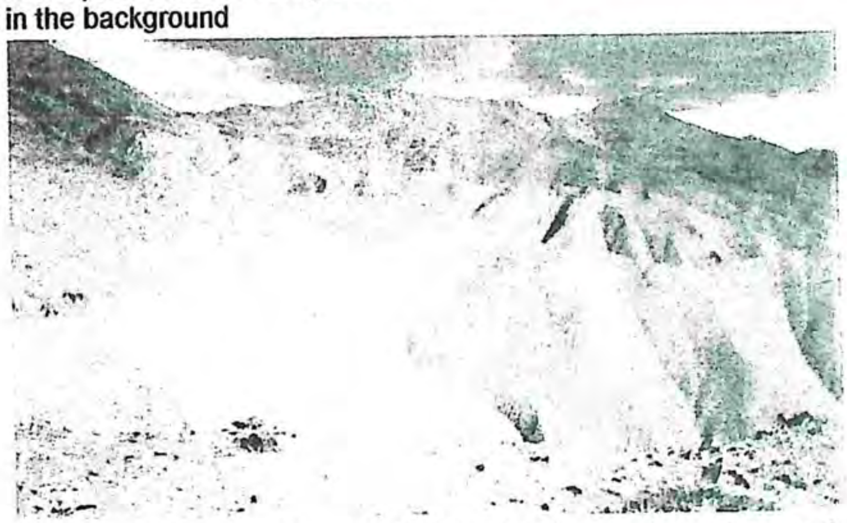
The differences between the two areas in terms of snow cover, different cover types and urial dung densities was tested using X^2 test of independence.

Table 3.4. Categories of snow cover measured in the study area (Nindum Wildlife Sanctuary- Proposed) and in the Skambur-Dzaothang area of Lamayuru

Category	Description
NS	Areas with no snow cover or very little snow
LS	Areas with light snow cover
S	Areas with relatively deep snow cover

PLATE - 1

Study area showing middle elevation plateau in the foreground and Sasong peak in the background



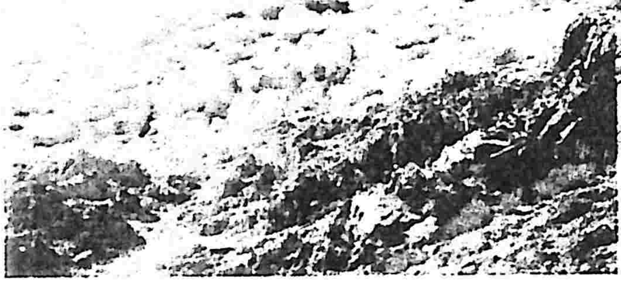
Study area showing undulating terrain and gentle and intermediate slopes in lower and middle elevations (foreground: broken terrain)

Sheep and goat feeding on Caragana spp. in relatively snow-free areas

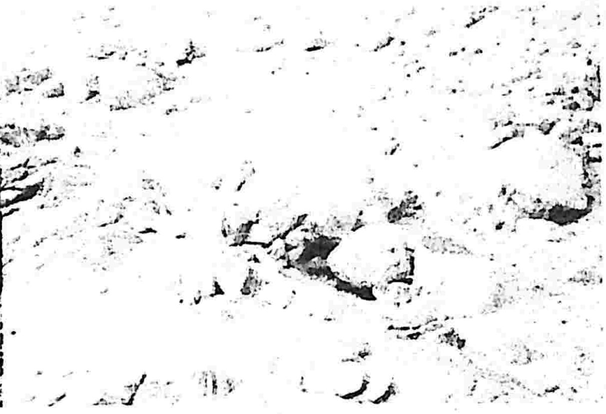
PLATE – 2

Age-Sex Classes of Ladakh Urial, *Ovis vignei*

(L to R) Class I Male, Adult female, Class III Male and Class II Male



(L to R) Adult Males: Class III, Class I, Class II



(L to R) Adult Males: Class III, Class III and Class II

Female and young

4. RESULTS

Observations on urial group sizes, age-sex composition, habitat and diet use and selection (including use and selection by livestock) and separation with livestock are detailed in the following sections. These results are based on observations on urial and livestock present in the study area. Information on dependence of the local human and livestock population on urial habitat, in terms of pasture usage in winter and biomass removal is also shown. The "new" area, where the urial "migrated" to in mid-February (Section-3.2.2.), is compared with the study area in order to identify the possible reasons for the migration.

4.1. Urial Population

A total 46 urial groups of urial (with 834 individuals) were obtained in 46 groups during the period of the study (not including off-trail sightings). Group sizes varied extremely (Section 4.1.2.). This had implications on sample sizes and analyses resulting in high variation in the mean values for population density and group sizes and a limitation on the sample size of observations (section 4.1.2. and 5.2.).

Of the 834 animals seen, 573 could be classified with respect to their age and sex. Most (75%) of the animals were 'active' i.e. observed to be feeding or foraging or engaged in other activities (moving, standing) and only a few (25%) resting. This was mainly a function of the time chosen for observations on the urial (see Section-3.1), which coincided with their period of maximum activity.

4.1.1. *Density*

The study area had 4.03 (± 0.9) urial per km^2 and an overall population of *ca.* 157-165 individuals. The group density was found to be 0.22 (± 0.05) groups per km^2.

4.1.2. *Group Size and Composition*

The mean group size of urial (n= 46) was 18.1 (± 2.9), while the typical group size was found to be 38.6. Seventy one percent of the individuals classified into age groups (n=579) were adults. Only eight percent of the population consisted of lambs, while yearlings comprised another 12 percent.

Fourteen of the groups observed were all male groups (Table 4.1) consisting of adult males. Thirty-one were mixed groups comprising adult males, females with young and yearlings. There was one group consisting of 2 females. Mixed groups were larger than all other group types. The mean and typical group sizes of the various group types are given in (Table 4.1). For every 100 females, the proportion of adult males, yearlings and lambs was 196.7: 47.4: 32.9. Class 3 males (43%) dominated the male population (n=299), followed by class 2 (23%) and then class 1 males (22%).

4.1.3. *Livestock Holdings and Composition*

The five hamlets that comprised the study area had about 44 households. A total of ca. 820 livestock, primarily comprising of sheep and goat (*ca.* 600-700) were grazed in the study area. There were a few yak and hybrid cattle (*ca.* 65), donkeys (*ca.* 50) and horses (4).

Table 4.1. Group sizes of Ladakh urial under different group types.

Group type (n=46)**	Mean size	Typical size*
All male (n= 14)	2.8 (±0.8)	5.71
Female group or female with young (n=1)	2	-
Mixed (n=31)	7.7 (±1.9)	20.91
Overall	18.1 (±2.9)	38.6

* Typical group size is explained in section under methods
** There was one all female group consisting of 2 females

4.2. Study Area Characteristics

The study area is described in term of the habitat variables, ground cover and snow cover available.

4.2.1 *Distribution of Various Habitat Variables*

The availability of various habitat variables is described for the three elevation zones demarcated and for the entire study area (overall). This is to provide an understanding of the features that defined the habitat of the urial and to compare the proportional use of these features.

Elevation

As already described, three elevation zones were demarcated in the study area. All the zones covered approximately equal areas (Table 4.2). In the higher elevation zone, the area above 5,000m (20.9%) consisted of steep and rocky slopes that rose sharply (slope angle > 40°) to the peaks forming the northern ridgeline bounding the area. This area was found to be effectively unavailable to both the urial and livestock. Therefore, the actual area practically available to them in the higher elevation was between 4,400m to 5,000m (79.1%).

Slope

More than half (53%) the study area (Table 4.2) fell under the 'gentle' slopes (11-20°). A very small proportion (6%) had 'steep' slopes (>30°), mostly the area between 5,100-5,400 m in the higher elevation zone. The lower parts of the higher elevations were otherwise characterized by 'gentle' slopes (37.2%) and 'intermediate' (21-30°) slopes. The middle and lower elevations were dominated by 'gentle' (about 62%) and 'very gentle' (0-10 °) (about 31%) slopes. These zones were devoid of 'steep' slopes.

Distance to Ridgeline

Almost half the study area (44%) fell within 50m of a ridgeline (Table 4.2), and no area was further than 500m from the same. A similar pattern was observed in the three elevation zones. It must be noted that for this study, ridgelines include all the crests of the smaller slopes and not just the major ridgelines formed by the high peaks.

Distance to Cliff

About 40 percent of the study area was close to cliffs i.e. within 100m distance (Table 4.2). The middle and lower elevation zones were mostly (*ca.* 70%) beyond 100m from the nearest cliffs. However, most of the higher elevations (42%) had cliffs within 50m distance.

Aspect

Majority of the study area (64%) was south-facing (Table 4.2). A similar pattern was seen in all the elevation zones. This had considerable influence on the snow depth and compactness as seen in section 3.2.2.

Terrain Types

'Smooth' and 'Rocky' terrain dominated much of the study area (38.5% and 33.3% respectively) (Table 4.2). Higher elevations were mainly rocky (53.5%) while middle elevations were characterized by both smooth (39.5%) and broken (39.5%) terrain. Lower elevations had predominantly smooth terrain (58.3%).

Ground Cover

Over half the study area (60%) was barren i.e., covered by stones, soil, scree or rocks and had no vegetation (Table 4.2). Vegetation cover was ca. 38 percent. Dung of various animal species formed the rest of the cover.

The higher elevations had 44 percent area under vegetation and approximately 53 percent was barren. Middle elevations also showed similar pattern. Lower elevations, had greatest barren areas (68%) and least vegetation cover (29%) of all the zones.

Plant Species Composition

The species composition of the overall vegetation cover in the three elevation zones in the study area is given in Fig. 4.1. Stunted shrubs were the most dominant group comprising of species like *Caragana*, *Artemisia*, *Eurotia*, followed by the graminoids, i.e. grasses and sedges. Erect herbs like *Causinia*, *Rheum*, *Corydalis*, *Thermopsis*, prostrate herbs like *Polygonum*, *Salsola*, *Oxytropis*, *Potentilla*, and cushionoid, low biomass herbs like *Acantholimon*, *Astragalus*, *Lentopodium* were also available.

