Interactions between argali and livestock, Gya-Miru Wildlife Sanctuary, Ladakh, India

Final Project Report

by

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CHAPTER 1

GENERAL INTRODUCTION

Livestock production is the major land-use in Ladakh region of the Indian Trans-Himalaya, and is a crucial sector that drives the region's economy (Anon, 2002). Animal products like meat and milk provide protein to the diet of people, while products like wool and *pashmina* (soft fibre of goats) find their way to the international market. Such high utility of livestock and the recent socio-economic changes in the region have caused an increase in livestock population (Rawat and Adhikari, 2002; Anon. 2002), which, if continue apace, may increase grazing pressure and deteriorate pasture conditions. Thus, there is an urgent need to assess the impact of such escalation in livestock population on the regions wildlife.

Although, competitive interaction between wildlife and livestock has been studied elsewhere in the Trans-Himalaya (Bhatnagar *et al.,* 2000; Mishra, 2001; Bagchi *et al.,* 2002), knowledge on this aspect in the Ladakh region is very rudimentary. The rangelands of Ladakh are characterised by low primary productivity (Chundawat & Rawat, 1994), and the wild herbivores are likely to compete with the burgeoning livestock on these impoverished rangelands (Mishra *et al.,* 2002). Thus, given that the area supports a diverse wild ungulate assemblage of eight species (Fox *et al.,* 1991b), and an increasing livestock population (Rawat and Adhikari, 2002), the nature of interaction between wildlife and livestock needs to be assessed. During this project, we primarily evaluated the influence of domestic sheep and goat grazing on the habitat use of Tibetan argali *Ovis ammon hodgsoni* in a prospective wildlife reserve in Ladakh.

Tibetan argali, henceforth 'argali' is one of the eight ungulate species that enrich the biodiversity of the Trans-Himalaya. This sheep is one of the prey species of the endangered snow leopard *Uncia uncia,* and belongs to the subfamily Caprinae, and has wide distribution encompassing the high Himalaya and the entire Tibetan Plateau (Schaller, 1998). Ladakh region of the Trans-Himalaya also harbours a small population of *ca.* 200 argali (Fox *et al.,* 1991a). Nevertheless, very little is known about its distribution in the region. Based on a GIS model, Chundawat & Qureshi (1999) identified *ca*. 10,988 km^2 in eastern Ladakh as potential habitat for argali, but Bhatnagar and Wangchuk (2001) say that vast areas in between do not have argali, and they are now largely confined to few small pockets. This pattern of population fragmentation could be related to usurpation of suitable habitat for livestock production (Schaller, 1998), and to severe persecution by trophy hunters and the military personnel in the recent past (Fox *et al.,* 1991b). Such hunting once rampant in the region is now illegal under the Jammu and Kashmir Wildlife Protection Act of 1978. The Indian Army also put an end to shooting wild animals by military personnel. Despite such conservation efforts, the argali population remains low. This slow recovery, if at all, of argali population needs immediate attention, as its status is precarious not only in India, but throughout its range (Schaller, 1998). The increasing livestock suppressing the argali population cannot be ruled out, especially in the wake of a theoretical analysis suggesting competitive exclusion of the species by livestock in other parts of Trans-Himalaya (see Misha *et al.,* 2002)

Bearing these in mind, we studied the nature of interaction between argali and domestic sheep and goats, hereafter collectively termed shoats (as per Prins, 1992), which share its range in Tsabra catchment of the proposed Gya-Miru Wildlife Sanctuary. In this resource deficient area (Rawat and Adhikari, 2002), the ecologically similar argali and shoats are expected to compete, and the latter accompanied by herders and guarding dogs may displace argali to sub-optimal areas, thereby suppressing their population growth. Therefore, we evaluated the influence of shoats' grazing on argali habitat use during winter when the resources are limited and competition more likely, which has important implications for argali conservation and livestock management in the area.

The only information available on argali's abundance in Ladakh is that *ca*. 200 individuals exist here (Fox *et al.,* 1991a), with a concentration of *ca.* 80 individuals in the proposed Gya-Miru Wildlife Sanctuary. Therefore, we conducted an intensive survey in winter, when the animals are expected to be concentrated at lower altitudes, to update the estimate of the species' population size in Ladakh. Besides these we also investigated the intensity of livestock depredation by snow leopard*,* Tibetan wolf *Canis lupus chanku* and Eurasian lynx *Lynx lynx isabellina.*

Study area

The status survey of argali was conducted in the proposed Gya-Miru Wildlife Sanctuary (GMWS), and the adjacent Tsokar basin (33^{o} to 34^{o}N, 77^{o} to 78^{o}E), Ladakh, India. Ladakh is situated in the Indian Trans-Himalaya, which includes Tibetan Marginal Mountains and a small part of the Tibetan Plateau. The survey area encompassing *ca.* 500 km^2 is located at the western fringe of the Tibetan Plateau and forms a transition zone between the plains of western Tibet and the rugged mountains of central Ladakh. The prospective reserve has thus a unique assemblage of wild flora and fauna. The elevation in the area ranges from 3900 to

5700 m. The southern part is open and rolling, while the northern part is relatively rugged. Myriad livestock: yaks, horses, donkeys, cows and shoats graze the area round the year. The ecological study was carried out in Tsabra catchment of the proposed reserve, which encompasses approx. 60 km^2 (Fig. 1.1). This area is located at *ca.* 65 km southwest of Leh, the major city of Ladakh. Domestic shoats graze this area during late winter. In fact the area is earmarked for exclusive grazing by these species during winter. There are four villages: Gya, Miru, Rumtse and Sasoma in the reserve, with a population of *ca.* 5000. All the inhabitants of the area are agro-pastoralists, with major emphasis on livestock production. Individual families own the livestock, and graze on communal grazing pastures. Furthermore, pastoralists extract resources such as bushes from the area for fuel purposes.

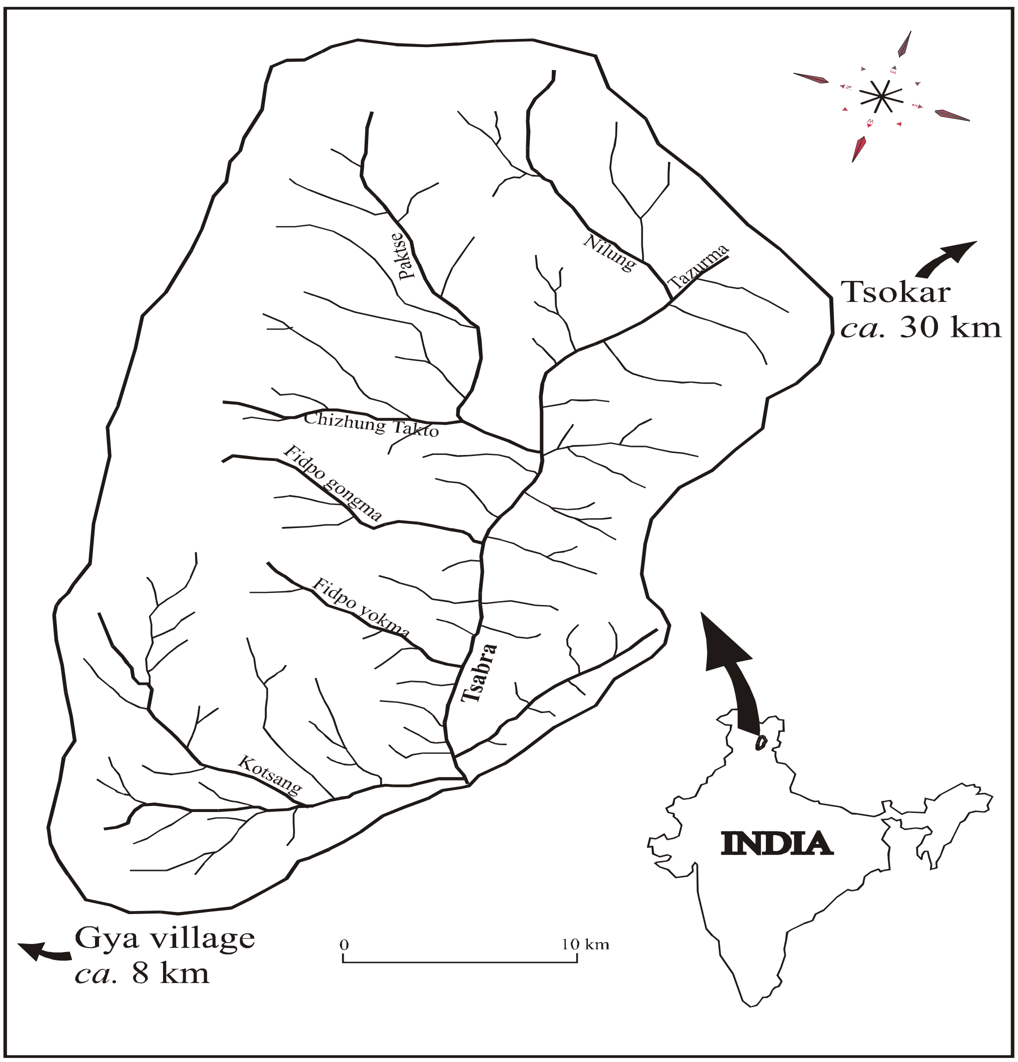


Fig. 1.1. Tsabra catchment, the intensive study area in the proposed Gya-Miru Wildlife Sanctuary, Ladakh, India.

Climate

Ladakh is aptly classified as a cold desert for its aridity and coldness. The monsoon clouds hardly penetrate Ladakh, as it is situated in the rain-shadow of the Greater Himalaya. Thus the magnitude of precipitation is low and erratic. The mean annual precipitation hardly crosses 93 mm. The precipitation is mostly in the form of snow in winter, which is associated with the extra-tropical disturbances of mid-latitudes known as "Western Disturbances" (Dhar & Mulye, 1987). The temperature ranges from -30^{o}C in peak winter (Dec-Jan) to $+35^{o}$C in summer. The minimum temperature recorded in the intensive study area (ISA) was -27^{o}C on the 28^{th} of December 2002.

