

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

FINAL REPORT

Submitted to

THE INTERNATIONAL SNOW LEOPARD TRUST

By

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INTRODUCTION AND OBJECTIVES

1.1. Introduction

The Ladakh urial (*Ovis vignei vignei*) is a highly endangered animal (IUCN Red List 2000) listed in the Appendix 1 of CITES and Schedule 1 of the Indian Wildlife Protection Act 1972. Its numbers had been reduced to a few hundred individuals in the 1960s and 70s through hunting for trophies and meat (Fox *et al.* 1991, Mallon 1983, Chundawat and Qureshi 1999, IUCN Red List 2000). However, with the protection bestowed by the IWPA 1972, and resultant decrease in hunting, the population seems to have shown a marginal increase to about 1000-1500 individuals in its range in Ladakh (Chundawat and Qureshi 1999, IUCN Red List 2000).

Although the species had in the past, been able to coexist with the predominantly Buddhist society of Ladakh, the recent increase in the population of both humans and their livestock has placed immense pressures on its habitat (Shackleton 1997, Chundawat and Qureshi 1999, Raghavan and Bhatnagar 2003). This is especially important considering that the Ladakh urial habitat coincides with the areas of maximum human activity in terms of settlements, agriculture, pastoralism and development, in Ladakh (Fox *et al.* 1991, Chundawat and Qureshi 1999, Raghavan and Bhatnagar 2003). Increased developmental activities such as construction of roads, dams, and military bases in these areas have also increased the access to their habitat. This has consequently made the species more vulnerable to the threats of poaching and habitat destruction (Fox *et al.* 1991, Chundawat and Qureshi 1999, Raghavan and Bhatnagar 2002).

Pressure from increased livestock grazing is one of the major threats faced by the species today (Shackleton 1997, Fox *et al.* 1991, Mallon 1983, IUCN Red List 2000 Chundawat and Qureshi 1999, Raghavan and Bhatnagar 2003). In the impoverished habitat provided by the Trans-Himalayas, there is great competition for the scarce resources between various animal species surviving here (Fox 1996, Mishra 2001). The presence of livestock intensifies this competition and can either force the species out of its niche (competitive exclusion) by displacing it from that area or resource, or lead to partitioning of resources between the species, spatially or temporally, for coexistence (Begon *et al.* 1986, Gause 1934).

1.2. Objectives

This study thus, aimed to investigate the resource partitioning between the Ladakh urial and livestock in the resource crunch period of winter, by looking into how they separate at various scales of resource selection. Competition for food and habitat would result in the inferior competitor bearing the cost of decreased availability of resources. This cost would be reflected in the population as increased mortality (especially in certain vulnerable age and sex classes such as lambs and rutting males) or decreased reproductive success (Schoener 1977, Clutton-Brock *et al.* 1988). Keeping this in mind, the following objectives were framed: -

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.

The Ladakh urial forms one of the prey species of the snow leopard in Ladakh. A reduction in its numbers would mean a reduction in the prey base of the snow leopard and thus, possibly, some imbalances including increased depredation on livestock by it. This study

would address some important research and information needs relating to snow leopard conservation, as determined by the ISLT's SLSS consultations for the Himalayan region. These include- 'prey species distribution and "hot spots"', 'prey population baseline and trends', 'wild ungulate-livestock interactions (competition)', 'grazing pressure and range conditions', 'socio-economic profiling of herder communities', and 'livestock and human population status and trends'.

1.3. Background Information

1.3.1. Prior Research And Conservation Action- Though there have been a few studies on the distribution and abundance of the Ladakh urial, none of these have been directed solely at the species. Most of them have dealt with surveys of Trans-Himalayan mammals, and the Ladakh urial has formed a part therein. These studies include those by Schaller (1977) and Roberts (1978) in Pakistan, Mallon (1983), Fox et al (1991), Shackleton (1997), Chundawat and Qureshi (1999), and more recently a short survey by the authors (Raghavan & Bhatnagar 2003) in India.

As far as studies on interactions between livestock and wild mountain ungulates is concerned, studies have been conducted on Blue sheep (*Pseudois nayaur*) by Mishra (2000), Himalayan Ibex (*Capra ibex sibirica*) by Bhatnagar (1997). However, this study would be the first to address the issue between the Ladakh urial and livestock. It would also be the first systematic study on the Ladakh urial.

The proceedings of the recently held workshop on 'Evolving Sustainable Livestock Grazing Policy Guidelines and Practices in the Himalaya', at the Wildlife Institute of India, Dehradun, show that there is very little information available on the issue of grazing practices and conflict with wildlife. The policy guidelines on grazing, developed in the course of the workshop will be discussed with the local government in Ladakh in November 2002. If accepted, the implementation of these suggestions in the Changthang plateau (which has a primarily pastoralist community) of Ladakh, would be the first of its kind for this region

1.3.2. Study Area- The intensive study area lies in the Chipskianchan-Potorche-Fotu la area of western Ladakh, Jammu and Kashmir (see map), between 76° 45' E and 76° 37' W latitudes and 34° 23' N and 34° 16' S longitudes, covering approximately 70 Km² (see map in Appendix 1) This area was proposed as the Nindum Wildlife Sanctuary (Chundawat and Qureshi 1999) and seen to have a good population of urial, moderate livestock density and was also logistically viable (Raghavan and Bhatnagar 2003).

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 the 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).

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 the 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 on use (obtained through direct observations from monitoring trails) 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 as soon as animals were seen feeding.

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

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	3800-4120m
	Middle	4120-4400m
	Upper	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
	Rocky	Usually gentle to steep slopes with rock or stone cover >20% but <30 %, and relatively lesser vegetation cover than smooth terrain (includes scree slopes)
	Broken	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 3.4. 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

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 head held above shoulders
Resting	Sitting or sleeping

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. 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 (Geist 1971). 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. These 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.

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. 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 and results considered significant at $P \geq 0.05$. 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. Compositional analysis (Aebischer *et al.* 1993) was performed to rank plant species according to their importance in urial diet.

The Morista-Horn index (C_{MH}) 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 compared.

Due to shortage of time and personnel, unforeseen and record snowfall in the study area this year (making logistics of movement and data collection difficult), and shortage of funds, two other objectives of the study could not be met with. These were: 1) to study the population size and structure of Ladakh urial in relation to the varying livestock pressures at different sites within the Ladakh urial range, and 2) to study the resource use patterns of local communities and social transformations in different sites within the Ladakh urial range.