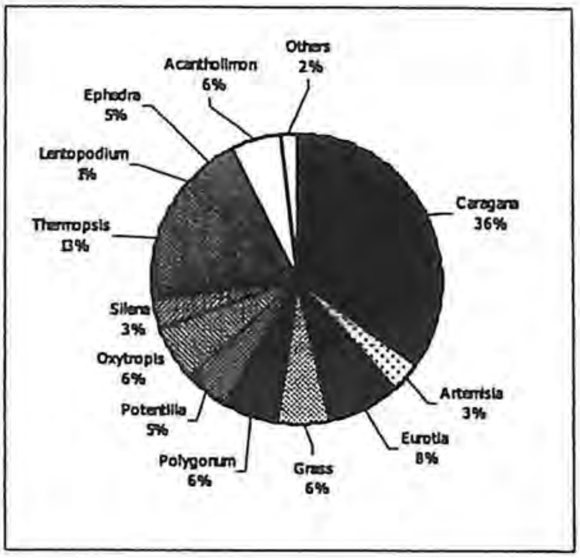
The three elevation zones had similar richness with 15, 16 and 17 different genera in the higher, middle and lower elevations respectively. Forty-six percent of plant species in the higher elevations were erect shrubs or herbs and about 40 percent were prostrate forms. In the middle elevations, erect shrubs and herbs dominated (53%) while prostrate forms constituted only 29 percent area under them. In the lower elevations too, the erect shrubs dominated (57%) over the prostrate forms (31%). The graminoid cover was the same through out all the zones. However, most grasses were already heavily grazed at the start of the winter season (*pers. obs.*).

Table 4.2. The availability of various habitat variables under the three elevation zones in the study area.

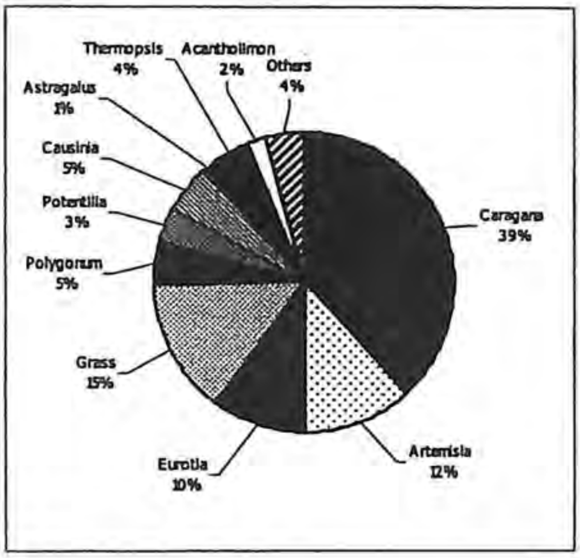
Habitat Variables	Percentage availability				
	Elevation zone				
	Categories	Higher (n=43)	Middle (n=38)	Lower (n=36)	Overall
Elevation (m)	3800-4120			100.0	30.8
	4121-4400		100.0		30.8
	4401-5000	79.1			30.8
	5001-5400	20.9			7.7
Slope (degrees)	0-10 (Very gentle)	16.3	34.2	30.6	26.5
	11-20 (Géntle)	37.2	63.2	61.1	53.0
	21-30 (Intermediate)	30.2	2.6	8.3	14.5
	>30 (Steep)	16.3	0.0	0.0	6.0
Distance to ridgeline (m)	0-50	41.9	50.0	41.7	44.4
	51-100	30.2	36.8	30.6	32.5
	101-200	16.3	13.2	27.8	18.8
	201-300	7.0	0.0	0.0	2.6
	301-500	4.7	0.0	0.0	1.7
	>500	0.0	0.0	0.0	0.0
Distance to cliff (m)	0-50	41.9	5.3	8.3	19.7
	51-100	11.6	21.1	27.8	19.7
	101-200	20.9	15.8	19.4	18.8
	201-300	0.0	18.4	19.4	12.0
	301-500	4.7	7.9	11.1	7.7
	>500	20.9	31.6	13.9	22.2
Aspect	North	2.3	2.6	5.6	3.4
	South	67.4	63.2	61.1	64.1
	East	4.7	7.9	2.7	5.1
	West	25.6	26.3	30.6	27.4
Terrain types	Smooth	20.9	39.5	58.3	38.5
	Broken	25.6	39.5	19.5	28.2
	Rocky	53.5	21.0	22.2	33.3
Cover types*	Barren	25.35	31.29	43.36	59.25
	Snow	0.00	0.00	0.00	0
	Dung	2.82	2.14	2.79	2.58
	Vegetation	44.10	43.27	29.13	38.17

*n= 780 for higher elevation zone, n= 936 for middle elevation zone and n= 1040 for lower elevation zone

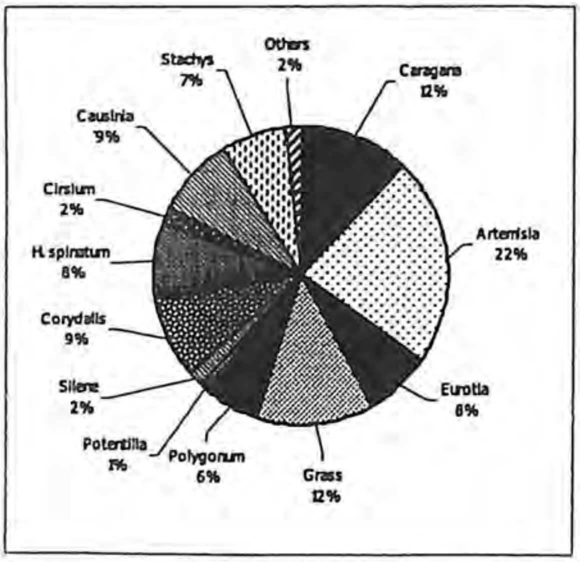
Fig. 4.1. Species composition of overall vegetation cover in each elevation zone



a) Higher elevations
Others= *Causinial* spp, *Aconogonum* spp, *Veronica* spp



b) Middle elevations
Others = *Heracleum* spp, *Stachys* spp, *Oxytropis* spp, *Silene* spp, *H. spinatum*, *Aconogonum* spp, *Sonchus* spp



c) Lower elevations
Others = *Heracleum* spp, *Oxytropis* spp, *Saxifraga* spp, *Astragalus* spp

4.3. Habitat Use and Selection by Urial and Livestock

The use and selection (preferences) of various habitat variables by the urial and by two primary species of livestock, i.e. yak and sheep-goat is presented. The category of a variable was said to be 'preferred' if it was used more than its proportional availability and 'avoided' if it was used less than its proportional availability. It was said to show no selection if it used the variable in proportion to its availability. It may be noted that the terms are relative and have a strong relationship with the availability of that category. The term 'avoided' should especially be viewed with caution as that category may still show substantial use, though the use would be lesser than expected based on its availability. Due to this reason the actual proportion use has also been discussed, as even the 'most used' (principal) category may not necessarily come out as 'preferred'.

Livestock have little choice in the use or selection of variables like distance to ridgeline and cliff as most of them are herded or left on pastures that reflect the convenience of their owners. Hence, use of habitat variables by livestock has been analyzed only so far as they serve to compare against use by urial. For more on habitat use by livestock, refer to Section 4.3.2.

4.3.1. *Habitat Use by Urial*

Though middle (48%) and higher (41%) elevations were used the most, urial showed no preference for them. Lower elevations however, were avoided. They primarily used and preferred very gentle slopes (48%), while gentle and intermediate slopes were less used (Table 4.3., Fig. 4.2.).

Proximity to ridgelines and to cliffs (within 50m) was preferred and such areas were the most used (70% and 53% respectively). Areas further than 300m of a ridge or cliff were avoided (Table 4.3.).

Urial used southern aspects more (47%). However, the northern aspects showed preference. Urial seemed to use and prefer broken (37%) and smooth (24%) terrain.

4.3.2. *Livestock Habitat Use and Movement Patterns on Pastures*

Except for horses, which primarily used gentle slopes (66%), all livestock species mostly used very gentle slopes (77% for sheep-goat and donkey and about 82% for yak; Fig. 4.2.). However, neither yak nor sheep-goat showed any selection or preferences. Middle elevations (73% for sheep-goat and yak and 66% for donkey) were used the most, followed by the lower elevations (Fig. 4.2.). Yak was the only species to use higher elevations (13%) (However, during the course of this study, this was restricted to the period of early winter i.e. late November-early December).

Most livestock were sighted fell within 100 m from ridgelines (80-90%; Fig. 4.2.). Horses did not use areas beyond 100m from ridgelines. Like urial, livestock, too, tended to be well within 100m from nearest cliffs (40-50%) and rarely beyond 500m (Fig. 4.2.). However, as shall be seen in the following paragraphs, this may not reflect their true use.

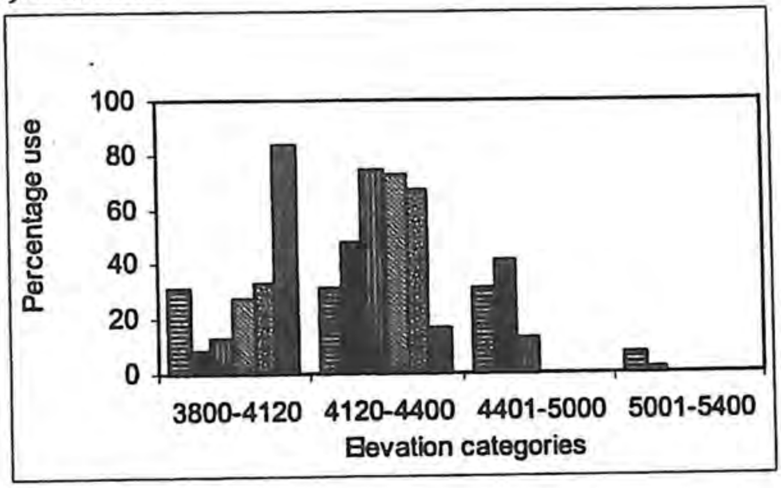
Southern and eastern aspects (80-88% for sheep-goat and donkey, 65% for yak and 55% for horses) were used more than northern or western ones but there was no selection observed (Fig. 4.2.). Yaks did not use broken terrain at all, preferring smooth slopes (78%) over all others (Fig. 4.2.).