Flora

Vegetation is characterised by dry alpine steppe (Rawat and Adhikari, 2002). There are no trees in the area except in glens and oases. The major trees are poplar *Populus* spp. and willow *Salix* spp. The most common vegetation includes *Caragana* spp., *Artemisia* spp. and *Eurotia* sp., which are found almost everywhere in the area. *Aconogonum* sp. is quite abundant in the ISA. The major graminoid species are *Stipa* spp., *Poa* spp., *Elymus* spp., *Festuca* sp., *Carex* spp. and *Kobresia* sp., the latter two mostly occurring along streambeds. *Thermospsis* sp. occurs on sandy slopes where the sheep prefer to rest. Some other common forbs in the area include *Potentilla* spp., *Oxytropis* spp., *Astragalus* spp., *Dracocephalum* sp. etc.

Fauna

Besides Tibetan argali, there are other wild herbibvores such as blue sheep *Pseudois nayaur,* Ladakh urial *Ovis vignei vignei* (only a small population) and kiang *Equus kiang* that share the resources with several livestock *viz*., yaks, horses, donkeys, cows and shoats. Within the ISA there are only argali and blue sheep, with the former using relatively open areas with shoats, and the latter using more rugged terrain. There are myriad small mammals: Tibetan woolly hare *Lepus oiostolus,* mouse hare *Ochotona* spp. and marmot *Marmota bobak* (hibernating during the present investigation) that also share the pastures with the above mentioned ungulates. The mammalian predators include snow leopard *Uncia uncia* (quite rare in the ISA), wolf *Canis lupus,* wild dog *Cuon alpinus,* lynx *Lynx isabellina* and red fox *Vulpes vulpes montana.* Avian predators include the golden eagle *Aquila chrysaetos,* which has a tendency to attack lambs (see Appendix I for a checklist of birds).

Brief outline of the report

The report largely addresses the nature of interaction between argali and shoats in the proposed GMWS. Despite the growing concern of wildlife being competitively excluded by livestock, the aspect of competition between these species on the Trans-Himalayan rangelands is little understood. In the present study, we investigated the nature of interaction between argali and shoats with an objective of determining the factor that is hindering the population recovery of argali. Chapter 2 presents the result of a status survey of Tibetan argali in the GMWS and the neighbouring Tsokar area. This survey was carried out in the wake of an urgent need to know the current status of argali population in Ladakh. An updated estimate of the population in the region is suggested. Chapter 3 describes the influence of shoats' grazing on argali habitat use and the latter's habitat shift in response to competition with shoats. Chapter 4 explore the intensity of livestock depredation by snow leopard, Tibetan wolf and Eurasian lynx. Finally, Chapter 5 revisits the main findings of the survey and ecological study of argali; important management issues and future prospects for argali in the proposed sanctuary are discussed.

References

Anonymous, 2002. Annual Report for 2001-2002. Sheep Husbandary Department, Leh.

Bagchi, S., Mishra, C. Bhatnagar, Y.V. & McCarthy, T., 2002. Out of Steppe? Pastoralism and Ibex conservation in Spiti. CERC Techinical Report No. 7. Nature Conservation Foundation, Mysore.

Bhatnagar, Y.V. & Wangchuk, R. 2001. *Status Survey of Large Mammals in Eastern Ladakh & Nubra.* In Anon. 2001. *Conservation Biodiversity in the Trans-Himalaya: New Initiatives for Field Conservation in Ladakh.* First Annual Technical Report (1999-2000). Wildlife Institute of India, Dehra Dun, India

Bhatnagar, Y.V., Rawat, G.S., Johnsingh, A.J.T. & Stuwe, M., 2000. *Ecological separation between Ibex and Resident Livestock in a Trans-Himalayan Protected Area.* In Richard, C., Basent, K., Sah, J.P. & Raut, Y. (Eds) *Grassland Ecology and Management in Protected Areas of Nepal*. International Centre for Integrated Mountain Development, Kathmandu, Nepal

Chundawat, R.S. & Qureshi, Q., 1999. *Planning wildlife conservation in Leh and Kargil districts of Ladakh, Jammu & Kashmir*. Wildlife Institute of India, Dehra Dun, India.

Chundawat, R.S. & Rawat, G.S. 1994. Indian cold deserts: a status report on biodiversity. Wildlife Institute of India, Dehradun, Uttaranchal.

Dhar, O.N. & Mulye, S.S., 1987. A brief appraisal of precipitation climatology of the Ladakh region. In Pangtey, Y.P.S. & Joshi, S.C. (Eds). *Western Himalaya: Environment, Problems and Development.* Gyanodaya Prakashan, Nainital.

Fox, J.L., Nurbu, C. & Chundawat, R.S., 1991a. Tibetan argali (*Ovis ammon hodgsoni*) establish a new population. *Mammalia* 55: 448-451.

Fox, J.L., Nurbu, C. and Chundawat, R.S., 1991b. Mountain ungulates of Ladakh, India. *Biol. Conserv.* 58: 167-190.

Mishra, C. 2001. High altitude survival: conflicts between pastoralism and wildlife in the Trans-Himalaya. Ph.D. thesis, Wageningen University, the Netherlands.

Mishra, C., Van Wieren, S.E., Heitkonig, I.M.A. & Prins, H.H.T., 2002. A theoretical analysis of competitive exclusion in a Trans-Himalayan large-herbivore assemblage. *Anim. Conserv.* **5:** 251-258.

Namgail, 2001. *Habitat selection and ecological separation between sympatric Tibetan argali and blue sheep in northern India.* M.Phil. thesis, University of Tromsø, Norway.

Prins, H.H.T., 2000. The pastoral road to extinction: competition between wildlife and traditional pastoralism in East Africa. *Environ. Conserv.* **19:** 117-123.

Rawat, G.S. & Adhikari, B.S., 2002. Vegetation characteristics and patterns of livestock grazing in Changthang plateau, eastern Ladakh. In Anon. 2002. *Conservation Biodiversity in the Trans-Himalaya: New Initiatives for Field Conservation in Ladakh.* First Annual Technical Report (2000-2001). Wildlife Institute of India, Dehra Dun, India.

Schaller, G.B., 1998. *Wildlife of the Tibetan Steppe,* pp. 373, University of Chicago Press, Chicago

CHAPTER 2

STATUS SURVEY AND POPULATION STRUCTURE OF TIBETAN ARGALI IN LADAKH, INDIA

Summary

Tibetan argali *Ovis ammon hodgsoni* has a very patchy distribution on the Tibetan Plateau and its marginal mountains. It is one of the prey species of the highly endangered snow leopard *Uncia uncia,* and is declining globally, with a most recent estimate of *ca.* 7,000 individuals. Within India the argali occurs in Ladakh, Himachal Pradesh and Sikkim. The only information on argali population in Ladakh is that *ca.* 200 individuals occur in the region, with a relatively high concentration of *ca.* 80 individuals in the proposed Gya-Miru Wildlife Sanctuary. Therefore, we conducted an intensive survey of the Tibetan argali in the said reserve, and the neighbouring Tsokar Basin to update its status in Ladakh. A total of 127 argali were observed in an area of *ca.* 500 km^{2,} of which 48 individuals were found in the Tsabra Catchment of the proposed sanctuary (our intensive study area). We calculated an argali density of 0.6/km^2 for the entire survey area, and 0.8/km^2 for the intensive study area.

We also evaluated the population structure of argali in the intensive study area. There was a relatively high occurrence of adult males in the population with 75 males for every 100 females. The lamb : female ratio was 45 : 100, and that of yearling : female was 20 : 100.

Objective

- To estimate the population size of argali in the proposed Gya-Miru wildlife sanctuary

Methods

Study area

Surveys were conducted in Puyul, Gya, Kyam-Tsabenama, Tsabra, Tisaling-Shiabuk catchments, and subsequently in the Tsokar Basin (Fig. 2.1; 33 to 34^o N, 77 to 78^o). The distribution of argali in these blocks was determined by a preliminary survey in August 2002. The entire survey area encompassed *ca.* 500 km^2. Altitude in the area ranges from 3900-5700 m. Topography ranges from sandy plains in Tsokar Basin to undulating terrain in Tisaling-Shiabuk catchments to relatively rugged terrain in Puyul catchment. Climate is severe in winter with the minimum plunging to –25^{o}C or sometimes lower (Namgail, 2003). The region gets moderate precipitation in the form of snow in winter. There is both an annual and a diurnal variation in temperature. Thus, nights are extremely cold and the days relatively warm.

The area is located at the western fringe of the Tibetan Plateau. Vegetation is characterised by dry alpine steppe. The dominant plant species include *Caragana* spp., *Artemisia* spp., *Eurotia* sp., *Festuca* sp. and other graminoids such as *Stipa* spp., *Carex* sp. and *Kobresia* sp. The area has a low primary productivity with low plant diversity (Rawat & Ahikari, 2002). The entire survey area is subjected to various levels of livestock grazing. Trophy hunting was common in the area untill the early ’70s. The last trophy of argali was taken by an American hunter in 1975 from the Tsabra catchment.

The other large ungulates in the area include blue sheep *Pseudois nayaur*, a small population of Ladakh urial *Ovis vignei vignei,* and kiang *Equus kiang*. There are small herbivores such as Royle’s pika *Ochotona royeli*, Tibetan woolly hare *Lepus oiostolus* and marmot *Marmota bobak himalayana*. Furthermore, there are myriad large mammalian predators such as snow leopard, Tibetan wolf *Canis lupus chanko*, wild dog *cuon alpinus*, lynx *Lynx lynx isabellina* and red fox *Vulpes vulpes montana*.

Field methods

The surveys were conducted in the months of March and April 2003. Using topographic features such as ridges and streams as references, the entire area was split into six major blocks *viz*., Puyul (Block 1), Gya (Block 2), Kyam-Tsabenama (Block 3), Tsabra (Block 4), Tisaling-Shiabuk (Block 5) catchments, and the Tsokar Basin (Block 6) (Fig. 2.1). Each block was surveyed walking on trails and ridgelines. On an average, we spent 17 hours surveying each block.