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 of 46 groups of urial (with 834 individuals sighted) were seen 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 individual sightings, 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 km² and an overall population of *ca.* 157-165 individuals. The group density was found to be 0.22 (± 0.05) groups per km².

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%).

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

4.1.3. 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).

4.2. Study Area Characteristics

The study area is described in terms 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 also 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). However, in the higher elevation zone, the area above 5,000m (20.9%) consisted of steep and rocky slopes that rose sharply (slope angle $> 40^\circ$) 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) consisted of gentle slopes (11-20°). A very small proportion (6%) was steep ($>30^\circ$), 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 (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 (refer to section 3.1).

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 35% respectively) (Table 4.2). Higher elevations were mainly rocky (51%) while both middle and lower elevations were characterized by smooth terrain (39.5% and 58 % respectively).

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. Seventy-two per cent of plant species in the higher elevations were erect shrubs, herbs, or graminoids and 22% were prostrate forms, the rest being cushionoid forms. In the middle elevations, erect shrubs, herbs and graminoids dominated (88%). Prostrate forms covered 9% area. In the lower elevations too, the erect forms and graminoids dominated (90%) over the prostrate forms (10%). The graminoid cover was least in the higher elevations (0.6%). The middle and lower elevation zones had between 12-15% grass cover. However, most grasses were already heavily grazed at the start of the winter season (*pers. obs.*).

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'.

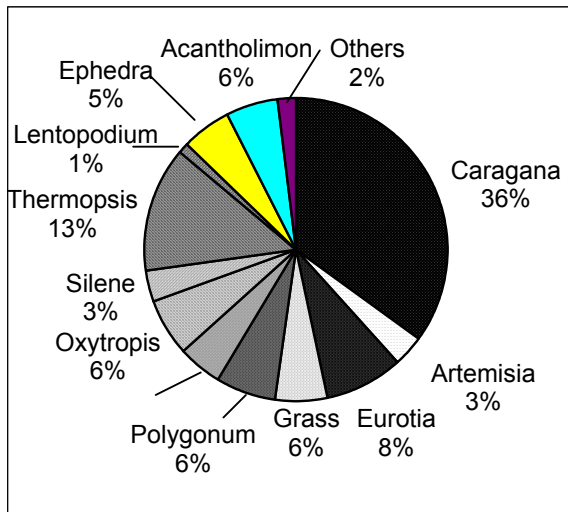
Livestock have little choice in the use or selection of variables like distance to ridgeline and cliff as most of them are herded or left on pastures that reflect the convenience of their owners. Hence, use of habitat variables by livestock has been analyzed only so far as they serve to compare against use by urial, and do not necessarily reflect selection exercised by them. In the season of study (winter), horses were seen to use an area close to the highway, near the eastern boundary of the study area, that was never used by urial. Hence, they have not been considered in any analysis. However, they might possibly compete with urial in the

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

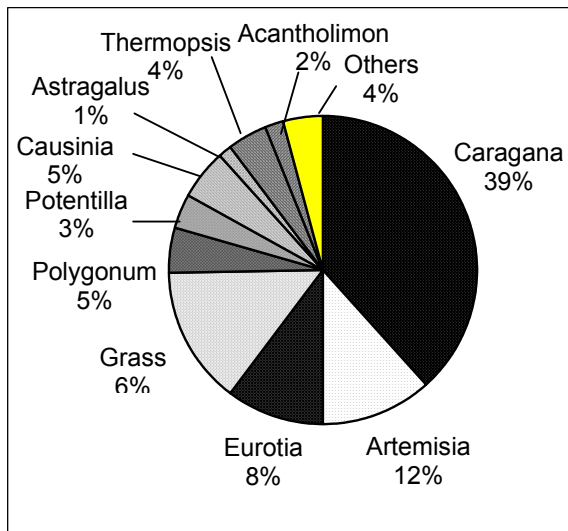
Habitat Variables	Percentage availability				
	Elevation zone				
	Categories	Higher (n=43)	Middle (n=38)	Lower (n=36)	Overall
Elevation (m)	3800-4120			100.0	30.8
	4121-4400		100.0		30.8
	4401-5000	79.1			30.8
	5001-5400	20.9			7.7
Slope (degrees)	0-10 (Very gentle)	16.3	34.2	30.6	26.5
	11-20 (Gentle)	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	27.9	34.2	16.6	26.5
	Rocky	51.2	26.3	25.0	35.0
Cover types*	Barren	53.08	54.59	68.08	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

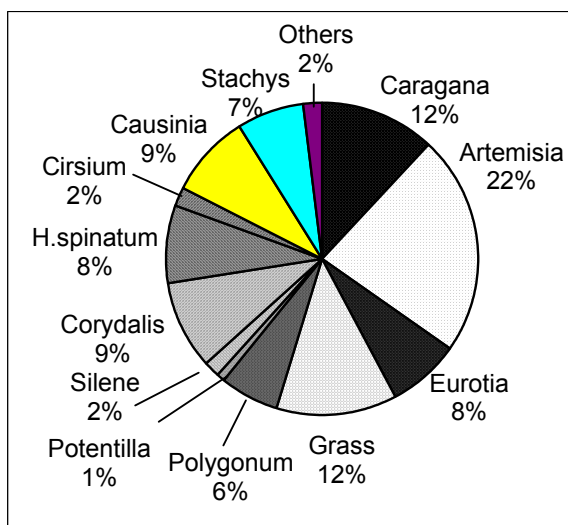
Fig. 4.1. Species composition of overall vegetation cover in each elevation zone



a) Higher elevations
 Others= *Causinia* 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.

summer months when they use similar areas as 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 (44%) 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 100m of a ridge or 300m of a cliff were avoided (Table 4.3.).

Urial used southern aspects more (47%). However, the northern and eastern aspects showed preference. Urial seemed to use and prefer broken (22%), smooth (24%) and rocky (35%) terrain, but avoided snow.

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 avoided areas with slope angle $>10^\circ$. 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 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.) unlike Sheep-Goat which are more comfortable than yak on such slopes and used all terrain types except rocky (4%).

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.