Table 4.3. Preference indicies of Ladakh urial forsifferent habitat variable categories based on the Marcum and Loftsgarden (1980) non-mapping technique for habitat availability-use analysis. 90% confidence intervals were used for all categories. Preference rating- 'Preferred' implies the variable is used more than its proportional availability, 'Avoided' implies it is used less than its proportional availability and 'Proportional' implies that it is used in proportion to its availability. However, these ratings are not absolute and should be used with caution.

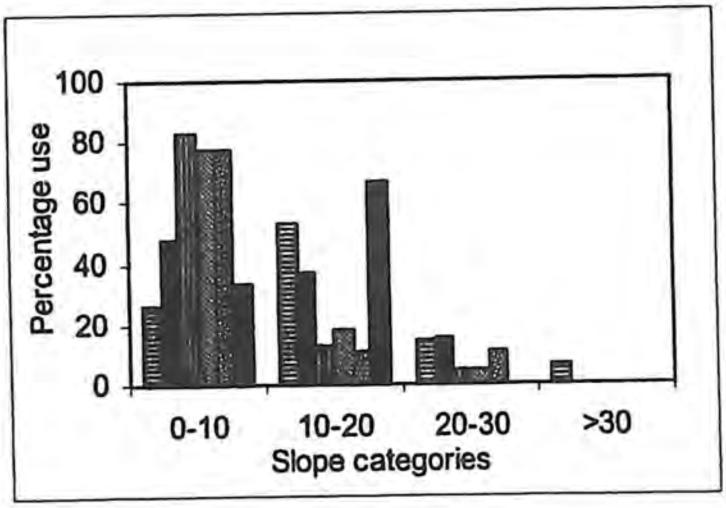
Habitat variables	Categories	% Available	% Used	Bonferroni Intervals		Preference rating
Aspect	**Northern**	3.4	19.6	0.0679	-0.0864	Preferred
	Southern	64.1	47.8	0.4391	0.0604	Proportional
	East	5.1	26.1	0.0959	-0.0368	Avoided
	West	27.4	6.5	0.3559	0.1476	Avoided
X^2, df, p	**6.3,3,0.1**					
Terrain	**Smooth**	9.0	23.9	-0.0052	-0.2927	Preferred
	Broken	6.6	37.0	-0.1421	-0.4648	Preferred
	Rocky	7.8	19.6	0.0163	-0.2513	Proportional
	Snow	76.6	19.6	0.7076	0.4321	Avoided
X^2, df, p	**77.0,3,0.1**					
Slope	**0-10**	26.5	47.8	-0.0247	-0.4019	Preferred
	10-20	53.0	37.0	0.3503	-0.0296	Proportional
	20-30	14.5	15.2	0.1324	-0.1462	Proportional
	>30	6.0	0.0	0.1089	0.0107	Avoided
X^2, df, p	**9.05,3,0.1**					
Elevation	**3800-4120**	30.8	8.7	0.3470	0.0945	Avoided
	4121-4400	31.6	47.8	0.0099	-0.3463	Proportional
	4401-5000	37.6	43.5	0.1526	-0.2034	Proportional
X^2, df, p	**9.3,2,0.1**					
Distance to ridgeline	**0-50**	44.4	69.6	-0.0677	-0.4347	Preferred
	50-100	32.5	19.6	0.2921	-0.0339	Proportional
	100-200	18.8	6.5	0.2377	0.0079	Avoided
	>200	4.3	4.3	0.0786	-0.0801	Avoided
X^2, df, p	**9.2,3,0.1**					
Distance to cliff	**0-50**	19.7	56.5	-0.1731	-0.5642	Preferred
	50-100	19.7	21.7	0.1490	-0.1906	Proportional
	100-200	18.8	13.0	0.2044	-0.0892	Proportional
	200-300	12.0	8.7	0.1552	-0.0898	Proportional
	300-500	7.7	0.0	0.1358	0.0180	Avoided
	>500	22.2	0.0	0.3141	0.1304	Avoided
X^2, df, p	**29.7,5,0.1**					

Fig. 4.2. Overall availability *vs.* use of various habitat variables by the Ladakh urial and livestock in the Nindum Wildlife Sanctuary- Proposed, during November 2002- March 2003

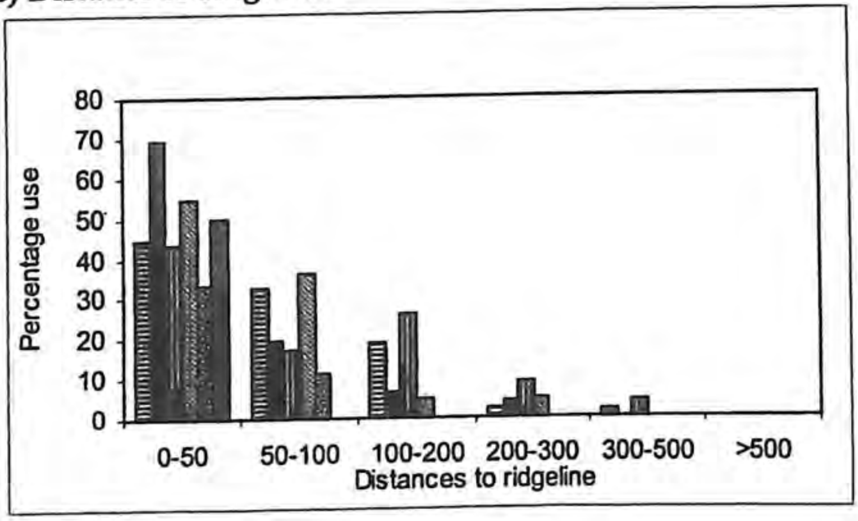
a) Elevation



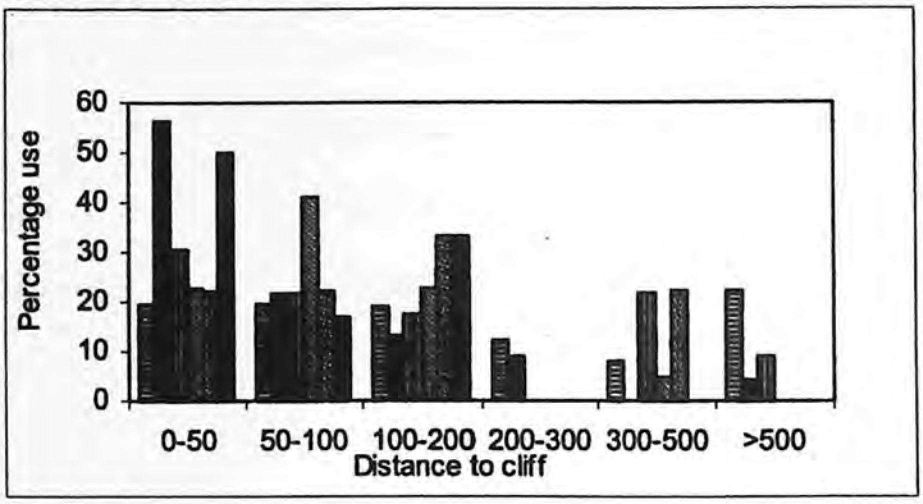
b) Slope angle



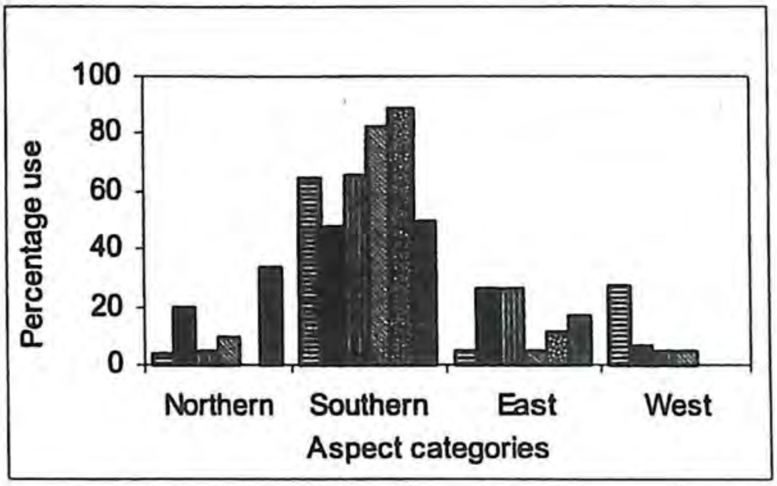
c) Distance to ridgeline



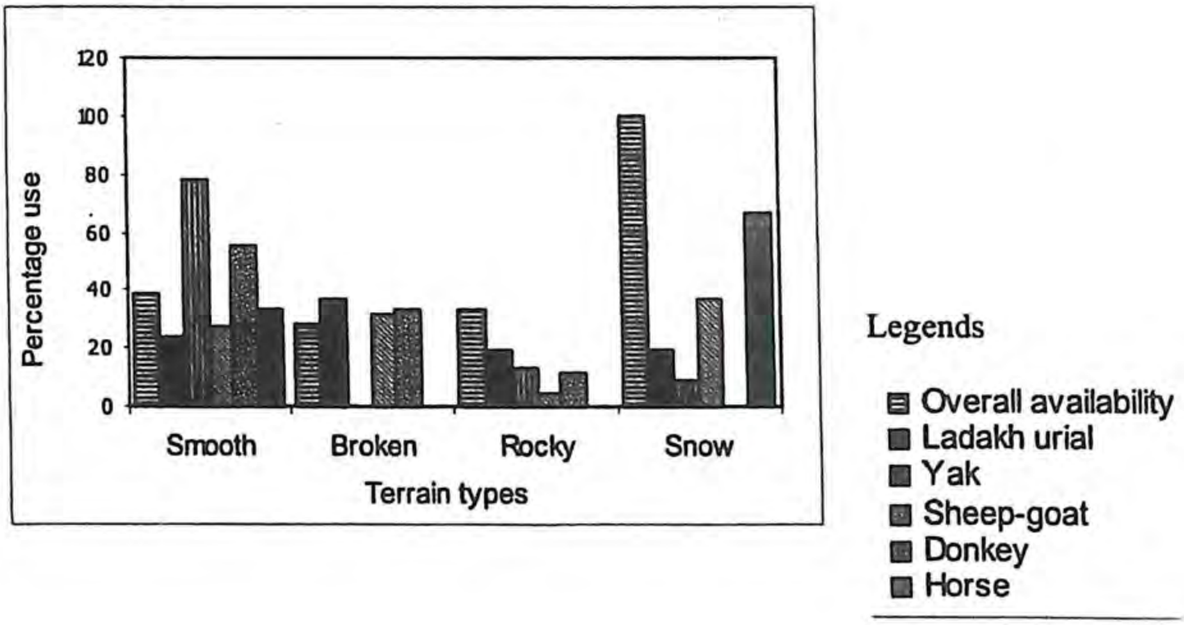
d) Distance to cliff



e) Aspect



f) Terrain types



Sheep-Goat uses all terrain types except rocky terrain (4%) as they are more comfortable than yak on such slopes.