Surveys were conducted on foot and horseback. From the trails and ridgelines, the slopes were scanned with 8x40 binoculars. Once a group was spotted, we recorded the time, date and group size, and subsequently its location was marked on a topographic map. Further, the group was closely examined with a 15-45X spotting scope to determine the age and sex composition, whenever possible. Ewes and yearlings were taken as separate classes. Males were classified as class I, II, III and IV (as per Fedosenko *et al.,* 1995). For the calculation of age/sex ratio, only the data from the intensive study area (ISA) was used, as most of the groups outside the ISA could not be classified into sex/age classes due to long observation distances.

The survey team was comprised of the first author and two trained assistants. Counts were repeated in all six blocks in order to get at least one replicate from each block. The area of each block was determined from a 1 : 250,000 digitised map of the survey area in a GIS format. Within Tsokar Basin (Block 6), the flat areas, where the argali is not known to occur, were excluded from the area calculation.

Analytical methods

Population size of argali was estimated based on numbers seen on the second day, which were invariably higher than the first day's count for each block. For animal density for the entire survey area, all the sightings from the survey routes were totalled, which was divided by the area. For the calculation of true density of a block, the total count i.e., the second day's count of that block was multiplied by a correction factor (the ratios between the second day's count and the first day's count), and the resultant figure was divided by the area of the block (Rodgers, 1991).

Results

A total of 127 argali were seen in the proposed Gya-Miru Wildlife Sanctuary and the neighbouring Tsokar Basin. Mean group size was 7.6 (range 1-29, standard deviation 8.0). Out of these, 48 (38%) individuals were seen in the Tsabra catchment (Block 4), which encompassed *ca.* 60 km^{2}. The density of argali in this area was thus 0.8/km^{2}, thereby qualifying it as the area with abundant argali (Table 2.1; Fig. 2.1).

Table. 2.1. Block-wise estimate of argali population and density in the proposed Gya-Miru Wildlife Sanctuary and the neighbouring Tsokar Basin, Ladakh, India.

Block no. (n = 2)	Block name	Terrain type [b]	Area (km^{2})	Total animal	*Corrected density(/km^{2})*
1	Puyul	Rugged	37	0	-
2	Gya	Moderate	30	0	-
3	Kyam-Tsabenama	Moderate	47	0	-
4 [a]	Tsabra	Moderate	60	48	0.8
5	Tisaling-Shiabuk	Undulating	134	15	0.2
6	Tsokar Basin	Undulating	164	64	0.5
Total	Entire survey area		500	127	0.6[c]

[a] ISA (n = >2; true density given, see text for details); [b] Terrain type is qualitative, [c] total density is calculated only for the blocks where we observed argali

In Tisaling-Shiabuk area (Block 5; *ca*. 134 km^{2}), we counted a total of 15 argali thereby yielding a corrected density of 0.2 argali/km^{2}. The Tsokar Basin (Block 6; *ca*. 164 km^{2}) had an argali density of 0.5/km^{2}. The corrected density of argali for the entire survey area (excluding the blocks no. 1-3, where argali were reported in the past but not seen during the present survey) was 0.6/km^{2} (Table 2.1).

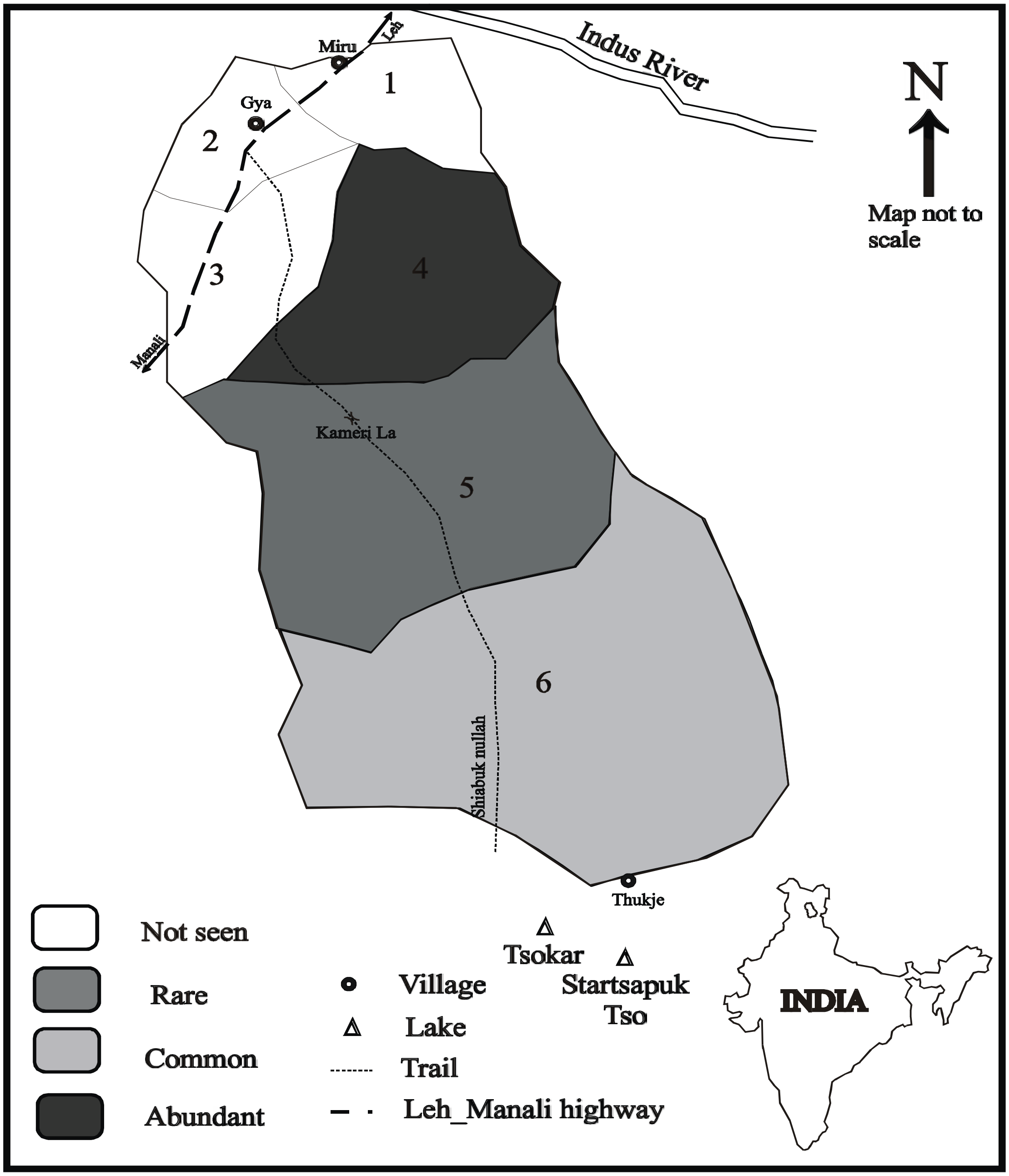


Fig. 2.1. The qualitative pattern of Tibetan argali density in Puyul (1), Gya (2), Kyam-Tsabenama (3), Tsabra (4), Tisaling-Shiabuk (5) and Tsokar Basin (6).

The argali population in the ISA comprised of 15 (31%) males, 20 (42%) females, 4 (8%) yearlings and 9 (19%) lambs. The sex ratio in the population was thus 75 : 100 in favour of female. The lamb : ewe ratio was 45 : 100, and that of yearling : female was 20 : 100 (Table 2.2). Amongst the males, there was a preponderance of class III and IV (Table 2.2). The age-wise percentages for the ESA are however unreliable, because only few groups were classified into different age/sex classes.

Table 2.2. Sex and age composition of argali in the proposed Gya-Miru Wildlife Sanctuary and the neighbouring Tsokar Basin (figures in parenthesis indicate sex/age ratio (/100 females).

		Percent				Percent male according to class			
Area	n	Ewes	Lambs	Yearling	Male	I	II	III	IV
ISA	48[b]	41.7	18.7 (45)	8.3 (20)	31.2 (75)	13.3	20.0	40.0	26.7
ESA[a]	38	42.1	13.1 (31)	7.9 (19)	36.8 (88)	14.3	28.6	28.6	42.8

ISA = Intensive study area; ESA = Entire survey area (excluding ISA)

[a] should be taken with caution, because only few groups were classified to different age/sex classes

[b] Population known (see text)

Discussion

Effective conservation strategies for argali cannot be developed without accurate and reliable information on its population status and distribution, which is poorly understood for Ladakh. Based on a GIS model, Chundawat & Qureshi (1999) identified *ca*. 10,988 km^2 in eastern Ladakh as potential habitat for argali, but Bhatnagar and Wangchuk (2001) say that vast areas in between do not have argali, and there is no recent evidence of their presence in the area. Thus the argali is either absent in these areas or very rare and confined to small pockets. Nevertheless, apart from the Gya-Miru region, Bhatnagar and Wangchuk identified two more potential areas: Tygermale and Chumur with relatively higher abundance of the species. Therefore an intensive survey in these areas is needed to confirm it.

Based on our observation of 127 argali in the survey area, and other small populations in Ladakh, e.g., *ca.* 25 individuals each in Tygermale and Chumur (Y.Bhatnagar, pers. comm.), *ca.* 20 in Hemis National Park (Namgail *et al.,* 2004), *ca.* 30 individuals towards Kharnak (M. Ali, pers. comm.), *ca.* 10-25 in the area between Tsokar and Tsomoriri (T. Namgail, pers. obs.) and *ca.* 10-15 individuals above Nyoma (Y. Bhatnagar, pers. comm.), it is likely that there could actually be slightly more than 200 argali estimated for Ladakh by Fox *et al.* (1991).