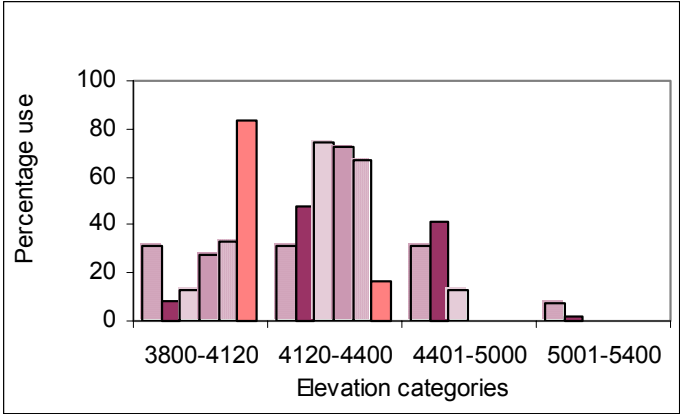
The semi-structured interviews with the local herders suggested that the over-riding factor was the proximity of the pasture to the settlements. Further, it was important that the pasture had enough forage for the herds. Depending on the amount and compactness of the snow, the livestock were herded into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

Table 4.3. Preference indices of Ladakh urial for different 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.

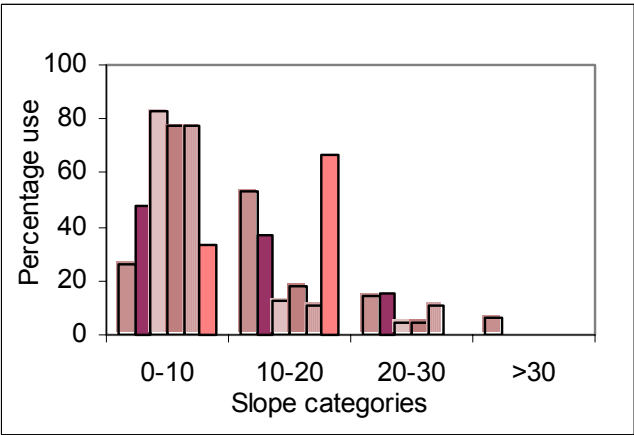
Habitat variables	Categories	% Available	% Used	Bonferroni intervals		Preference rating
Aspect	Northern	3.4	19.6	-0.0251	-0.2977	Preferred
	Southern	64.1	47.8	0.3553	-0.0298	Proportional
	East	5.1	26.1	-0.0575	-0.3616	Avoided
	West	27.4	6.5	0.3315	0.0851	Avoided
X², df, p	6.3,3,0.1					
Terrain	Smooth	9.0	23.9	-0.0052	-0.2927	Preferred
	Broken	6.6	37.0	-0.0169	-0.2936	Preferred
	Rocky	7.8	19.6	-0.1060	-0.4254	Proportional
	Snow	76.6	19.6	0.7076	0.4321	Avoided
X², 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
X², 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
X², 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
X², 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
X², 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