As mentioned earlier, livestock exercised little or no choice in the use of various habitat variables or pastures, this being decided by the herders. Hence, to understand the patterns of habitat use by livestock and compare them with urial, it is necessary to understand their grazing and movement patterns as decided by the herders.

While livestock grazed mostly in the lower and middle elevation zones in winter, within these areas they tended to over utilize some areas and under use others. Such a patchy use reflected the convenience and selection exercised by the herders. Although all area under the urial habitat comes under heavy livestock use in summer, in winter this is limited to the middle and lower elevation zones.

The semi-structured interviews with the local herders suggested that the over-riding factor was the proximity of the pasture to the settlements. Further, it was important that the pasture had enough forage for the herds. Depending on the amount and compactness of the snow, the livestock were herded into relatively snow-free areas such as the ridgelines and crests (wind-blown sites) or stall-fed (if snow cover was thick or impenetrable).

A compilation of resource use, in terms of removal of plant biomass from urial habitat and some aspects of herding and grazing of livestock by the local people of the study area, are also given in (Appendix 2.a). The village of Lamayuru, under which falls almost the entire study area, grazes majority of its livestock on the study area pastures in the summer and autumn. Data from the past thirteen years shows that livestock populations have been fluctuating greatly (Appendix 2.b). The present decline in the population is attributed by herders, to the continuing drought over the past four years.

Based on the above information and personal observation, a plot of the various pastures used by livestock in winter in the study area is shown in Fig. 4.3. The areas where urial were mostly observed have been shaded in grey in order to show the relative spatial distance between the two groups. Livestock from the five hamlets grazed their animals in mostly separate areas and had little overlap. Also, while yak (in December) and donkeys were left very close to the settlements, sheep and goats were mostly herded on the middle elevations that had slightly better amount of forage (43% cover *vs.* only 29% at lower elevations).

4.3.3. *Comparison of Habitat Use by Urial and Livestock*

Overall the use of slope categories differed between urial and livestock (X^2=9.71, p=0.008). The three groups (urial, yak, sheep-goat) used different elevation zones (X^2=15.49, p=0.000) and terrain (X^2=15.75, p=0.003). However, there was not much difference in the use of aspect between urial and livestock (X^2 =8.37, p=0.079). Use of distance to ridge and distance to cliff differed significantly between the two groups (X^2 =10.77, p=0.05 and X^2 =13.50, p=0.001).

Ordination using Principal component analysis (PCA) on the use of various habitat variables by urial and livestock represented by yak and sheep-goat showed separation along three main components. The first component explained 27.7 percent of the variation and included increasing distances to ridgeline and cliff. The second component explained 23.3 percent of the variation and included increasing slope angle and elevation while the third component explained 17.9 percent of the variation and included increasing solar insulation (aspect) and brokenness of terrain (detailed output in Appendix 3). An examination of the PCA ordination (Fig. 4.4.) revealed that though there was a large overlap between urial and livestock in the middle elevations and moderate slopes, urial clearly had a tendency to also occur on steeper slopes at higher elevations and also areas closer to ridgelines and cliffs. Livestock on the other hand, tended to be spread more towards areas further from ridgelines and cliffs.

Non-metric multidimensional scaling (NMDS) of the species use of habitat variables in a one-dimensional habitat space consisting of increasing elevation and decreasing slope angle, distance to ridge and distance to cliff showed horses to occur closest to urial (Fig.4.5, detailed output in Appendix 4). This implied a similarity in use of habitat variables but the two were quite separated spatially Sheep-goat were the next closest to urial, followed by donkey and yak.

Fig 4.3: Grazing patterns of livestock from the five hamlets in the study area during winter (Dec 2002 to March 2003)

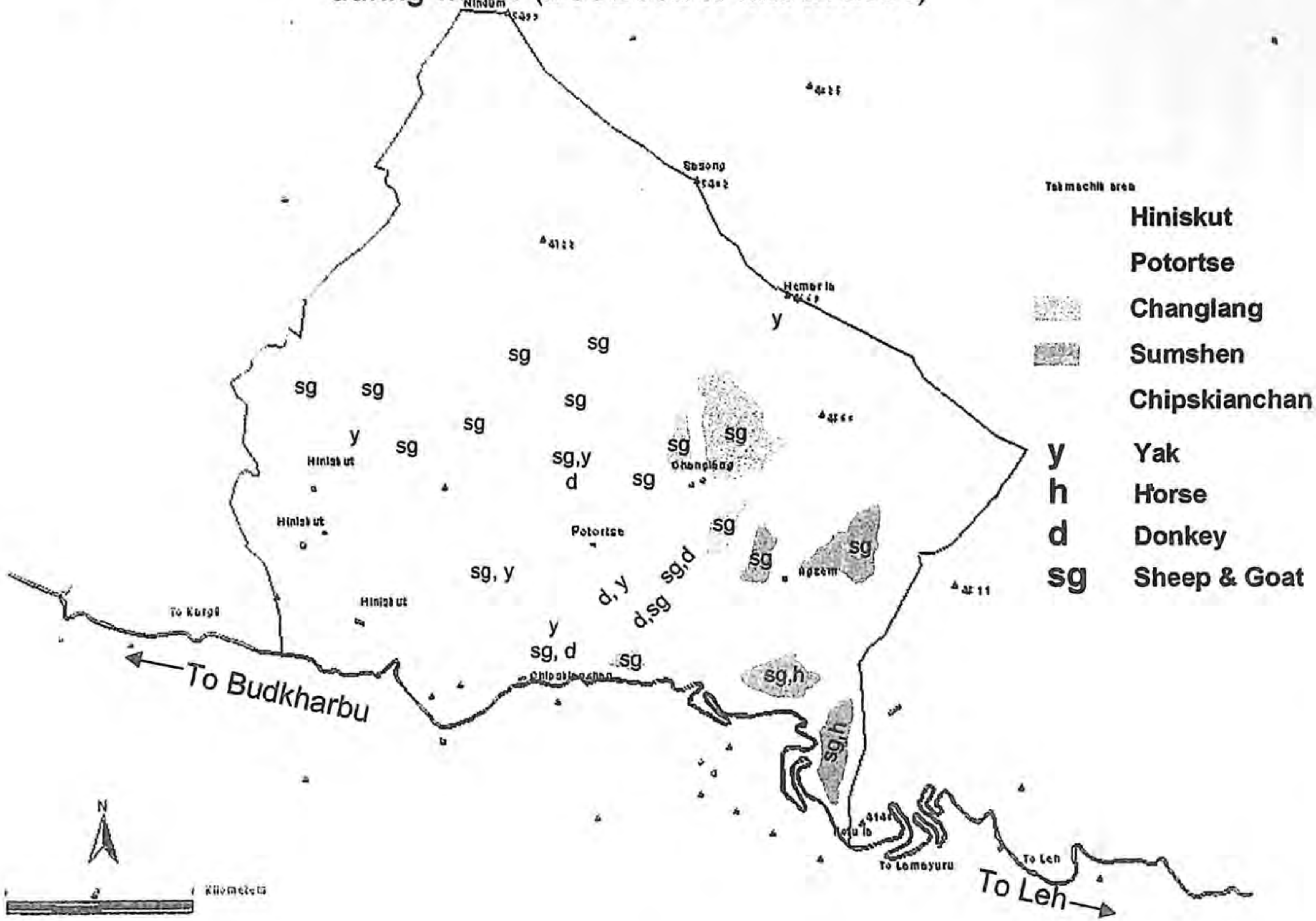


Fig. 4.4. Principal Component Analysis ordination of Urial and Livestock habitat use