Nevertheless, we cannot infer an increase in the population, and the implied discrepancy may be fallout of the different survey techniques. Recognising the fact that Fox *et al.* may well have underestimated, because some surveys were conducted by wildlife officials with unaided eye, we suggest that argali population in Ladakh may have remained static to be very conservative, or even declined in the past one decade. This implies that there are additional factors that are counteracting the positive effects of the moratorium on argali hunting. The increased livestock population (Bhatnagar and Wangchuk, 1999; Rawat and Adhikari, 2002) is one such factor, which may hinder the recovery of argali population. The numerical response of Altai argali to reduction in livestock population in Altai and Tuva regions is reported by Fedosenko (Unpubl. data), where 50% decrease in livestock population over a period of *ca.* 7 years led to 57% increase in argali population. Furthermore, there are recent theoretical analysis and empirical studies, which suggest of potential competition between argali and livestock on the Trans-Himalayan rangelands (Mishra *et al.,* 2002; Chapter 3). Thus, there is an urgent need to assess the nature of interaction between domestic ungulates and argali, and workout measures to mitigate competitive interactions, if exist, to safeguard the remnant argali population in India.

The argali density (corrected) in the Tsabra catchment of the GMWS was 0.8/km^2, while the Tisaling-Shiabuk and Tsokar Region had densities of 0.2 and 0.5/km^2, respectively. This conforms to the previous suggestion of high concentration of argali in the area (Fox *et al.,* 1991). Based on the results of a survey conducted by wildlife officials, Fox *et al.* calculated a corrected density of 0.4/km^2 in an area (location not specified) of *ca.* 170 km^2 in GMWS, while our density is for the Tsabra catchment (*ca.* 60 km^2) of the sanctuary. However, given that they counted in winter, it is likely that their estimate was also for the Tsabra catchment, because argali occur only in this part of the sanctuary during winter (T. Gyatso, pers. comm.). In any case, these densities are quite low as compared to argali densities elsewhere in its range e.g., 1.3/km^2 for Dulan County, China (Zhen and Zhu, 1990 cited in Schaller, 1998). It is however problematic to compare different survey results due to different censusing techniques (Johnsingh *et al.,* 1999).

In GMWS, there were 45 lambs for every hundred females. This is comparable to a lamb : female ratio of 41 : 100 (Schaller, 1998), 42 : 100 for argali *O. ammon* (Maroney, 1999), and 43 : 100 in Kirghistan (Fedosenko *et al.,* 1995). This may however be below the potential of the species, which is reported to produce twins in Ladakh (Ward, 1924; Fox *et al.,* 1991). Furthermore, this ratio is for the Tsabra catchment, which is the major stronghold of argali in Ladakh, and it may be lower if one calculates for the entire Ladakh. Thus, it is apparent that the fecundity of argali in Ladakh is very low, which could be attributed to competition with livestock.

In summary, argali population in Ladakh has not increased greatly in response to the ban on hunting, which has been quite effective (T. Gyatso, pers. comm.). Moreover, the efficacy of the law is corroborated by the high percentage of class III and IV rams (hunted heavily in the past for trophy) observed during the present survey. Thus suspicion lurks that the burgeoning livestock population is undermining conservation efforts to protect the relic population of argali in India. Although, we evaluated the nature of interaction between argali and domestic sheep and goats (Chapter 3), more extensive studies with sufficient comparative (both spatial and temporal) data are needed to address this rather polemical issue. Secondly, there is a great need to design standard-survey techniques for long-term monitoring of the species throughout its range. The present survey is the first intensive survey of argali in Ladakh with replicates from each survey block, and may serve as a baseline for further monitoring of its population in the region.

References

Bhatnagar, Y.V. & R. Wangchuk, 2001. *Status Survey of Large Mammals in Eastern Ladakh & Nubra.* In Anon. 2001. *Conservation Biodiversity in the Trans-Himalaya: New Initiatives for Field Conservation in Ladakh.* First Annual Technical Report (1999-2000). Wildlife Institute of India, Dehra Dun, India.

Chundawat, R.S. & Q. Qureshi, 1999. *Planning wildlife conservation in Leh and Kargil districts of Ladakh, Jammu & Kashmir*. Wildlife Institute of India, Dehra Dun, India.

Fedosenko, A.K., P.I. Weinberg & R. Valdez, 1995. Argali sheep survey in the headwaters of the Korunduk River, Kirghizstan. *Mammalia* **59:** 452-455.

Fox, J.L., Nurbu, C. and Chundawat, R.S., 1991. Mountain ungulates of Ladakh, India. *Biol. Conserv.* **58:** 167-190

Maroney, R.L., 1999. Argali (*Ovis ammon*) conservation in western Mongolia and Altai-Sayan. M.Sc. thesis, University of Montana.

Mishra, C., S.E. Van Wieren, I.M.A. Heitkonig, & H.H.T. Prins, 2002. A theoretical analysis of competitive exclusion in a Trans-Himalayan large-herbivore assemblage. *Anim. Cons.* **5:** 251-258.

Namgail, T., 2003. Gya-Miru: last refuge of the Tibetan argali. *Sanctuary Asia.* **23:** 16-21.

Namgail, T., J.L. Fox and Y.V. Bhatnagar, 2004. Habitat segregation between sympatric Tibetan argali *Ovis ammon hodgsoni* and blue sheep *Pseudois nayaur* in the Indian Trans-Himalaya. *J. Zool. (Lond.)*. **262:** 57-63.

Rawat, G.S. & B.S. Adhikari, 2002. Vegetation characteristics and patterns of livestock grazing in Changthang plateau, eastern Ladakh. In Anon. 2002. *Conservation Biodiversity in the Trans-Himalaya: New Initiatives for Field Conservation in Ladakh.* First Annual Technical Report (2000-2001). Wildlife Institute of India, Dehra Dun, India.

Rodgers, W.A., 1991. *Techniques for wildlife census in India: a field manual*. Pp. 81. Wildlife Institute of India, Dehra Dun.

Schaller, G.B., 1998. *Wildlife of the Tibetan Steppe,* pp. 373, University of Chicago Press, Chicago.

Ward, A., 1924. The mammals and birds of Kashmir and the adjacent hill provinces. *J. Bombay Nat. Hist. Soc.* **29:** 879-887.

CHAPTER 3

HABITAT SHIFT BY TIBETAN ARGALI: THE INFLUENCE OF LIVESTOCK GRAZING

Summary

We evaluated the influence of domestic sheep and goats grazing on habitat use by Tibetan argali *Ovis ammon hodgsoni* in the proposed Gya-Miru Wildlife Sanctuary, Ladakh, India. Based on information of the mutual preference of open areas by argali and sheep and goats, we hypothesised that meticulously reared sheep and goats displace argali from its preferred habitats, and relegate them to marginal habitats. To test this hypothesis, we estimated the habitat use of argali in terms of slope angle, distance to cliff, elevation and vegetation cover in the absence of livestock and compared with the estimates of these variables in the latter's presence. The results showed that argali shift its habitat in response to sheep and goats' presence. For example, it used relatively gentle slopes with higher vegetation cover in the absence of sheep and goats, and moved to steeper areas with lower vegetation cover as the sheep and goats moved in its habitat. The relationship was further substantiated by the results of Non Metric Multidimensional Scaling (NMDS), which indicated that sheep and goats, after their arrival in the argali habitat, used those areas, which were earlier occupied by argali. We suggest that such habitat shift by argali in the presence of sheep and goats is due to a combination of behavioural avoidance and competition between these wild and domestic ungulates.

Objective

- To study the nature of interaction between snow leopard prey: argali (wild) and sympatric domestic sheep and goats

Methods

Study area

Tsabra catchment of the proposed Gya-Miru Wildlife Sanctuary (Fig. 1.1; N-33^o, E-77^o) is located at *ca.* 65 km from Leh, the principal town of Ladakh. The reserve is located at the western fringe of the Tibetan Plateau, and constitutes a transition zone between the vast plains of Western Tibet and the rugged mountains of Central Ladakh. The study area encompasses *ca.* 60 km^2. Elevation in the area ranges from 3500-5500 m. Like rest of the Trans-Himalaya, the proposed sanctuary is in the rain-shadow of the Greater Himalaya, and thus receives very little precipitation, mostly in the form of snow. The winter temperature ranges from –5 to –30^{o}C. The vegetation is classified as dry alpine steppe (Champion & Seth 1968), and is characterised by low primary productivity (Chundawat and Rawat, 1994). The growth season is confined to the few summer months (Jun.-Aug.). The Tsabra catchment is grazed by *ca.* 3,000 sheep and goats during late winter. Virtually, except for sporadic grazing by some horses during summer, the area is exclusively earmarked for late winter grazing by shoats. During the present study, the shoats grazed in the area from the 10th of Jan. - 30th of Mar. 2003.

Within the study area, besides argali there are blue sheep *Pseudois nayaur*, snow leopard *Uncia uncia* (very rare), wolf *Canis lupus chanku*, lynx *Lynx isabellina,* red fox *Vulpes vulpes montana,* Tibetan woolly hare *Lepus oiostolus,* mountain weasel *Mustela altaica,* stone marten *Martes foina* and Royle's pika *Ochotona royeli*. As far as the avian species are concerned, we recorded 26 species, which include rare species like Tibetan Partridge *Perdix hodgosoniae* and Tibetan Sow-cock *Tetraogallus tibetanus*.

Vegetation is characterised by dry alpine steppe. The dominant plant species include *Caragana* spp., *Artemisia* spp., *Eurotia* sp., *Festuca* sp. and other graminoids such as *Stipa* spp., *Carex* and *Kobresia* spp.

Field methods

The data were collected during Nov. 2002 to Apr. 2003. Tibetan argali was observed by walking on selected trails, and from vantage points. Four trails and two vantage points were established for the study. Each trail and vantage point was visited at least three times a month.

The walking routes and vantage points were selected without *a priori* knowledge of the ungulate occupancy and all the sightings were considered to be random observations.