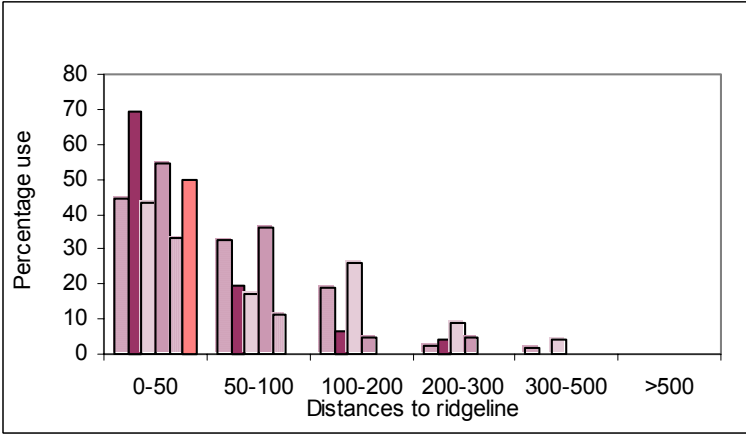
a) Elevation



b) Slope angle



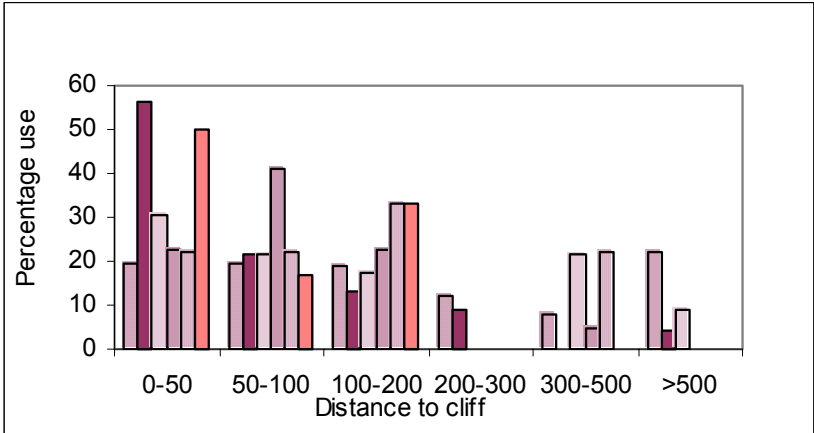
c) Distance to ridgeline



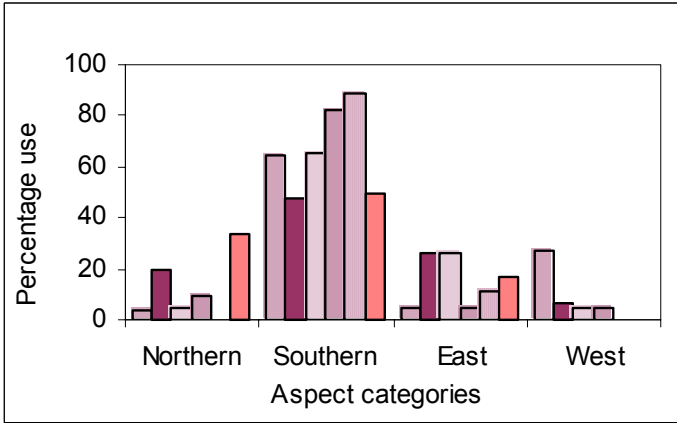
Legends

- Overall availability
- Ladakh urial
- Yak
- Sheep-goat
- Donkey
- Horse

d) Distance to cliff



e) Aspect



f) Terrain types

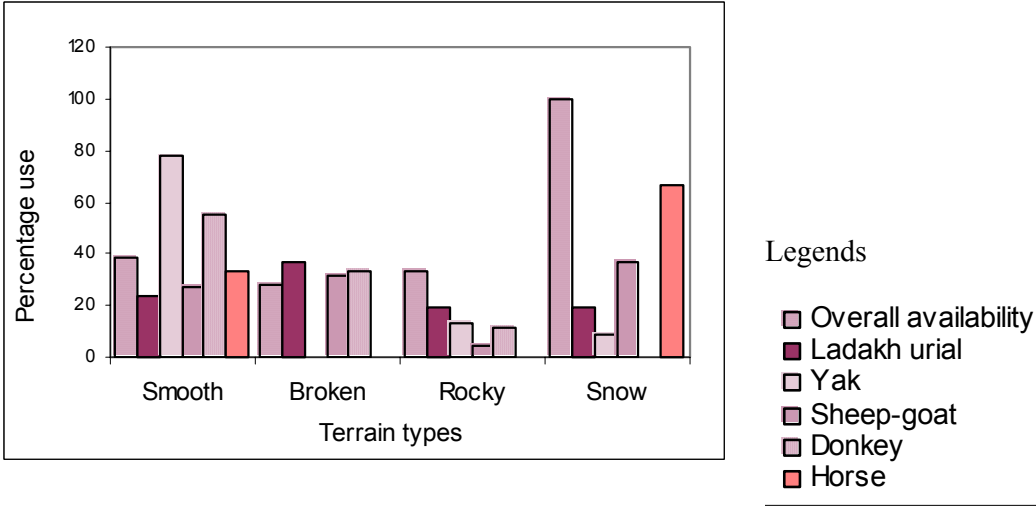


Fig. 4.4. Principal Component Analysis ordination of Urrial and Livestock habitat use

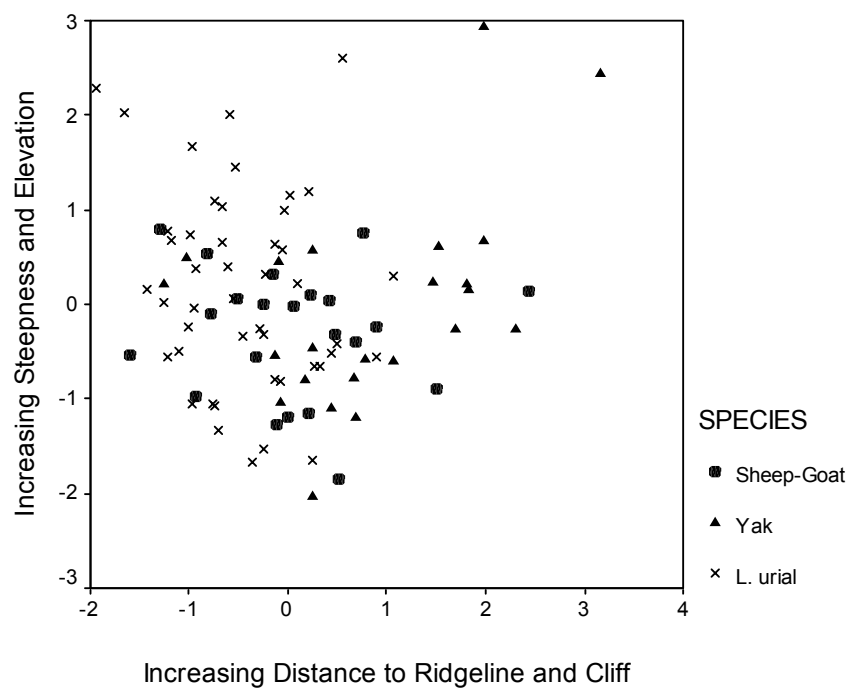
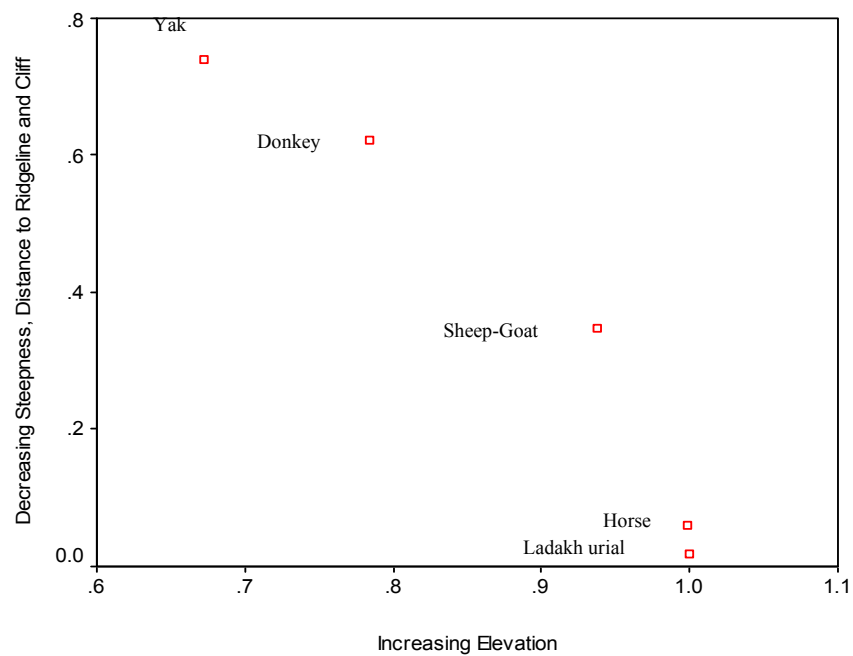


Fig. 4.5. Non-Metric Multi dimensional Scaling of Urrial & livestock habitat use patterns



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, is 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. Livestock from the five hamlets grazed their animals in mostly separate areas and had little overlap. Also, while yak (post 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). However, it is noteworthy that almost all pastures in middle and lower elevations were used throughout winter, as also summer, while those in the higher elevations were used in summer.

4.3.3. Comparison of Habitat Use by Urial and Livestock

The use of slope categories differed slightly 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, the difference in the use of aspect between urial and livestock was not significant ($X^2=8.37$, $p=0.079$). Use of distance to ridge and distance to cliff differed to some extent 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 insolation (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 (personal observation). Sheep-goat were the next closest to urial, followed by donkey and yak.

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 comprised of five species – *Polygonum plebium*, *Silene moorcroftiana*, *Thermopsis* spp., *Causinia thomsonii*, and graminoids (81%) and most of the others contributed a small percentage to the diet (Table 4.4.). Compositional analysis of plant

species contributing > 2% to urial diet revealed the following importance ranking of species in urial diet: -

E. ceratoides (0.71) > Graminoids (0.58) > *C. thomsonii* (0.46) > *P. plebium* (0.33) > *S. moorcroftiana* (0.27) > *Caragana* spp. (0.27) > *Thermopsis* spp. (0.11)

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 plant species in urial diet contributed to 81 percent of its diet (Table 4.4.). The relative contribution of the same species to livestock diet was highest for yak (65%), followed by sheep-goat (60%), donkey (56%) and horses (32%). However, the seven most important species (based on ranking) in urial diet, constituted 85%, 70% and 56% of diet of sheep-goat, yak and donkey, respectively. Of these, graminoids were the most foraged upon by all livestock species (25-35%). *Polygonum plebium*, *Silene* spp. and *Thermopsis* spp. had a fairly large contribution to the urial diet (58%) but their contribution to all livestock diets was minimal. It is noteworthy that all three species are prostrate forms in winter and therefore, probably difficult to forage upon.