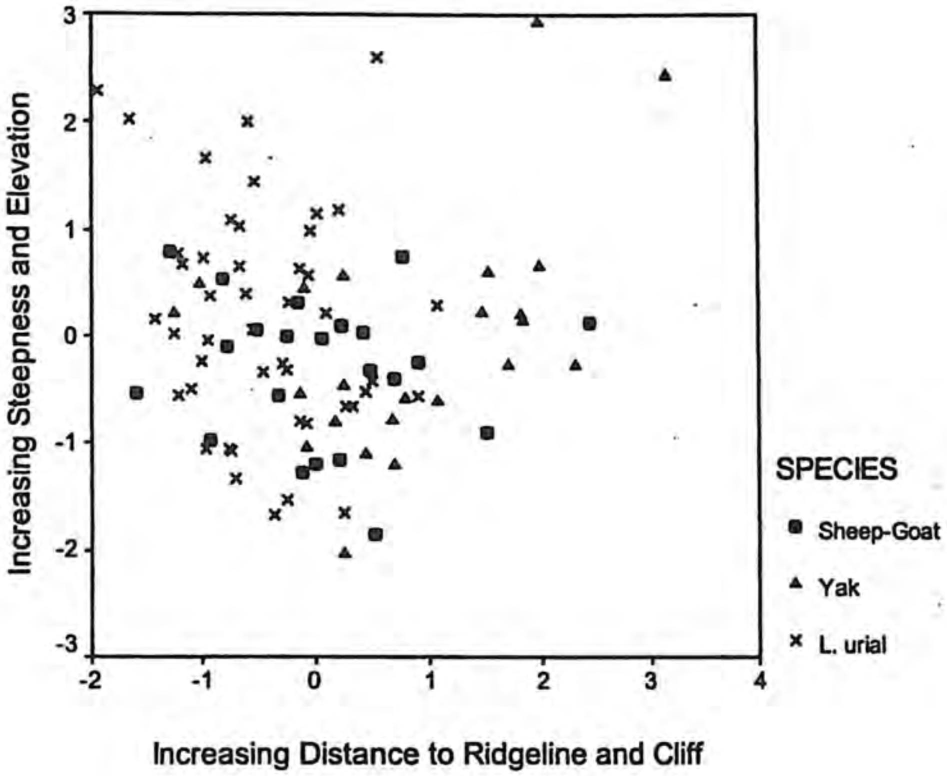
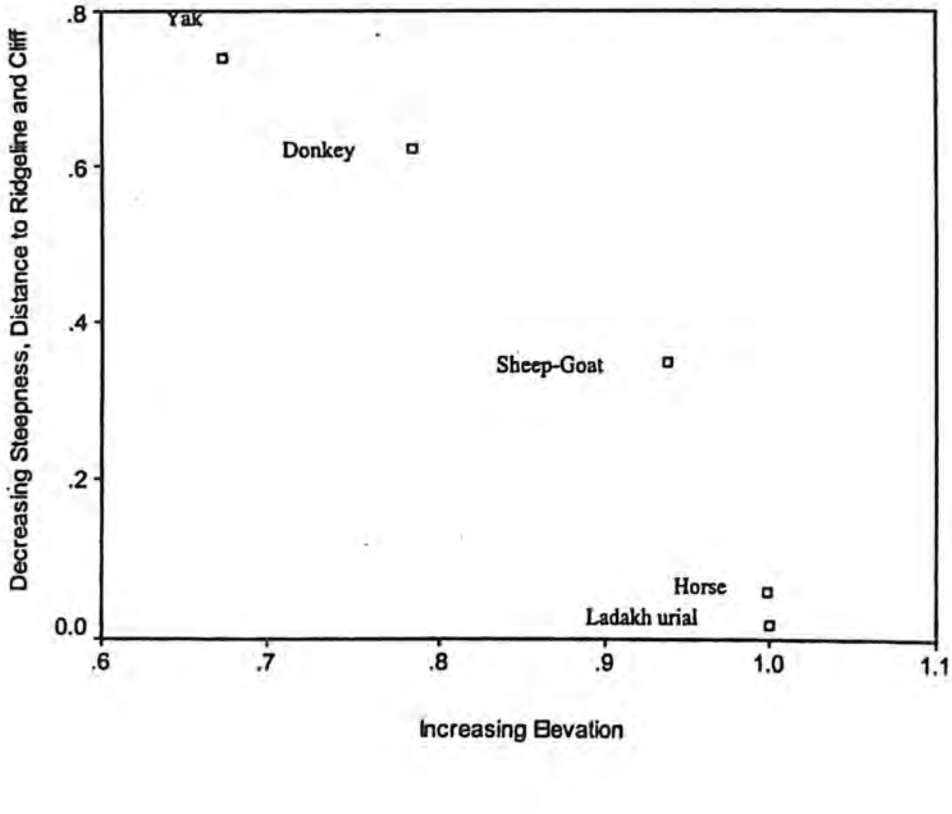


Fig. 4.5. Non-Metric Multi dimensional Scaling of Urial & livestock habitat use patterns



4.4. Diet Selection by Urial and Livestock

4.4.1. *Diet Selection by Urial*

The diet of the urial was found to consist of at least twenty-six different plant species. Bulk of the diet was contributed by four species – *Polygonum plebium, Silene moorcroftiana, Thermopsis* spp., *Causinia thomsonii* (71.5%) and most of the others formed a small percentage of total contribution to the diet (Table 4.4.).

4.4.2. *Livestock Diet*

Artemisia spp., *Polygonum plebium, Caragana* spp. and *Causinia thomsonii* and various grasses put together formed the bulk of the diet of yak (73%) and donkey (81%) (Table 4.4.). Similarly, over 75 percent of the sheep-goat diet comprised of *Polygonum plebium, Causinia thomsonii, Caragana* spp. And some grasses. Horses used a high proportion (74%) of grasses and *Caragana* spp. and were the only species that consumed relatively large amounts of *Eurotia* spp. (19%).

4.4.3. *Diet Separation Between Urial and Livestock*

The five most dominant species in urial diet contributed to 82 percent of its diet (Table 4.4.). For the same species, their relative contribution to livestock diet was highest for yak (65%), followed by sheep-goat (60%), donkey (56%) and horses (32%). Within these, all livestock species foraged most (>25%) on different graminoids while their proportion in the urial's diet was relatively low (9.6%). *Polygonum plebium* was foraged upon most by urial (23%) but its proportion was high mainly for yak (14%) and sheep-goat (14%). *Silene* spp.

and *Thermopsis* spp. had a fairly large contribution to the urial diet (35%) but their contribution to all livestock diets was minimal. *Causinia thomsonii* was another species that had a fair contribution to the urial diet (13%) and its use by all livestock except horses, was also fairly high (>8.5%).

Based on the above, it is evident that there are some similarities in the proportionate consumption of various species between urial and livestock diet but there were differences, too. Further, the overlap (Morista-Horn overlap Index) in diets between urial and sheep-goat was the highest (0.600), followed closely by yak (0.518). The overlap was relatively low with horses (0.224) and was least with donkeys (0.073).

4.5. Spatial Separation Between Urial and Livestock

The locations of both urial and livestock sighted during the study and plotted on a 1: 50,000 SOI toposheet (Fig.4.6.), revealed that urial were quite spread out in their distribution in the study area, mainly in the middle and higher elevations. Livestock sightings concentrated in the middle and lower elevations. From the distribution map of these locations, it is quite evident that the middle elevations were the zone of overlap between both urial and livestock, especially sheep-goat and yak. Fifty percent of the grids on the map shown in Fig.4.7. consisted of 'only urial' locations, 24.5 percent had 'only livestock' locations, while 15.5 percent grids had both urial and livestock.

Table 4.4. Species composition and percentage contribution of different plant species to Urial and livestock diet in the study area.

Species	Percentage Use				
	Urial (n=1254)	Donkey (n=1932)	Yak (n=2287)	Sheep-Goat (n=1856)	Horse (n=554)
Polygonum spp.	**22.9**	9.8	**13.9**	**14.2**	0.0
Silene spp.	**20.8**	0.7	3.4	2.3	0.0
Thermopsis spp.	**14.7**	0.0	3.1	0.0	0.0
C. thomsonii	**13.1**	9.3	8.5	**16.5**	0.0
Grass	9.6	**36.4**	**35.9**	**26.9**	**32.1**
Eurotia spp.	6.1	2.0	3.6	6.7	19.3
Caragana spp.	2.3	0.0	0.3	**18.2**	**42.2**
E. tibetica	1.6	0.0	0.0	0.0	0.0
P. microphylla	1.3	3.6	0.3	6.8	0.0
Artemisia spp.	1.1	**34.9**	**23.2**	0.0	0.2
A (7/12)	1.0	0.0	0.0	0.0	0.0
N. podostachys	1.0	0.0	0.0	0.0	0.0
Corydalis spp.	0.9	0.0	0.0	0.2	0.0
X (14/12)	0.7	0.0	0.0	0.0	2.7
H. spinatum	0.2	0.8	0.9	2.1	2.2
Potentilla spp.	0.2	0.0	1.3	0.4	0.0
A. lycopodoides	0.1	0.1	0.4	0.5	1.3
S. prostrata	0.0	0.4	2.1	2.6	0.0
UI (22/12)	0.0	0.0	0.9	0.0	0.0
Others*	2.6	2.0	2.2	2.6	0.0

*'Others' includes all forage species contributing not greater than 1 to all animal species' diet, and some unidentified plant species.

The spatial overlap (Sorenson's overlap) between urial and livestock was quite low (C_s= 0.37). This indicated that on the whole, though the urial and livestock used similar resources with respect to habitat variables and diet, they were quite separated ecologically at the level of space, especially along the use of elevations and distance to ridgelines and cliff. However, whatever overlap did occur was mainly seen in the middle elevations. This could be explained by the fact that the higher elevations were deficient in the principal plant species of the urial diet, such as *C. thomsonii*, which were quite abundant in the middle and lower elevations. Thus, urial might be using the middle elevations primarily for access to food.

4.6. Comparison between Study Area and Skambur-Dzaothang

After the first major snowfall in the study area, sightings of the study population of urial reduced drastically. It was then theorized that they should have moved to adjacent, more open, relatively snow free areas with more exposed vegetation than in the study area. This "new" area, known as Skambur-Dzaothang, was identified on the basis of interviews with locals to confirm presence or absence of urial in adjoining areas, trail walks in adjoining areas and vehicle transects wherever possible.

It was expected that the two areas would show significant differences in snow cover, which should be lesser in the new area, vegetation cover which should be greater in the new area and the dung densities of urial which should be greater or at least be comparable with that of the study area.