Whenever a group of argali was encountered, its group size, time, date and age/sex compositions were recorded. The observations were aided by 8x40 binoculars and a 15-45X spotting scope. Habitat variables *viz.,* slope angle, distance to cliff, elevation and vegetation cover at the animal locations were determined and duly recorded. Each argali observation was plotted on 1:50,000 topographic map of the study area. The distance to cliff and slope angle were visually estimated in the field, while elevation was determined from the topographic map. Vegetation cover was determined by estimating the percentage cover within 15 m radius around the animal location.

Data on shoats' habitat use were collected during noontime when they were relatively stationary and fed at least for an hour, unlike during other times of the day when they were on the move (i.e., moving up to pasture and returning back to the camp). The shoats' locations were plotted on the topographic map and the habitat variables at their locations were determined in the same way as described for argali.

Analytical methods

The effect of shoats' grazing on argali habitat use was determined by assessing the latter's habitat use in the presence and absence of shoats, and subsequently comparing the two using a one-way Analysis of Variance (ANOVA). Analysis of variance is used to test the hypothesis that variable means are equal. This procedure produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. The assumptions of normality and homogeneity of variance were fulfilled for most of the variables; ANOVA is however quite robust with respect to these assumptions, provided the sample sizes are large and equal or nearly equal between the groups (Zar, 1984).

The differential use of habitat by the three groups: argali (with shoats), argali (without shoats) and shoats was analysed using the Non Metric Multidimensional Scaling (NMDS). Multidimensional scaling attempts to find the structure in a set of distance measures between objects or cases. This is accomplished by assigning observations to specific locations in a conceptual space such that the distances between points in the space match the given dissimilarities as closely as possible (Norussis, 1997). Iterations were stopped when the Sstress plunged below 0.005. Maximum iteration was set at 30. All statistical procedures were performed with SPSS 8.0 for windows.

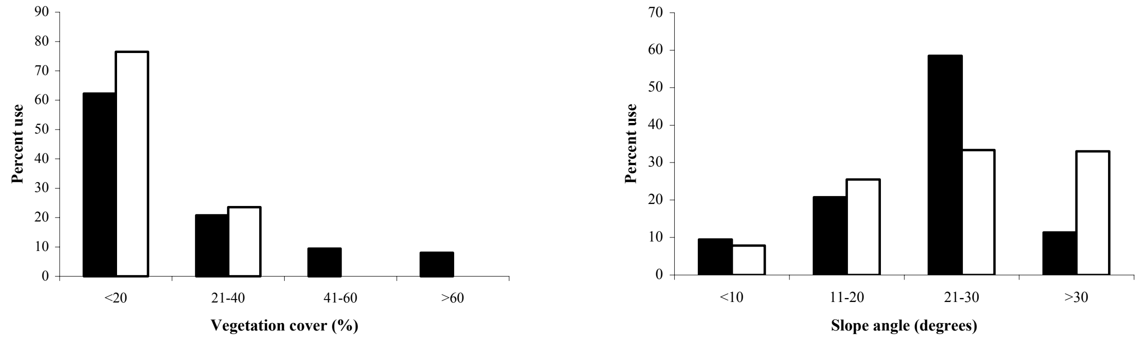
Results

Fifty-three observations on argali habitat use without shoats and 51 observations with shoats were made during the six-month study period. Besides these, 45 observations were made on the shoats' habitat use. There were 48 individuals of argali in the study area, which comprised of 31% males, 42% females, 8% yearlings and 19% lambs. Five herds of shoats, each comprising of an average 600 individuals grazed in the area.

Seventeen percent of the argali observations were made in areas with more than 40% ($n = 53$) vegetation cover when the shoats were absent, while no argali ($n = 51$) occupied such habitat after the arrival of the shoats (Fig. 3.1a). In other words, argali used areas with higher vegetation cover in the absence of shoats, and shifted to habitats with less vegetation cover as the shoats entered the area ($F = 9.581$, $p < 0.005$). Similarly, argali used gentle slopes in the absence of shoats but shifted to steeper slopes following the shoats' arrival ($F = 4.017$, $p < 0.05$) (Fig. 3.1b).

Argali use of habitat in terms of distance to cliff did not differ between the periods of shoats' presence and absence ($F = 0.810$, $p = 0.370$). Nevertheless, there is a trend of argali shifting to areas closer to cliffs after the shoats' arrival. For example, prior to the shoats' arrival, argali were observed in habitats more than 400 m from cliffs, while it vacated such habitats after the shoats came in (Fig. 3.1c). Twenty nine percent of the argali observations were made in habitats with elevation ranging from 4900-5100 m compared to only 13% after the shoats' arrival (Fig. 3.1d). Nevertheless, the overall differences in elevation use between the two periods were not significant ($F = 0.019$, $p = 0.890$).

a. **b.**



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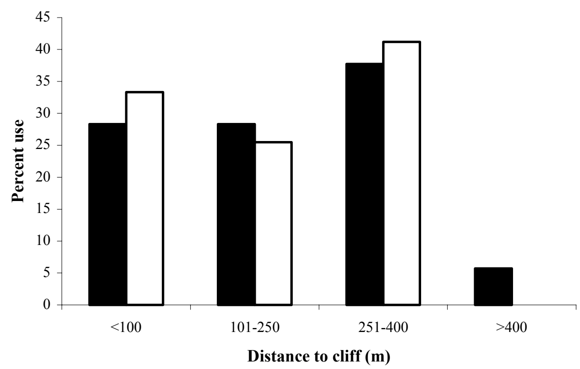

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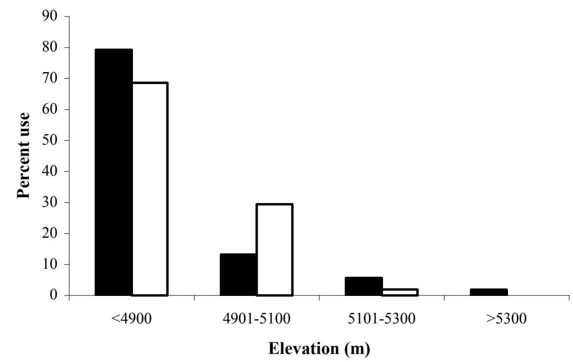


Fig. 3.1. Argali habitat use in terms of a) vegetation cover, b) slope angle, c) distance to cliff and d) elevation in the presence (white) and absence of shoats (black).

Differential habitat use by the three groups, argali (with shoats), argali (without shoats) and shoats, was explained by two dimensions in NMDS, which are represented by X (first dimension) and Y (second dimension) axes in Fig. 3.2. Vegetation cover had the highest loading (stimulus co-ordinate = 1.4) on the first dimension, thereby explaining the variability in habitat use. Distance to cliff had the highest loading (stimulus co-ordinate = 1.3) on the second dimension. Thus it is apparent that argali shifted to areas closer to cliffs with less vegetation cover after the arrival of shoats, which occupied argali's previous habitat, characterised by high vegetation cover and far from cliffs (Fig. 3).

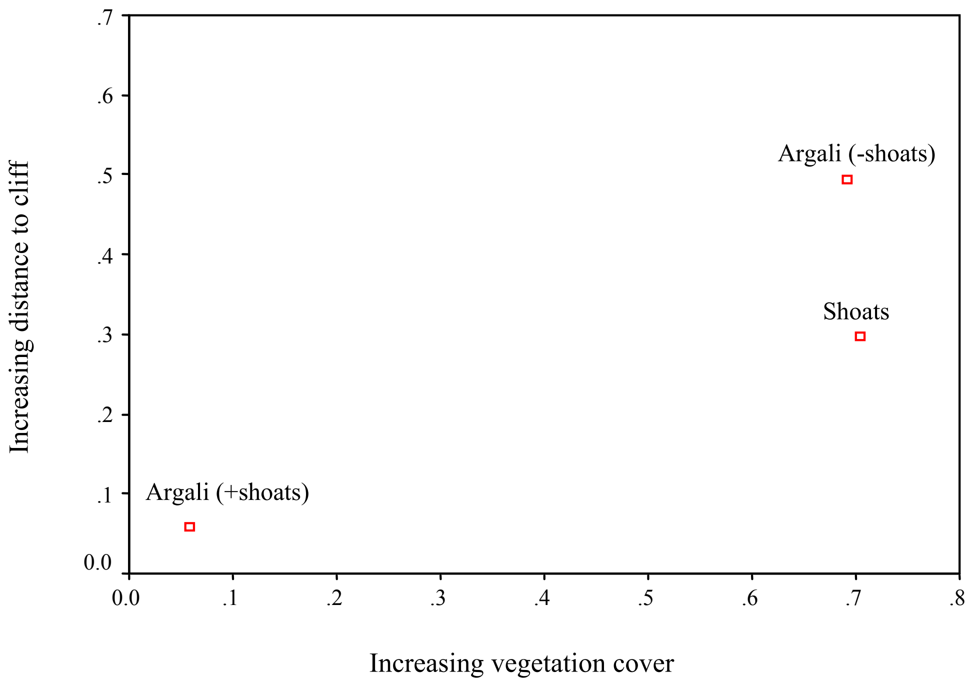


Fig. 3.2. Result of Non Metric Multidimensional Scaling, which show relative positions of argali (with shoats), argali (without shoats) and shoats in a conceptual space.

Discussion

The results of the study suggests of potential competition between argali and shoats in the proposed sanctuary. After the arrival of the shoats, although argali remained in the same area, they started using the habitat features differently. For example, it used gentle slopes in the absence of shoats, but shifted to steeper areas following the shoats' arrival. Such a relationship could be attributed to the mutual preference of undulating terrain by both argali and shoats, and the consequent usurpation of such areas by the latter. The shoats are accompanied by guarding dogs, which is known to prey on juvenile argali. Therefore, the shift in habitat use by argali after the shoats' arrival may be a reflection of its avoidance of predation on juveniles by the guarding dogs. Although, given the escape strategy of argali, i.e., running from predators, they may not be efficient in steeper areas, but seems like they do not have choice other than maintaining a safe distance irrespective of the terrain type.