Based on the above, it is evident that urial and livestock diets were similar with respect to composition but differed in the proportionate consumption of these species. Further, the overlap (Morista-Horn overlap Index) in diets between urial and sheep-goat was the highest (0.6), followed closely by yak (0.52). The overlap was relatively low with horses (0.23) and was least with donkeys (0.07).

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, 34.4 percent had 'only livestock' locations, while 15.5 percent grids had both urial and livestock.

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, trail walks in adjoining areas and vehicle transects wherever possible, to confirm presence or absence of urial in adjoining areas.

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).

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). Snow cover was maximum in the higher and middle elevations than in the lower elevations which were relatively warmer and less windy (Pers. obs.).

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. However, in the study area most of the vegetation was found in the middle and higher elevations which were mostly under snow. Hence, actual available or “exposed” vegetation would be that available in lower elevations. This proportion was quite low. In Skambur-Dzaothang also, it was the higher elevations which had more snow. But the percent snow cover itself was quite low (24%). The vegetation cover was higher in the middle and lower elevations (64.6% of total vegetation cover) than in the higher elevations. Hence, effectively more available to the animals than vegetation in the study area.

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

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

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

Area	Categories of Cover types	Percentage availability			
		Elevation zone			
		Upper	Middle	Lower	Overall
Study area		(n=43)	(n=936)	(n=1040)	(n=2756)
	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		(n=530)	(n=530)	(n=530)	(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

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 graminoid biomass, as with the African savannas, while in areas with low graminoid biomass, competition would be the dominant player (Jarman and Sinclair 1979, Van de Koppel and Prins 1998). A species sharing similar resources with another species can, by using that resource, limit its availability for the other species (Resource Limitation). Resource limitations can lead to competition if the resource use by the two species overlaps and the resource is scarce (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 competitors like 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). 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 (or 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, that often ranged from 30 to 73 animals, seen during the study. 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 anti-predatory 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 Alados 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 to 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 more 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 in winter). 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 1320 livestock (including livestock of Hiniskut) grazing an area of 40 Km² seems substantial. The lack of precipitation as snow or rain in previous years, 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 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 (44%), 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 ($C_h = 0.60$). 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 consist of mainly prostrate species which would be relatively difficult for animals to forage upon than erect shrubs like *Caragana* and *C. thomsonii*. The higher elevations were also poorer in terms of availability of three of the most important species of urial diet: *E. ceratoides*, *C. thomsonii*, and graminoids. These were most abundant in the middle elevations and they, especially the graminoids, also formed bulk of the diet of all livestock. 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 greater 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 possible 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, which 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, a decline.

5.7. Conservation Implications

Problems...

As seen from previous sections and chapters, wildlife conservation in Ladakh, is a task beset by several limitations. The conservation of urial, a species that inhabits the lower elevations (compared to other wild ungulates) and that are under the highest human pressures, poses even more challenges. The most important of these is the lack of adequate information

on the species. Even though several surveys have been carried out in the past, there is still no reliable estimate of the current numbers, population structure, distribution and status in Ladakh. Nothing is known about the resource use patterns of the species in its entire range (apart from this study which was restricted to one local population).

There is also no information on the factors that could be shaping the population numbers and structure of urial in Ladakh, such as the prevalence of disease in the population, its reproductive and health status, deaths due to starvation or winter die-offs, interactions with other species, and possible competition with them.

Information needs to be compiled on the human and livestock population trends in the urial range over the past few decades, in order to evaluate the changes in resource use patterns, and pressures acting on the urial habitat and resources. Rising human population and inhabited areas has meant substantial loss of urial habitat. The breakup of traditional joint families into several smaller family units has led to conversion of more land into habitations and cultivation. The increasing livestock populations herded by these families have also put severe pressure on the already scarce pasture resources. Entire sedge meadows along valley bottoms, critical spring habitat for urial, have now been converted to cultivation, plantations or orchards. Further, large tracts of land along valley bottoms in the lower elevations, areas used by urial, have been disturbed for construction of roads and water channels. The presence of large army encampments and training courses in these areas has also led to habitat loss, apart from the disturbance they pose.

There is also a need to assess the health and condition of the pastures in the area. Most of the pastures in Ladakh are already under pressure from grazing by livestock and biomass removal for fuel and fodder by the locals. The scarce water resources, too, are under pressure.

Hunting, although quite low compared to past levels, is still a threat in many parts of the urial range, especially in and around the Kargil district.

Lack of manpower and infrastructure severely incapacitates the enforcement and protection agencies. They are also not trained adequately in protection, or survey and monitoring protocols for wild animals. The local people, as also the Department seem to be unaware of the importance and use of wildlife and its conservation. Most of the time, the two groups are at loggerheads and co-operative conservation action is still a distant dream.

Conservation measures for the urial then would have to look at all these aspects in order to draw up a comprehensive strategy.

The road ahead...

Strategy for urial conservation in Ladakh can thus, be divided into three important aspects:

1. Information and data needs- This would require the following actions:
 - a) Systematic survey to establish baseline population estimate and population structure of the Ladakh urial, and regular monitoring of these for information on trends
 - b) Identifying pockets of urial populations that are large enough to justify adoption of active conservation, or management measures by the department, community and NGOs on a priority basis. These would include areas with urial populations > 50 individuals. Populations with lower numbers have little chances of surviving over a long-term and such populations should be given lower priority.

- c) Monitoring the urial populations for resource use patterns, changes in population structure (mortality, fecundity), health status, and other factors that are responsible for driving population numbers and survival.
- d) Monitoring and recording trends in populations of humans and livestock.
- e) Evaluating the 'health' of pastures available to, and used by, wild herbivores, in terms of their productivity, species composition, and nutrient quality.
- f) Monitoring and recording patterns of resource use by humans and livestock and the trends in the same, and how they affect urial habitat.
- g) Mapping the availability of suitable habitat for urial and comparing with current distribution. Data on urial habitat use from multiple sites should be then used to better understand extant factors resulting in the patchy & sparse distribution.