Figure 4.6 Map of Study area (Nindum Wildlife Sanctuary - Proposed) Showing Distribution of Ladakh Urial and Livestock (Dec. 2002 - Apr. 2003)

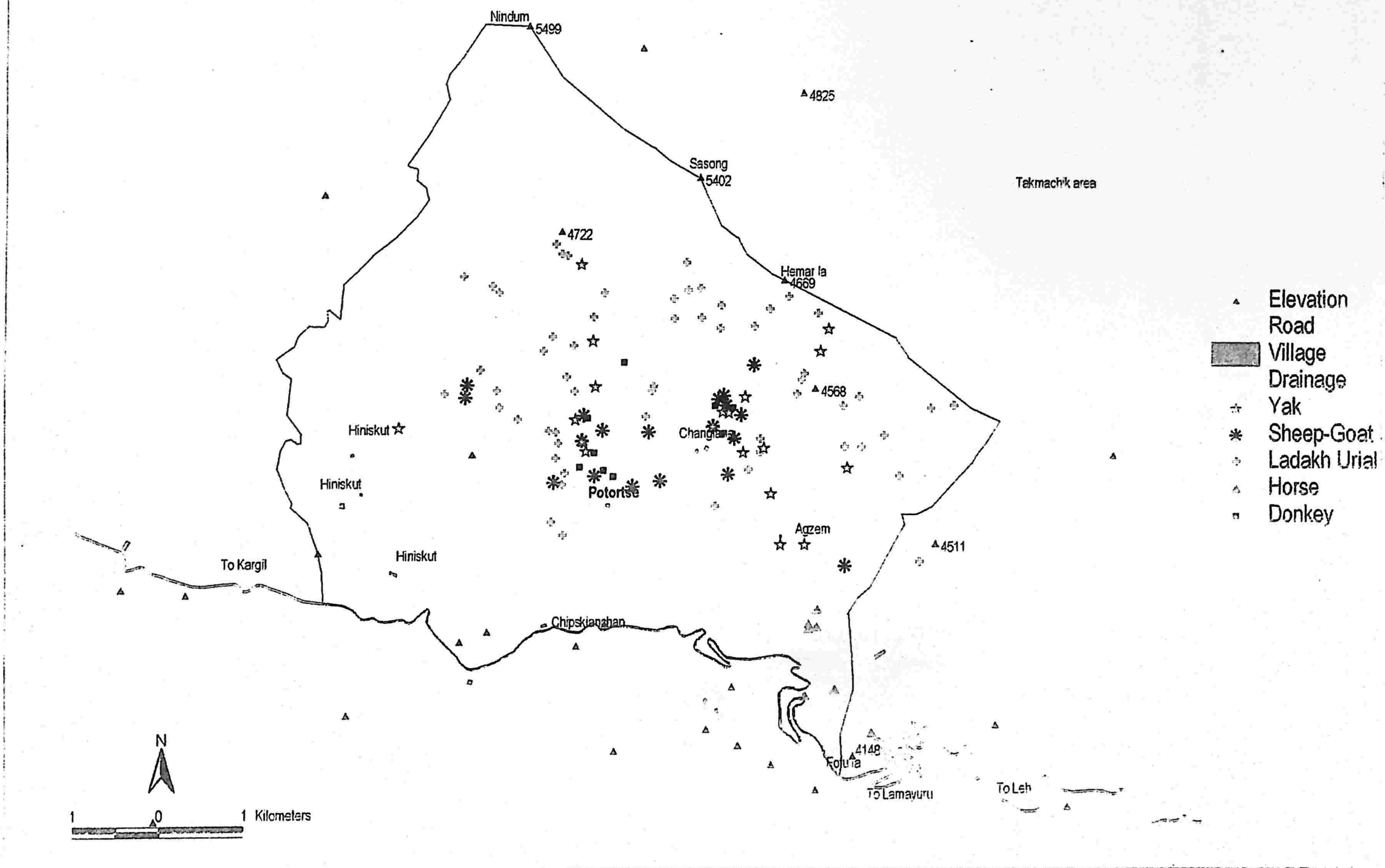
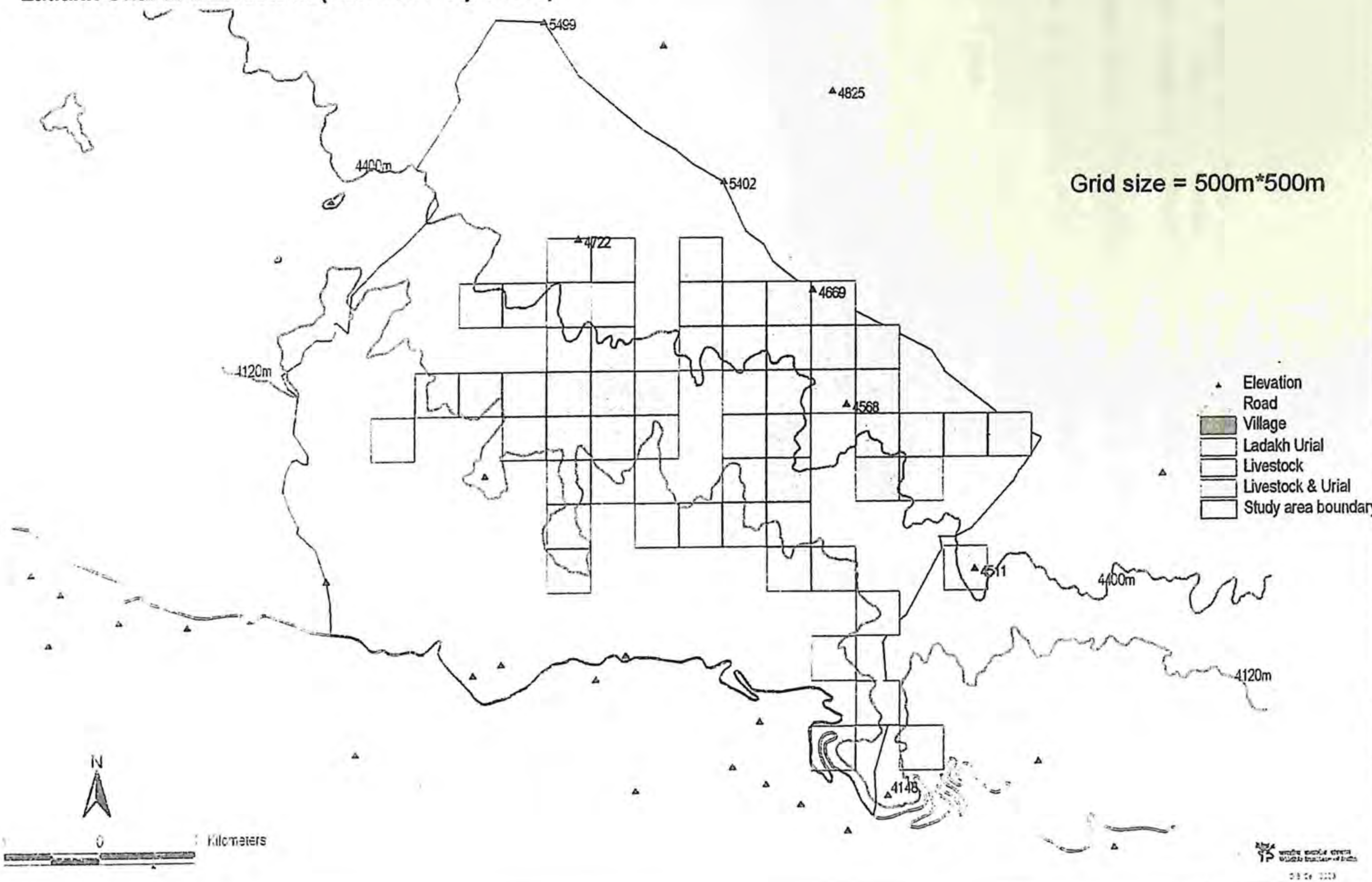


Figure 4.7 Map of Study area (Nindum Wildlife Sanctuary - Proposed) Showing Areas of spatial overlap between Ladakh Urial and Livestock (Dec. 2002 - Apr. 2003)



Snow Cover

During the season (late winter- early March) when snow cover was measured in the study area, total snow cover was found to be higher (75%, n=502) in the study area than in the Skambur-Dzaothang area (24%), which was more snow-free (76%). Most (71%) of the snow in the study area was deep (more than 1 ft in depth) and the rest light (>1 ft. deep).

Cover Type

The study area had more barren areas (60%) compared to vegetated area (38.17%) (Table 4.5.). The Skambur-Dzaothang area had comparatively more barren area (81%) and lesser vegetation cover (18%) than the study area.

Table 4.5. Availability of various categories of cover in the study area and in Sakmbur-Dzaothang

	Categories of Cover types	Percentage availability			
		Elevation zone			
		Higher (n=43)	Middle (n=936)	Lower (n=1040)	Overall (n=2756)
Study area	Barren	25.35	31.29	43.36	59.25
	Dung	2.82	2.14	2.79	2.58
	Vegetation	44.10	43.27	29.13	38.17
Skambur-Dzaothang area		Higher (n=530)	Middle (n=530)	Lower (n=530)	Overall (n=1590)
	Barren	78.9	84.2	79.8	81
	Dung	1.7	0.4	0.2	0.7
	Vegetation	19.4	15.5	20.0	18.3

5. DISCUSSIONS

5.1. Introduction

Interspecific Interactions among animals involve two dimensions- resource use and social interactions. Interaction based on resource use can occur at many levels and these can be broadly classified as facilitation and competition (Van de Koppel and Prins 1998). Facilitation among large herbivores is an important interaction in areas with high graminioid biomass, as with the African savannas, while in areas with low graminioid biomass, competition would be the dominant player (Jarman and Sinclair 1979, Van de Koppel and Prins 1998). A species interacting with another species can be using a particular resource, thus limiting the availability of that resource for the other species (Resource Limitation). Resource limitations can lead to competition if the resource use by the two species overlaps (Mishra 2001).

Under natural conditions, the competing species would evolve adaptive strategies to overcome the effects of competition. However, in the human influenced ecosystems that exist at present, wild animals stand little, if any, chance of out-competing domestic livestock, which have the advantage of stall fed supplementary diet and health care. Therefore competition between wild animals and livestock assumes greater importance in terms of the survival and maintenance of the population of wild animals.

The Ladakh urial, one of the highly endangered Himalayan caprinae (Shackleton 1997), is one of the many such wild animals affected by competition with livestock (Roberts 1977, Schaller 1979, Mallon 1991, Shackleton 1997, Chundawat and Qureshi 1999). The Ladakh urial radiated out from Central Asia, through parts of northern Pakistan, into the Ladakh region occupying the open alluvial fans along the Indus river valley. Through, most of their distribution range they have been found to occupy areas with gentle slopes and slightly undulating terrain (Roberts 1977, Schaller 1979, Mallon 1983, Mallon 1991, Shackleton 1997, Chundawat and Qureshi 1999, Raghavan and Bhatnagar unpublished). However, as seen earlier (Section 1.1), these areas are also the zones of maximum human activity, including cultivation, habitation, and development of roads and hydroelectric projects.