Both argali and shoats may be limited by food availability during winter. Hence, the probability of competition between the two is higher during this season. Theoretically, animals should avoid competition by partitioning food resources and/or habitat. As per competition theory, argali preference for habitats that are also preferred by shoats should decline as resources get depleted in these habitats. Nevertheless, since the plant diversity is so low in the Trans-Himalaya (Mishra, 2001) especially in winter, unlike in the dry season of the African savannas, that some overlap in diet is inevitable. Therefore, while faecal analysis is being carried out to assess the diet overlap and possible competition, we, at this juncture, speculate that the two species compete for the limited forage. Thus the habitat shift by argali in the presence of shoats may also be a strategy of avoiding competition, or it may well be a combination of avoiding competition and predation from guarding dogs, as discussed earlier.

Such habitat shift by wildlife in response to livestock grazing is reported from elsewhere. For example, Fritz *et al.* (1996) found that impala *Aepyceros siceros* shifted to 'refuge habitats' in the presence of cattle in an African savanna-woodland. The relegation of argali to marginal habitats by the livestock may have demographic consequences. In the marginal habitats the intake rate (foraging efficiency) may go down, which may ultimately reduce the reproductive fitness of argali. Furthermore, the displacement of argali to sub-optimal habitats increases the former's movement (Namgail, Fox and Bhatnagar, unpubl. data), probably because it needs to move constantly in search of forage in the impoverished habitats. Such increased movement may leave argali with less energy for other vital activities such as foraging, thereby compromising with the population performance.

The habitat shift by argali in response to shoats' grazing was substantiated by the results of NMDS, which revealed that shoats, on their arrival, occupied habitat characteristics that were earlier used by argali. After the shoats' arrival, argali used habitats characterised by low vegetation cover and closer to cliffs as against when the shoats were absent in the area (Fig. 3.2). Although, habitat (distance to cliff) use by argali (with shoats) and argali (without shoats) did not differ when the means were compared, it contributed to the level of segregation when livestock data were included in the NMDS model.

In sum, due to the mutual preference of open areas by both argali and shoats, the husbanded shoats with no natural regulating mechanism has the potential to displace argali from its preferred habitats, and relegate them to marginal areas, which may affect its fecundity and consequently population performance. The habitat shift by argali in response to shoats' grazing could be related to avoidance by argali of competition with shoats and/or avoidance of predation on juveniles by guarding dogs. In the face of a severe competition, the livestock is likely to out-compete the argali, not because of intrinsic competitive superiority but because of the presence of guarding dogs.

Management implications

Given the high utility of domestic stock and the consequent tendency of pastoralists to increase the livestock holding beyond the carrying capacity of the rangelands in the area, the husbanded shoats may competitively exclude argali from the prospective reserve, if management steps are not taken on the right time. Such exclusion is speculated to account for the absence of argali from the arid rangelands of the Trans-Himalayan region of Spiti (Mishra *et al.,* 2002). The present investigation has indicated that domestic shoats can displace argali from its preferred habitats, which deserves immediate conservation attention. The livestock population, which is not subjected to natural regulating mechanisms should be stabilised. The inexorable developmental activities leading to encroachment of wildlife habitats (Chapter 4) may further reduce the availability of suitable habitats for argali, which is highly sensitive to any man-made disturbance (see Geist, 1971).

References

Bell, R.H.V., 1987. Conservation with a human face: conflict and reconciliation in African land use planning. In Anderson, D. & R. Grove (Eds) *Conservation in Africa: people, policies and practice*, pp.79-101, Cambridge University Press, Cambridge.

Bhatnagar, Y.V. & R. Wangchuk, 2001. *Status Survey of Large Mammals in Eastern Ladakh & Nubra.* In Anon. 2001. *Conservation Biodiversity in the Trans-Himalaya: New Initiatives for Field Conservation in Ladakh.* First Annual Technical Report (1999-2000). Wildlife Institute of India, Dehra Dun, India

Champion, H.G. & S.K. Seth, 1968. *The forest types of India.* Government of India Press, Delhi.

Chundawat, R.S. & G.S. Rawat, 1994. Indian cold deserts: a status report on biodiversity. Wildlife Institute of India, Dehradun, Uttaranchal.

Fritz, H., M. de Garine-Wichatitsky & G. Letessier, 1996. Habitat use by sympatric wild and domestic herbivores in an African savanna woodland: the influence of cattle spatial behaviour. *J. Appl. Ecol.* **33:** 589-598.

Geist, V., 1971. *Mountain sheep: A study of behaviour and evolution,* pp. 383, University of Chicago Press, Chicago.

Mishra, C. 2001. *High altitude survival: conflicts between pastoralism and wildlife in the Trans-Himalaya*. Ph.D. thesis, Wageningen University, the Netherlands.
Mishra, C., S.E. Van Wieren, I.M.A. Heitkonig, & H.H.T. Prins, 2002. A theoretical analysis of competitive exclusion in a Trans-Himalayan large-herbivore assemblage. *Anim. Cons.* **5:** 251-258.
Norussis, M.J., 1997. Statistical Package for Social Sciences (SPSS) 7.5. SPSS Inc., Chicago.
Schaller, G.B., 1998. *Wildlife of the Tibetan Steppe,* pp. 373, University of Chicago Press, Chicago.
Zar, J.H., 1984. *Biostatistical analysis.* Pentice-Hall Inc.

CHAPTER 4

LIVESTOCK MORTALITY CAUSED BY LARGE CARNIVORES IN A PROSPECTIVE TRANS-HIMALAYAN RESERVE

Summary

The loss of livestock to wild predators is an important cause of anxiety amongst the Trans-Himalayan pastoralists. The dependency of these predators on livestock is perceived to have increased in the recent years, probably as a result of a decline in natural prey. In the present survey, we assessed the intensity of livestock depredation by snow leopard *Uncia uncia,* Tibetan wolf *Canis lupus chanku* and Eurasian lynx *Lynx lynx isabellina* in three villages, namely Gya, Rumtse and Sasoma, of the proposed Gya-Miru Wildlife Sanctuary, Ladakh, India. Wolf was the most important predator, accounting for 60% of the total livestock losses due to predation for the three villages over a period of two and half years, followed by snow leopard (38% and negligible depredation by lynx). Domestic goat (32%) was the major victim followed by sheep (30%), yak (15%) and horse (12%). Livestock were mostly killed in high-pasture corrals (33%), high pastures (31%), village corrals (19%) and village pastures (17%). The majority of the livestock losses occurred in summer (33%) and spring (31%), with lower losses in autumn and winter (each 18%). Altogether, the three villages incurred an estimated monetary loss of about US$ 30, 000 during the above-mentioned period. The total annual monetary loss was dependent largely on the depredation of the most valuable species such as yak and horse.

Objective

- To assess the intensity of livestock depredation by snow leopard, Tibetan wolf and Eurasian lynx in the proposed Gya-Miru Wildlife Sanctuary.

Methods

Study area

The proposed Gya-Miru Wildlife Sanctuary (GMWS, 33^o N, 78^o E) is located at about 65 km southeast of Leh, Ladakh, India. It encompasses *ca.* 340 km^2 at the western fringe of the Tibetan Plateau. Like the rest of the Trans-Himalaya, the proposed reserve is in the rain-shadow of the Greater Himalaya, and thus the precipitation is quite low. Owing to this, and the short growing season of four months (May-Aug.), the primary productivity is low (Chundawat & Rawat, 1994; Mishra, 2001). Vegetation is characterised by dry alpine steppe. The dominant plant species include *Caragana* spp., *Artemisia* spp., *Eurotia* sp., *Festuca* sp. and other graminoids such as *Stipa* spp., *Carex* sp. and *Kobresia* sp. Altitude in the area ranges from 3900-5700 m. The southern part of the sanctuary is relatively undulating, while the northern part is more rugged. Climate is severe in winter with the minimum temperature plunging to –25^{o}C or sometimes lower.

The major mammalian predators include the snow leopard, wolf and lynx. The former two opportunistically prey on all the livestock species, while the latter attack only young sheep and goats. Although, the wolf rarely attacks adult yaks and horses singly, a pack of 3-4 wolves can easily do so. The major avian predator is the golden eagle *Aquila chrysaetos,* which attacks juvenile sheep and goats.

Wild ungulates such as the Tibetan argali *Ovis ammon hodgsoni*, blue sheep *Pseudois nayaur* and Ladakh urial *Ovis vignei vignei* constitute the major wild prey of wolf and snow leopard in this area. These carnivores, including the lynx, also prey on myriad small mammals: Himalayan marmot *Marmota bobak,* long-tailed marmot *M. caudata,* Tibetan woolly hare *Lepus oiostolus* and Royle's pika *Ochotona royeli.* All these wild herbivores share the pastures with the livestock, which consist of yak, horse, sheep, goat, and a limited number of donkey, ox and cow. The large carnivores also take a toll on these domestic ungulates in the wake of non-availability of wild prey, which are believed to be in decline due to competition with the livestock. Yak and horse range freely, while sheep and goats were herded and penned in open corrals at night. The limited number of donkeys, cows and oxen grazed on the pastures in the vicinity of the villages and were sometimes stall-fed.

There are five villages within the boundary of the prospective reserve, and the three largest villages *viz.,* Gya, Rumtse and Sasoma were surveyed. The inhabitants are agro-pastoralists with a major emphasis on livestock production. Other than rearing livestock, people resort to some extractive activities, mostly for fuel.

Data collection

Data were gathered by interviewing both villagers and herders during Jan.-Jul. 2003. All the livestock reportedly killed over a period of two and half years (Jan. 2001-Jun. 2003) were recorded. For every loss, species, sex, age, month, year, site type (i.e., high pasture, high-pasture corral, village corral and village pasture) and predator species were recorded. Information on livestock populations was gathered from the headman of Gya Village, who maintains a record of annual population size "*Gyalug tho*" for the three villages. This information was compared with the records of the Sheep Husbandry Department, Leh, and our own counting for the households, which had grazing rights in our ecological study area.