2. Departmental action

- a) An important and necessary step to be undertaken by the enforcement and protection departments is to increase their manpower so as to be able to protect all areas effectively. At present, the department has just 30 field staff protecting almost 13000 Km² in Leh district alone.
- b) They also need adequate infrastructure and other facilities, and resources to train their staff for carrying out their duties. These would include adequate transportation facilities, field communication systems, proper equipment and clothing, adequate remuneration for the grueling task carried out by the field staff, life and medical insurance for field staff, basic training in computers and data management, and other such facilities.
- c) These staff should first be educated/trained about the need, use and importance of wildlife and conservation, as also about the methods employed towards conservation. This would enable the staff to better patrol the areas under them.
- d) They should also be trained in effective and practical knowledge of wildlife legislation and anti-poaching measures.
- e) The staff should also be provided training on carrying out survey and monitoring programs, and creation of a database of information on different species and protected areas.
- f) The wildlife and other enforcement and protection agencies should prepare a conservation strategy for the urial, as also other wild animals, based on information available through studies conducted on the species' ecology, behavior and threats acting on it.
- g) They should also develop an action plan for tackling problems associated with factors driving population numbers and survival, e.g. vaccinations against important diseases, supplemental feeding in resource scarce periods or areas, and other such measures. This could be done in co-operation with other agencies such as the departments of Animal Husbandry, and Agriculture and Fodder production
- h) The department should also create avenues for dialogue with all the stakeholders, including villagers, to initiate conservation action.
- i) These measures would ensure that the wildlife and enforcement agencies play a pro-active role in the conservation of all wildlife.

3. Community action and participation- The community plays an important role in any conservation action, and this has been seen in all successful conservation initiatives carried

out in the world. Therefore, all efforts should be made to include the community in any conservation program for urial. This would include:

- a) Educating the local people about the importance and use of wildlife and its conservation, especially with respect to the urial.
- b) Identification of stakeholders during creation of any protected area or initiating conservation action in an area.
- c) Providing built-in incentives to these stakeholders for conservation, as much as possible emphasizing benefits 'after' conservation action, not 'if' there is conservation action. E.g. hoping that villagers would be encouraged to conserve wildlife and natural resources *if* they are provided environment-friendly alternate sources of energy (benefits 'if' there is conservation action) would probably yield poorer results than a scheme whereby people who hold lower livestock holdings and use more environment-friendly resources are given better market prices for their products and are recognized for this venture (benefits 'after' conservation action).
- d) Developing measures for grassland and range management in collaboration with the people and concerned agencies. These measures could include practicing rotational grazing; developing fodder and silage resources for stall-feeding; encouraging use of environment-friendly, alternate sources of energy such as biogas, or solar energy to discourage use of pasture biomass for fuel.
- e) Developing measures for controlling human and livestock population growth in collaboration with the people and concerned agencies. These measures could include placing a ceiling on livestock and land holdings per family; giving incentives such as life insurance at lower premiums (for both cattle and livestock), better market prices, for people with smaller livestock holdings; subsidized higher education for children of small families; health benefits for smaller families.
- f) Encouraging people to keep track of animal movements and numbers and creating their own database, so that they are aware of the status of local wildlife populations and can initiate conservation action of their own. Fluctuations in populations of wild herbivores especially, could act as indicators of the health of the pastures; effects of competition between herbivores and influence of this on pasture resources; possible disease factors that could be transmitted to livestock; and other factors that could also affect the livestock.
- g) Encouraging a more pro-active role of the local people in the conservation and management of wildlife.
- h) Instilling a sense of pride in them about their natural heritage, its religious, aesthetic and cultural significance for them through education about this heritage, especially in schools, and ensuring their participation in its conservation.