Gentle terrain, except along the northern ridgeline, which consisted of cliffs and rocky terrain leading to the peaks, characterized the present study area also. Although, the area was higher in average elevation than most areas of urial distribution, the area under the higher elevation zone was mostly gentle, while the middle elevations formed a gentle, more or less smooth, plateau-like area. These factors and the generally south-facing aspect of the area, all favor urial inhabitation. The main difference between the study area and the rest of the urial range lies in the generally higher elevations, and the overall vegetation cover, which is dominated by *Caragana* spp. (a species almost absent from the urial distribution range along the Indus river) while the rest of the urial range consists of lower elevations dominated by *Capparis spinosa, Stachys tibetica* and *Ephedra* spp.

5.2. Urial in the Study Area

The urial's habitat use patterns confirm their preference for very gentle slopes with smooth to sometimes broken terrain. They generally used very little steep slopes or rocky terrain. Although, the urial were seen to be restricted to the higher elevation zones even during winter, this study resolved that this was more out of a lack of choice than because of it, as shall be discussed later in this section.

Urial preferred to stay close to ridgelines/crests and cliffs. This study found the distance to ridgeline, especially, to be an important variable for their escape strategy. The urial, like other wild sheep, use speed to escape predators. However, on perceiving danger they were seen to escape to the nearest crest or ridgeline, possibly to enable the monitoring of predators (danger) from a safer distance and to keep them in sight. It is worthwhile to mention here that probably due to the pressures of hunting in the recent past and some stray occasions still taking place, the flight distance of urial on sighting humans was extremely large (minimum distance being 150m, *pers. obs.*).

The openness of the terrain meant that the urial, too, were conspicuous to the predators. Since, they rarely use cliffs as escape terrain, preferring to use speed and as seen here, ridgelines to escape danger, the most favorable anti-predator strategy would be to stay in large groups (Geist 1971). Add to that the still persistent threat of hunting, the urial would form cohesive groups that ensure equal safety to all. This probably explains the occurrence of such unusually large groups seen during the study that often ranged from 30 to 73 animals. The typical group size was found to be 38 individuals. Such large group sizes have been reported from the same area by previous workers during other seasons also (Chundawat and Qureshi 1999, Raghavan and Bhatnagar unpublished, Ranjitsingh, M. K., *pers. comm.*,).

In a season with the least resources in the generally resource deficient Trans-Himalaya, consistent formation of such large groups seems unusual. Most other caprini in the region rarely formed such large groups. in the ibex, fluid aggregations of upto 70 were observed very briefly during spring at patches of snowmelt and sprout (Bhatnagar 1997). Similar observations on the bharal were made by Chundawat (1992). While antipredatory or anti-hunting strategy may be a factor, the trade-off between this and the possibility of increased inter-group competition (as suggested for other ungulates by Aldos 1985, Risenhoover and Bailey 1985, Gross *et al.* 1995) needs further investigation. The large group sizes also meant that the number of sightings reduced considerably, as most of the animals would occur in one to two large groups.

5.3. Migration out of Study Area

Sightings were reduced drastically in the period immediately after heavy snowfall (Late February to March) in the study area. Snow cover is a hindrance in the access of food by mountain ungulates though they still manage to dig the snow to access the underlying vegetation (unless the snow becomes hard and compact) (Schaller 1977, Schaeffer and Meissier 1995, Bhatnagar 1997). However, the benefits of such efforts are likely to be higher than the cost if the vegetation underneath is erect and easy to access, has more cover and is palatable to the animal (Geist 1971, Schaeffer and Meissier 1995). In the higher elevations to which urial are restricted, such 'erect' shrubs are few and prostrate forms dominate which get flattened on the ground and are difficult to forage upon. The cost of digging such forms is likely to be greater than the returns. Hence, the urial, like other mountain sheep (Geist 1971) are likely to undertake migrations to nearby areas that are snow free and have more 'exposed' vegetation. In the case of the present study, this happens to be the area of Lamayuru (snow cover=24% vs. 76% in the study area). Once the snow cover in the study area started diminishing, the urial probably migrated back as evident from their resighting in mid-April.

5.4. Livestock in the Study Area

The livestock population of the study area consisted of a total of about 820 animals (excluding the 300 heads of sheep-goat from Hiniskut, which were not grazed in the study area). The past four years were 'drought' years with very little or no summer/winter precipitation, forcing some people from the nearby villages of Lamayuru and Khalsi to graze an additional 200 odd livestock in this area during summer. Thus, the pressure of 1020 livestock grazing an area of 40 Km^2 seems substantial. The lack of precipitation as snow or rain that would have otherwise rejuvenated the pastures in the form of new sprout and growth, has also compounded the problem.

5.5. Ecological Separation between Urial and Livestock

As seen in the Chapter 4, livestock and urial use similar habitat. Both urial (48%) and livestock (> 60%, Table 4.3.) primarily used the middle elevations, though urial used higher elevations also almost as much. The use of very gentle slopes (48% for urial, and around 75% for livestock species) and proximity (within 50m for urial and 100m for livestock) to ridgelines and cliff (Table 4.3.) were also common to both. Although, the use of particular areas by livestock are a reflection of the choice made by the herders (Section 4.3.2.), it does not remove from the fact that they *are* using these resources and shall continue to do so as long as they are grazed in the same areas. We thus see that along the gradients of elevations, slope, distance to ridgeline, distance to cliff and aspect there was substantial overlap in usage. The important point to note is that in spite of this overlap, while urial continued to use steeper slopes on upper elevations to a substantial degree (> 40%), such areas were almost entirely avoided by livestock.

The Morista-Horn index of overlap also showed similarity between the diets of the two groups, with greater similarity between the diets of urial and sheep-goat (C_{λ} = 0.60). Three main species were shared between them including *Polygonum plebium* (urial=22.9%, sheep-goat=14.2%), *C. thomsonii* (urial=13.1%, sheep-goat=16.5%) and grasses to some extent (urial=9.6%, sheep-goat=26.9%). This clearly indicates an overlap in the resource use between the two groups. Could this also mean resource limitations for the urial?

When resources are sparse, the urial like other wild herbivores would disperse to areas where they can access better resources (Festa-Bianchet 1989). In the study area, this would mean the middle and lower elevations. But these areas are where the livestock also occurred and hence, maximum overlap for use of resources occurred in this region. This is evident from the map (Fig. 4.7.) showing the distribution of urial and livestock locations in the study area. The urial would then be 'forced' to go back to areas not being used by livestock at least in the winter season (period of the present study) – the higher elevations. The information on the vegetation cover and composition of the study area shows that the higher elevations consists of mainly prostrate species which would be relatively difficult for animals to forage upon than erect shrubs like *Caragana* and *C. thomsonii*. Thus it seems fair to conclude that livestock are limiting the use of better 'food' species (resources) by urial through their sheer presence in areas where such resources occur and by their use of these resources. Therefore, we suggest that the urial are being competitively 'excluded' out of the middle and lower elevations by the livestock.

Resource limitations in large herbivores have shown to reflect in their population characters as loss of body condition, greater mortality and lower fecundity (Clutton-Brock *et al.* 1988, Wilson and MacLeod 1991). During three years of sampling, Mishra (2001) found that pastures grazed 'moderately' by livestock consistently had higher young: adult female ratios for bharal, compared to the 'intensively' grazed ones. Even the intensively grazed pastures had a young: adult female ratio varying between 43 to 78 young per 100 females. Based on this, the ratio of 33 urial young to 100 adult urial females for the present study appears to be on the lower side, thus, reflecting resource limitation. The natural resilience of a population would allow the population under stress to bounce back to normal only if the limiting factors are removed. If that does not happen, the populations are likely to break down and the numbers will decline until they reach levels that can be maintained at the low resource that exists.

The question that remains to be answered is whether urial populations in the study area and Ladakh as a whole are undergoing, have undergone or will undergo such a situation!

5.6. The Urial in Ladakh- Status and Threats

Most surveys conducted in the recent past (Fox *et al.* 1991, Chundawat and Qureshi 1999) reported an urial population close to 1500 individuals. However, since the above-mentioned figures were at least 1000 individuals more than the previous estimate of 500 (Mallon 1983), it was concluded that the urial population in Ladakh (which had been undergoing a drastic decline due to heavy hunting) was finally recovering and on the increase.

However, based on the findings of this study and surveys conducted in summer 2002 and March 2003 (during the period of this study), we suggest that the urial numbers may actually be stagnant, if not on the decline. The March 2003 survey was conducted in parts of the urial range along the Indus river, from Khalsi to Leh. The survey yielded low urial sightings most of which were on steep slopes bisecting the plateaus and rolling slopes.

The survey also revealed the vast expanses of alluvial plains, plateaus and rolling slopes at lower elevations along the Indus (traditional habitat of the urial), to be highly degraded. Two places sampled near Saspol had less than 6% cover of closely cropped vegetation was grazed by livestock. Further, there is immense pressure from agricultural and horticultural activities. As mentioned before, the area along the Indus River valley is also the most fertile and sees maximum human activity. Entire valley bottoms with moist sedge meadows and water sources have been converted to cultivation. Since these meadows would have otherwise formed critical spring habitat for the urial, their conversion to cultivation or plantation making them unavailable to the urial creates avenues for resource limitation and conflict if the urial do manage to enter such areas.

Construction of roads along these gorges, leading to villages higher up and irrigation projects along the Indus river have disturbed the urial's habitat and further threatened its fragile population.

Thus, based on restricted pockets where the urial were seen to occur and can occur, given the major land-use changes that have taken place in their traditional habitat, we suggest that it is unlikely that urial population in Ladakh is increasing. In fact, it seems more probable that they are actually facing, if not already on, the decline.

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APPENDIX 1. ABOUT THE LADAKH URIAL

LADAKH URIAL, *Ovis vignei vignei*, Gmelin

Vernacular Names: *Shapo* (male), *Shammo, Shanmar* (female) (Ladakhi)

Size
Body Length: 130-185 cm
Shoulder Height: 62-110 cm
Weight: Male [illegible] kg, Female 40-[illegible]
Horn length: Male 100-145cm, Female 15-30cm, record 37

Distribution & Habitat

A subspecies endemic to the Ladakh region. Occurs is relatively less steep and rolling slopes usually below 4,200m – mainly along the Indus River and the Shyok River and their tributaries. Within India occurs along the Indus almost continuously from Upshi in the east till Dha-Hanu; a side population also occurs in the Wanla-Lamayuru-Nindum area towards the south and in the Markha Valley. The Shyok population is mostly concentrated around Tirit-Sumur and some occur further upstream along the Nubra River and along the Diskit-Khalsar area. Distribution in India covers *ca.* 2,000km^2. Small populations also reported from the Shigar valley, Gilgit and Skardu regions of PoK. Other related subspecies are distributed in the Kirthar, Safed Koh and Hindu Kush ranges in Pakistan and in parts of eastern Afghanistan and Tajakistan.