One adult person, preferably the head, from each family was interviewed; subsequently the herders were interviewed to assess accuracy of the information provided by the former. Thus, intentional exaggeration was minimized. The interviews were conducted following our presence in the area for at least a month, which we believe convinced them of the academic nature of our work. Only those depredation cases which they clearly remembered, and where the animal was either killed or maimed followed by death were taken into account. Care was taken to avoid mistakenly assigning snow leopard depredation to wolf and vice versa. The herders claimed that they could easily distinguish between a carcass killed by wolf from that of a snow leopard. For instance, wolf attacks the hindquarters of the animal, while snow leopard attack at the neck. Furthermore, wolves mostly killed in the Khemer Valley, where we did not find a single snow leopard sign, which suggested some spatial separation in the distribution of the two predators.

The prevailing market values for each type of livestock was determined by interviewing herders, traders as well as butchers in Leh. The approximate values were as follows: (1) yak US$ 107.1 (≤ 1 year old) to 338.3 (≥ 6 year old), (2) horse US$ 195.7 (≤ 1 year) to 389.2 (≥ 6 year old), (3) sheep US$ 10.3 (6 months) to 65.5 (≥ 4 years), (4) goat US$ 11.5 (≤ 6 months) to 59.9 (≥ 4 years), (5) others (donkey, cow and ox) US$ 16.3 (≤ 1 year) to 83.8 (≥ 6 year old). The prevailing economic values of the livestock were translated into US$ at the exchange rate of US$1:INR47.4.

Although we provide overall information for the entire area, the depredation cases of Rumtse and Sasoma (henceforth collectively Rumsoma) have been merged and analysed separately from those of Gya Village. Rumsoma is *ca.* 1 km upstream of Gya, and has undulating terrain in its surrounding, while Gya has more rugged terrain (the preferred snow leopard habitat) in its vicinity. We analysed our data separately for these villages for two reasons: 1) amongst the three villages, there is likely to be differences in livestock vulnerability to different predators (e.g., livestock of Gya Village perhaps more vulnerable to snow leopard), especially during the periods when the livestock are grazed on the pastures close to the villages, and 2) in the case of differences in the extent of depredation amongst the villages, remedial interventions could be appropriately targeted.

Results

The 37 households surveyed in Gya Village possessed 2367 heads of livestock, while 26 households in Rumsoma owned 1765 heads in early 2003, when the survey was conducted. The average per household livestock holding for Gya was 64 head, while Rumsoma had an average household holding of 67.9 head. Goat constituted bulk of the livestock population (Gya, 52% and Rumsoma, 56%) followed by sheep (Gya, 34% and Rumsoma, 30%). Yak constituted (Gya, 9 % and Rumsoma, 10) of the total livestock holding, followed by horse (Gya, 3% and Rumsoma, 2%), and others 2% (all villages). There were 9 permanent herders in Gya, and 18 in Rumsoma.

All villages

The three villages lost a total of 295 animals, i.e., 7.1% of the total livestock population over a period of two and half years. Overall, domestic goat (32%) was the major victim, followed by sheep (30%), yak (15%) and horse (12%). Annual data indicated that, in the year 2001, sheep comprised the maximum (28%) of the total animals lost, followed by goat (21%), yak and horse (each 20%) and others (11%), while in 2002, goat was the major victim (29%), followed by sheep (26%), yak (17%), horse (16%) and others (12%) (Fig.1). In the year 2003, goat again comprised the maximum (41%), followed by sheep (37%), yak (10%), horse (5%) and others (7%). Although, on an average, most of the livestock were killed on high pastures and high-pasture corrals, the highest number of losses in 2001 occurred in village corrals (Fig. 2). There were also seasonal differences in livestock loss. On an average, maximum losses occurred in summer (33%), followed by spring (31%), winter and autumn (each 18%).

Wolf was the most important predator accounting for 60% of the total livestock lost by all the three villages, followed by snow leopard, which killed 38% of the total number lost. Nevertheless, snow leopard took the heaviest toll on livestock in 2001 (Fig. 3a). Lynx depredation on livestock was negligible, i.e., no loss was attributed to lynx in 2001, while only 2% and 3% in 2002 and 2003, respectively (Fig. 3).

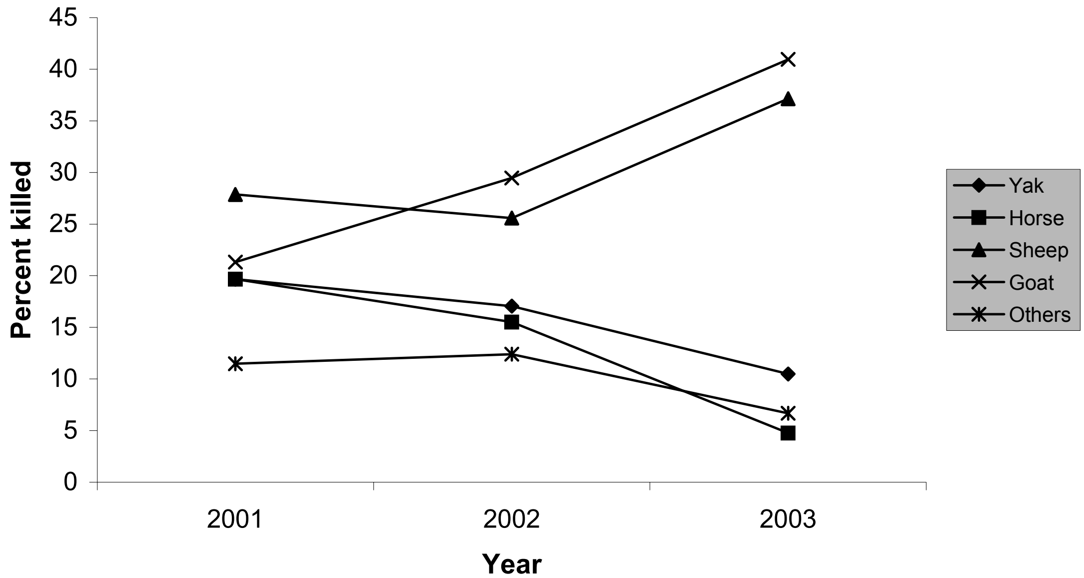
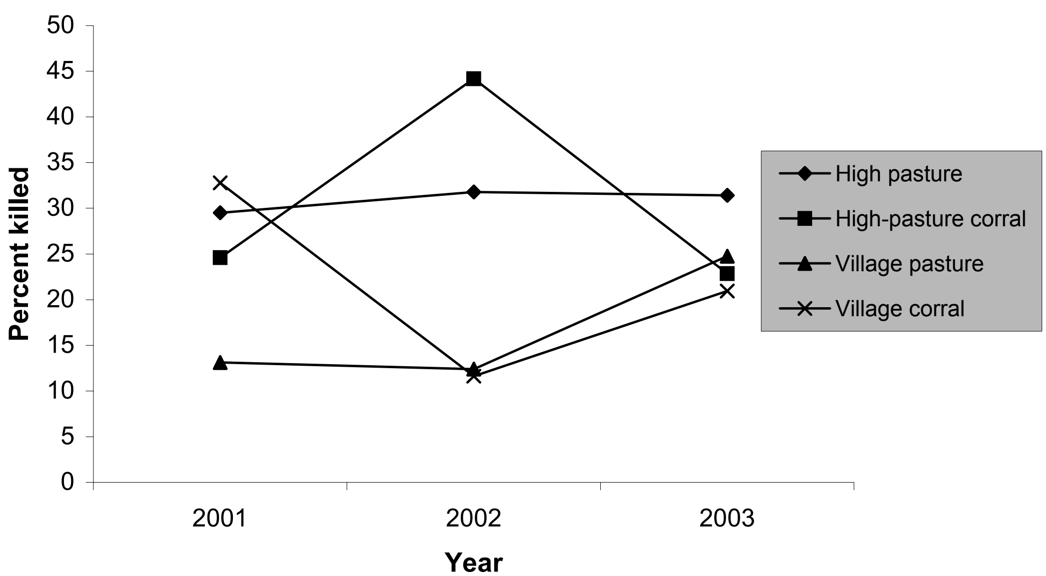
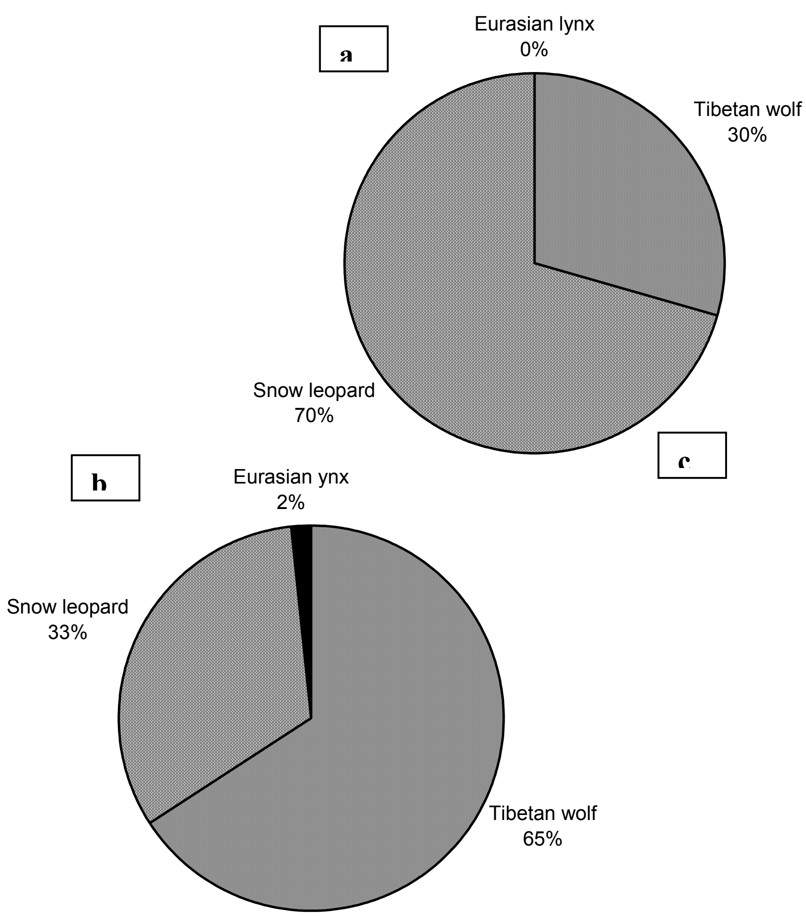


Fig. 1. Percent of different livestock species killed by large carnivores in 2001, 2002 and 2003 (Jan.-June).