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

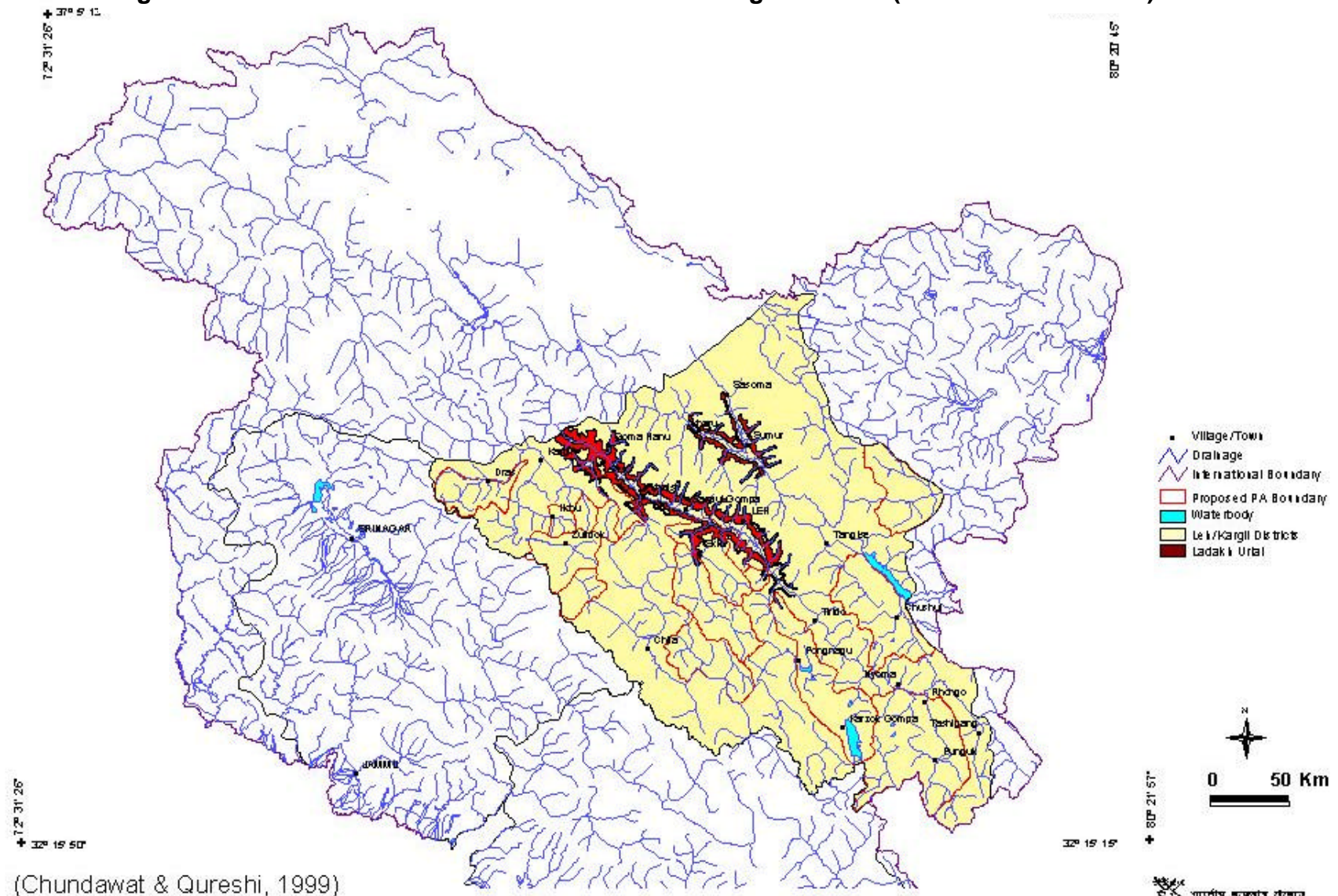


Fig 4.3: Grazing patterns of livestock from the five hamlets in the study area during winter (Dec 2002 to March 2003)

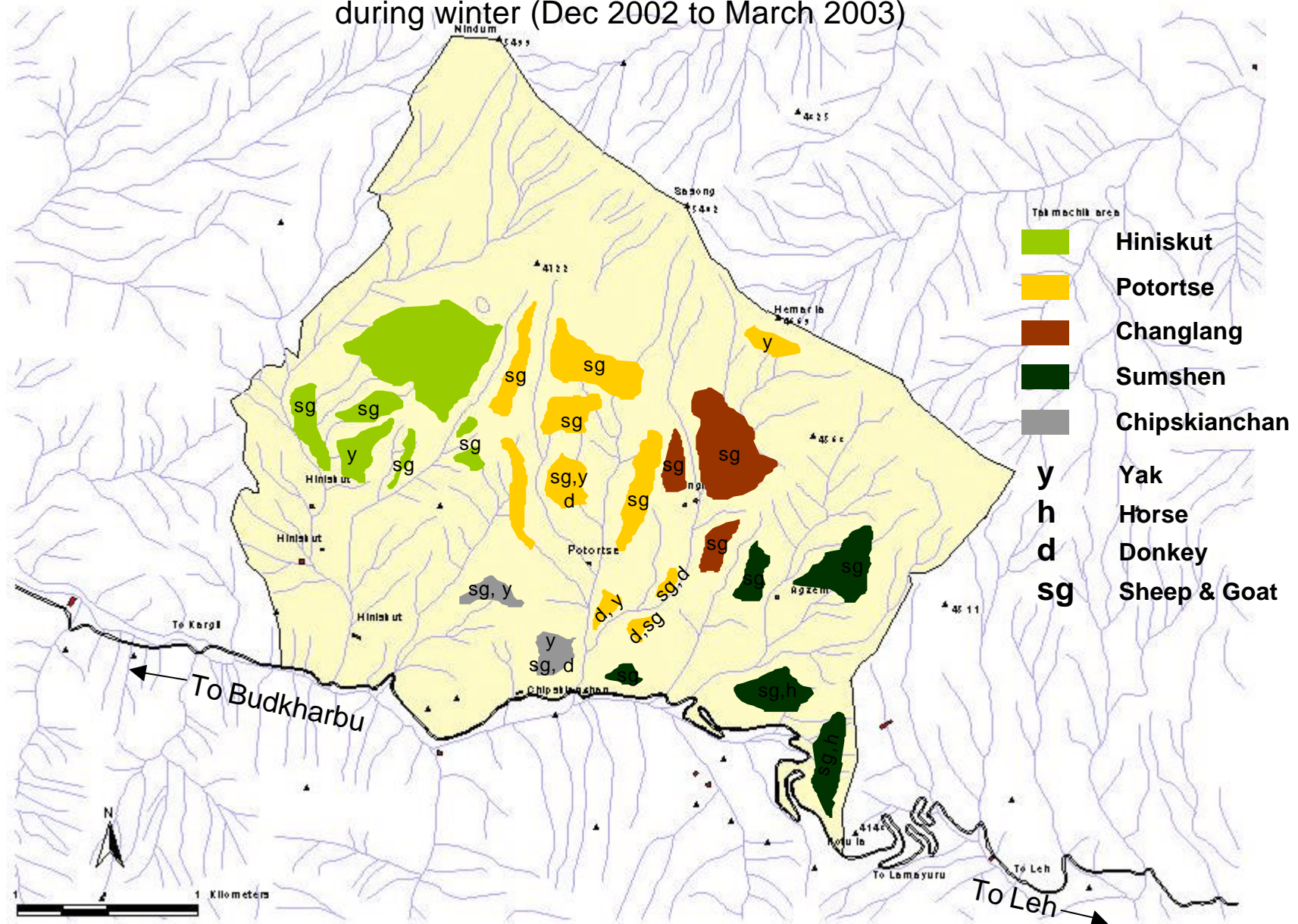


Figure 4.6 Map of study area (Nindum Wildlife Sanctuary-Proposed) showing distribution of Ladakh urial and Livestock (Dec.2002 - Apr.2003)