Description

Smallest wild sheep species. Adult urial are grey-brown in winter coat, but are rufous grey or brown during the rest of the year. Adult rams sport a black or grizzled ruff, which grows from the side of the chin and meets below and extends down the throat. The ruff is more pronounced during winter and in males older than about 5 years. In adult rams a dirty white and indistinct saddle patch is present. They have a dark spot under the foreleg that may extend on to a lateral stripe in some males. Females are similar, but lack the saddle patch and invariable have just a dark spot under their forelegs. Underparts and rump patch in all age-sex classes are white. Male horns curve up, back, downwards and in large males turn a bit inwards. Females have short, parallel horns and are not divergent as in bharal and argali. Grey patches on face from the eye till the chin is present in both sexes.

Behaviour

Ladakh urial are primarily animals of the lower slopes, usually below 4,200m; rarely occur up to 4,800m as in the proposed Nindum Wildlife Sanctuary. Occur on gradual to moderate slopes, but have probably been pushed to use steeper and rockier gorges along the side valleys of Indus due to excessive anthropogenic pressures. Has long, lithe limbs that facilitate fast flight from potential danger. They are also known to retreat into cliffs or steep slopes to escape predators such as wolf and snow leopard. Usually occur in small groups of 5-12 animals, however, in certain areas and in seasons such as spring may occur in larger groups of *ca.* 80 animals. Sexual segregation is reported during much of the year barring the rutting period.

Is an intermediate forager, consuming grasses, forbs and shrubs in different seasons. During the rut solitary males may travel vast distances in search of oesterous females. Contests between males are in the typical form of sheep, where two opposing rams clash into each other from some distance producing a loud clack. They may then involve in shoulder pushing and horn entwining.

Reproduction & Life Cycle

Gestation Period: 155-180 days.
Rutting: Peaks for about 15 days in Nov to Jan (varies between years and regions)
Young per Birth: 1 or 2
Weaning: Gradual, without a sharp cutoff.
Sexual Maturity: At 1.5-2 years, although males do not reach their full potential before age 5-7
Life span: Up to 10-15 years. Males rarely survive beyond their 7-8th year

Appendix 2.a. Some aspects of livestock herding and removal of plant biomass by humans in the study area, Nindum Wildlife Sanctuary- Proposed

Category of resource use	Resource use
Livestock population	
Yak/Demo	20
Cross-bred	45
Sheep-Goat	600-700
Donkey	50
Horse	4
Livestock species stall fed and amount fed (kg per day)	
Yak/Demo	0.5
Zho/Zhomo	0.5
Cross-bred	2-3
Sheep-Goat	1
Donkey	0.5
Horse	-
Plant species (pasture) stall fed	*C. thomsonii*, *Cirsium* spp., *Aconogonum* spp., *Caragana* spp., *H. spinatum*, *Stachys* spp., *Artemisia* spp., *Eurotia* spp.,etc.
Household waste, etc. stallfed	Barley flour cake, Barley waste from Chhang, Vegetable waste
Time period spent on pasture-winter (hours per day)	
Yak/Demo	6-7
Cross-bred	-
Sheep-Goat	4-6
Donkey	3-4
Horse	Throughout
Time period spent on pasture-summer (hours per day)	
Yak/Demo	Throughout
Zho/Zhomo	-
Cross-bred	-
Sheep-Goat	10-12
Donkey	7-8
Horse	Throughout
Plant biomass removed from Pastures (quintals per household per season)	
Fuel	10-20
Fodder	40-50
House building	10
Season of removal of pasture plant biomass	Aug-Sept
No. of days spent in removal of pasture plant biomass in a season	10-15
No. of hours spent per day in removal of pasture plant biomass in a season	10 hrs per day

Appendix 2.b Livestock holding trends in Lamayuru (Sheep Husbandry Department, LAHDC, Leh, Ladakh, Jammu and Kashmir)

Year	Livestock	Lamayuru	Total
2002-2003	Sheep	1082	2193
	Goat	1111	
2001-2002	Sheep	1438	3274
	Goat	1836	
1999-2000	Sheep	5956	10312
	Goat	4356	
1998-1999	Sheep	2513	6426
	Goat	3913	
1997-1998	Sheep	2257	5082
	Goat	2825	
1996-1997	Sheep	2480	5577
	Goat	3097	
1995-1996	Sheep	1975	4971
	Goat	2996	
1994-1995	Sheep	1649	3774
	Goat	2125	
1993-1994	Sheep	1940	4931
	Goat	2991	
1992-1993	Sheep	1787	4124
	Goat	2337	
1991-1992	Sheep	1284	2781
	Goat	1497	
1989-1990	Sheep	983	
	Goat	1224	2207

Appendix. 3. Detailed SPSS (Norussis 1997) output of Principal Component Analysis of habitat use by Ladakh urial and livestock

Correlation Matrix

		ASP	TERRAIN	SLOPE	RIDGE	CLIFF	ELEVN
Correlation	ASP	1.000	.064	.084	.063	.216	-.015
	TERRAIN	.064	1.000	.283	-.144	-.262	.033
	SLOPE	.084	.283	1.000	-.044	-.032	.308
	RIDGE	.063	-.144	-.044	1.000	.436	.145
	CLIFF	.216	-.262	-.032	.436	1.000	-.101
	ELEVN	-.015	.033	.308	.145	-.101	1.000
Sig. (1-tailed)	ASP		.274	.213	.277	.020	.443
	TERRAIN	.274		.003	.087	.006	.377
	SLOPE	.213	.003		.340	.381	.001
	RIDGE	.277	.087	.340		.000	.085
	CLIFF	.020	.006	.381	.000		.171
	ELEVN	.443	.377	.001	.085	.171	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.465
Bartlett's Test of Sphericity	Approx. Chi-Square	53.144
	df	15
	Sig.	.000

Communalities

	Initial	Extraction
ASP	1.000	.740
TERRAIN	1.000	.590
SLOPE	1.000	.662
RIDGE	1.000	.664
CLIFF	1.000	.724
ELEVN	1.000	.757

Extraction Method: Principal Component Analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.665	27.757	27.757	1.665	27.757	27.757
1	1.665	27.757	27.757	1.665	27.757	27.757
2	1.397	23.290	51.047	1.397	23.290	51.047
2	1.397	23.290	51.047	1.397	23.290	51.047
3	1.075	17.909	68.957	1.075	17.909	68.957

2	1.397	23.290	51.047	1.397	23.290	51.047
3	1.075	17.909	68.957	1.075	17.909	68.957
4	.771	12.843	81.800			
5	.673	11.214	93.013			
6	.419	6.987	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix

	Component		
	1	2	3
ASP	.211	.391	.737
TERRAIN	-.612	.275	.374
SLOPE	-.407	.704	2.811E-02
RIDGE	.650	.429	-.239
CLIFF	.786	.283	.163
ELEVN	-.202	.639	-.555

Extraction Method: Principal Component Analysis.
a 3 components extracted.

Component Score Coefficient Matrix

	Component		
	1	2	3
ASP	.127	.280	.686
TERRAIN	-.368	.197	.348
SLOPE	-.244	.504	.026
RIDGE	.390	.307	-.223
CLIFF	.472	.203	.152
ELEVN	-.121	.457	-.516

Extraction Method: Principal Component Analysis. Component Scores.

Component Score Covariance Matrix

Component	1	2	3
1	1.000	.000	.000
2	.000	1.000	.000
2	.000	1.000	.000
3	.000	.000	1.000
3	.000	.000	1.000

Extraction Method: Principal Component Analysis. Component Scores.

Appendix. 4. Detailed SPSS (Norussis 1997) output of Non-metric multidimensional Scaling of habitat use by Ladakh urial and livestock

```
Alscal Procedure Options


Data Options-

Number of Rows (Observations/Matrix).    4
Number of Columns (Variables) . . .      4
Number of Matrices    . . . . . .        5
Measurement Level . . . . . . .          Ordinal
Data Matrix Shape . . . . . . .          Symmetric
Type  . . . . . . . . . . . .            Dissimilarity
Approach to Ties  . . . . . . .          Leave Tied
Conditionality . . . . . . . .           Matrix
Data Cutoff at . . . . . . . .            .000000


Iteration history for the 2 dimensional solution (in squared distances)

                 Young's S-stress formula 1 is used.

               Iteration      S-stress       Improvement

                   0            .00009
                   1            .00005

                        Iterations stopped because
                        S-stress is less than    .005000

             Stress and squared correlation (RSQ) in distances

RSQ values are the proportion of variance of the scaled data
(disparities)
            in the partition (row, matrix, or entire data) which
             is accounted for by their corresponding distances.
              Stress values are Kruskal's stress formula 1.

         Matrix      Stress      RSQ    Matrix      Stress      RSQ
            1          .002    1.000       2          .000    1.000
            3          .000    1.000       4          .000    1.000
            5          .000    1.000


         Averaged (rms) over  matrices
      Stress  =    .00071      RSQ = 1.00000
```

Configuration derived in 2 dimensions

Stimulus Coordinates

Stimulus Number	Stimulus Name	Dimension 1	2
1	SLOPE	-.5950	-.6438
2	ELEVN	1.7319	1.7284
3	RIDGE	-.5670	-.6133
4	CLIFF	-.5699	-.4713

Subject Weights

Subject Number	Weird-ness	Dimension 1	2
1	.9434	.9998	.0181
2	.5492	.6729	.7397
3	.0604	.9380	.3465
4	.3969	.7837	.6211
5	.8152	.9982	.0593
Overall importance of each dimension:		.7886	.2114

Flattened Subject Weights

Subject Number	Plot Symbol	Variable 1
1	1	1.2114
2	2	-1.2990
3	3	-.0392
4	4	-.8946
5	5	1.0214