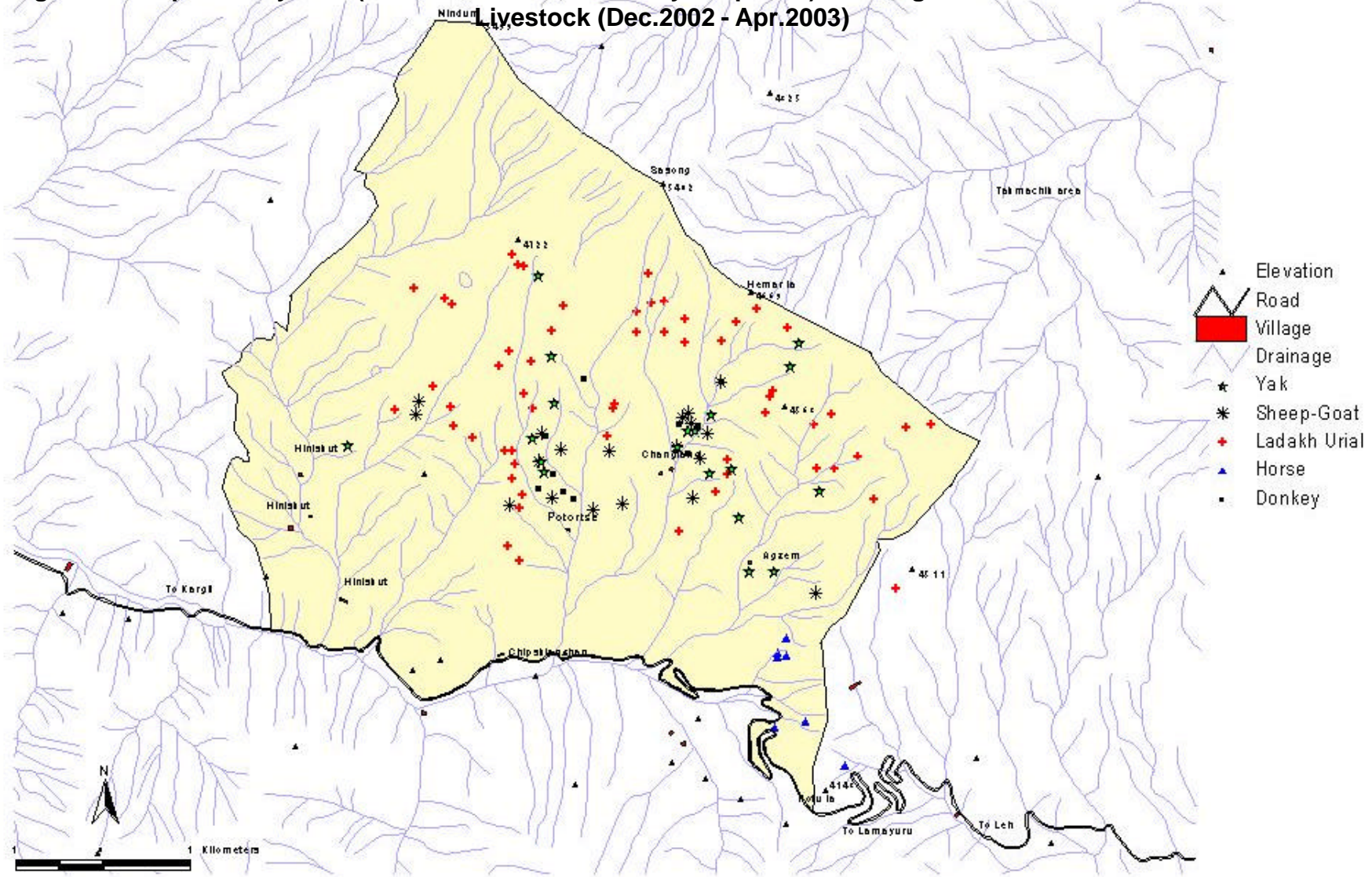


Figure 4.7 Map of study area (Nindum Wildlife Sanctuary- Proposed) showing areas of spatial overlap between Ladakh urial and Livestock (Dec.2002 - Apr.2003)

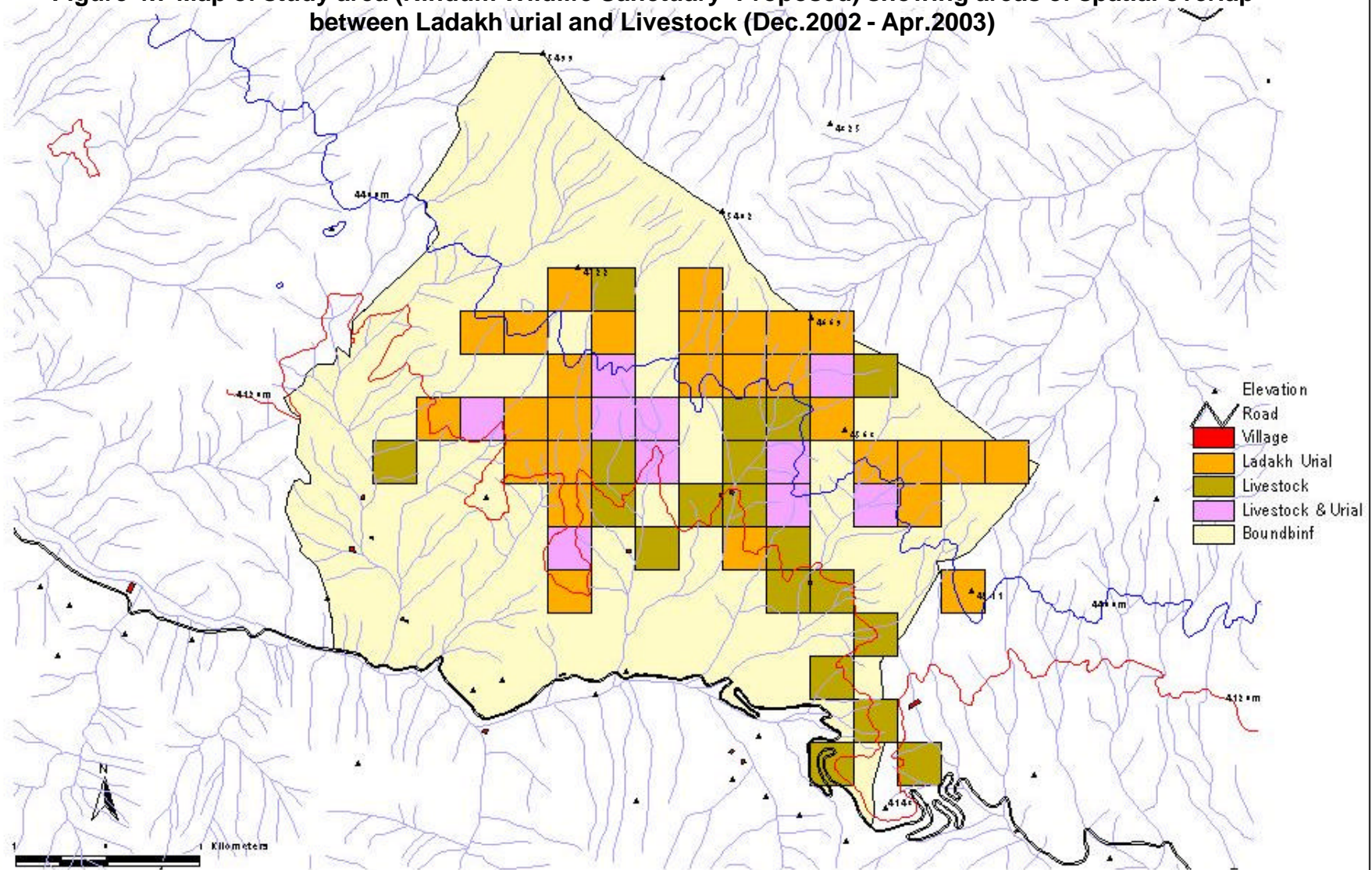


PLATE - 1



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 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