Fi g. 2. Percent of livestock killed by large carnivores at different sites in 2001, 2002 and 2003 (Jan.-June).

All together, the three villages incurred an estimated monetary loss of about US$ 30, 000 over the period of two and half years (Table 1). This amounts to US$ 185 per household per year. The total annual monetary loss depended largely on the depredation of the most valuable species such as yak and horse. The 63 families surveyed incurred an estimated monetary loss of *c.* US$ 9790.3 due to loss of yak, and *c.* US$ 11289.9 due to loss of horses. These translated to an average loss of *c.* US$ 59.8 per household per year due to loss of yak, and *c.* US$ 68.9 per household per year due to loss of horses



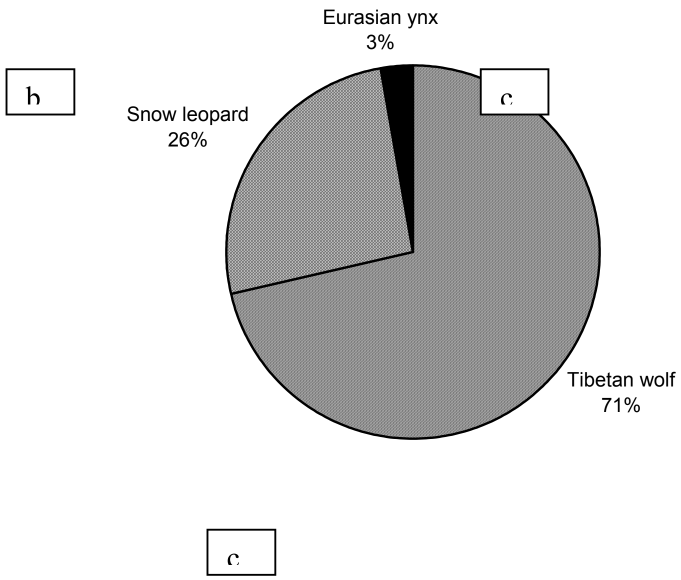


Fig. 3. Percent depredation of livestock by snow leopard, wolf and lynx in 2001 (a), 2002 (b) and 2003 (Jan-June) (c).

Table 1. Estimated total monetary loss incurred by Gya, Rumtse and Sasoma villages due to livestock lost to large carnivores over a period of two and half years (Jan. 2001-Jun. 2003). These losses were calculated on the basis of prevailing local prices in 2003.

			Monetary Loss (US$*)			
Village	Yak	Horse	Sheep	Goats	Others	Total
Gya	5327.3	5120.1	2205.9	2465.7	1304.7	16423.7
Rumsoma†	4463.0	6169.8	1139.2	1089.5	1017.7	13879.2
Total	9790.3	11289.9	3345.1	4555.2	2322.4	30302.9

*1 US$ ≈ 47.4 INR; † Rumtse and Sasoma

Gya

Gya Village lost 182 head of livestock, of which goat comprised 36%, sheep (31%), yak (13%), horse (9%) and others (11 %) (Table 2). Out of these, 59 % were attributed to wolf, 38 % to snow leopard, and only 2% to lynx (Table 3). Thirty two percent of the losses occurred on the high pastures, 30% in high-pasture corrals, 20% at village pastures, and 18% in village corrals. Thirty six percent of the losses occurred in summer, followed by 25% in spring, 21% in winter and 17% in autumn. Gya Village incurred an estimated total monetary loss of *c.* US$ 16, 424 due to livestock losses during the two and half year period (Table 1).

Table 2. Livestock losses to large predators over a period of two and half years (Jan. 2001-Jun. 2003) in Gya, Rumtse and Sasoma of the proposed Gya-Miru Wildlife Sanctuary, Ladakh (Figures in parenthesis indicate column percentages).

Animal	Gya				Rumsoma[†]			
	2001	2002	2003*	Total	2001	2002	2003*	Total
Yak	7 (17)	12 (17)	4 (6)	23 (13)	5 (25)	10 (18)	7 (19)	22 (19)
Horse	5 (12)	9 (13)	3 (4)	17 (9)	7 (35)	11 (19)	2 (6)	20 (18)
Sheep	15 (37)	13 (18)	29 (42)	57 (31)	2 (10)	20 (35)	10 (28)	32 (28)
Goat	9 (22)	29 (40)	27 (39)	65 (36)	4 (20)	9 (16)	16 (44)	29 (26)
Others[a]	5 (12)	9 (13)	6 (9)	20 (11)	2 (10)	7 (12)	1 (3)	10 (9)
Total	41	72	69	182	20	57	36	113

[a] limited number of cows, oxen and donkeys; * (Jan.-June); [†]Rumtse and Sasoma

Rumsoma

Out of 113 animals lost by Rumsoma, sheep comprised 28%, goat (26%), yak (19%), horse (18%) and others (9%) (Table 2). Of these depredation incidences, 62% were ascribed to wolf, 37% to snow leopard and only 1% to lynx (Table 3). Forty percent of the animals were killed in high-pasture corrals, 29% were killed on high pastures, 19% in village corrals and 12% on village pastures. Animals were mostly lost in spring (40%), followed by in summer (28%), autumn (20%) and winter (12%). Rumsoma incurred a total estimated monetary loss of *c.* US$ 13, 879 over the period of two and half years (Table 1).

Table 3. Livestock depredation by large predators over a period a period of two and half years in Rumtse, Sasoma and Gya villages of the proposed Gya-Miru Wildlife Sanctuary, Ladakh (Figures in parenthesis are column percentages)

Predator	Gya				Rumsoma[†]			
	2001	2002	2003*	Total	2001	2002	2003*	Total
Tibetan wolf	15 (37)	41 (57)	52 (75)	128 (59)	3 (15)	44 (77)	23 (64)	70 (62)
Snow leopard	26 (63)	29 (40)	15 (22)	70 (38)	17 (85)	13 (22)	12 (33)	42 (37)
Eurasian lynx	0 (0)	2 (3)	2 (3)	4 (2)	0 (0)	0 (0)	1 (3)	1 (1)

Total	41	72	69	182	20	57	36	113

†Rumtse and Sasoma; *(Jan.-June)

Discussion

Livestock production being the primary means of livelihood in several parts of the Indian Trans-Himalaya (Bhatnagar *et al.,* 1999; Mishra, 2001), depredation of domestic stock by wild carnivores and the antagonism it generates resulting in retaliatory killing of large carnivores by pastoralists is becoming a serious conservation issue in the region. In the proposed GMWS, wolf was the most important predator that killed livestock, followed by snow leopard with lynx depredation negligible. Nevertheless, lynx depredation could have been underestimated, as it attacks juvenile sheep and goats, and pastoralists often tend to forget such incidences, perhaps due to their relatively low economic value. However, similar studies elsewhere in Ladakh also reported low livestock depredation (2%) by lynx (Bhatnagar *et al.,* 1999).

Wolf is therefore the most despised of all the large predators in this area as well as other rangelands in the Trans-Himalaya (Mishra, 1997). According to the villagers, the wolf population is increasing, which they ascribed to the recent implementation of conservation laws. Nevertheless, illegal abduction of wolf-pups continues, although at a lower intensity than previously. Herders break into wolf dens and abduct the pups, which are then killed. These herders are much applauded and rewarded for such activities (Tashi Gyatso, pers. comm.). Therefore, the long-term survival of wolf in the Trans-Himalaya is highly uncertain. Snow leopard on the other hand is notorious for breaking into livestock pens, often killing dozens of sheep and goats in one incidence, and is consequently clubbed and stoned to death (Bhatnagar *et al.,* 1999, Jackson, 1998). As mentioned, depredation by lynx was very uncommon, and incidences of retaliatory killing of lynx was apparently few.

The three villages lost 7.1% of their total livestock population, which is quite high compared to similar figures from other Trans-Himalayan rangelands, e.g., 2.6% of the total holding in Manang, Nepal, with only snow leopard (Oli *et al.,* 1994), and 1.2% of the total livestock holding in Qomolungma Nature Reserve (Jackson, 1991), but is low compared to 18% in Kibber Wildlife Sanctuary with both wolf and snow leopard (Mishra, 1997). When analysed separately, Gya Village incurred most of the losses 8% of the total livestock population, while Rumsoma lost only 6% of the total population. Such a difference, although not much, may be accounted for by the differences in terrain type around the concerned villages. For instance, Gya Village is located closer to rugged terrain (snow leopard's preferred habitat), therefore the livestock there may be more subjected to multiple killings by snow leopard in corrals, as compared to Rumsoma, which has undulating surroundings. Four incidences of multiple killings by snow leopard in Gya Village were reported over the period of two and half years, as against none in Rumsoma. Nevertheless, the disparity could also be attributed to herding practices. For example, in Rumsoma there is twice as more herder as in Gya Village, which may substantially reduce depredation rate in Rumsoma.

Sheep and goat were the major victims in all the years, and the loss of these stocks somewhat increased in 2002 and 2003. But the depredation cases for 2001 could have been underestimated, because, as mentioned earlier, pastoralists did not remember depredation of animals, especially sheep and goats that had occurred in 2001. Although, we collected depredation information only until June for the year 2003, yak and horse depredations were minimal in that year. Generally most of the losses occurred on high pasture and high pasture corrals. Nevertheless, in the year 2001, the highest number of losses occurred in village corrals. This could be attributed to multiple killings in village corrals by snow leopard in that year (Fig. 3a).

Although, the per capita income for recent years is currently not available for the area, the average annual loss per household US$ 185 is quite significant, given that there are limited commercial activities due to the harsh environmental conditions. The annual per household monetary loss in this area is higher than the US$ 128 amounting to 52% of the annual per capita income reported from Kibber Wildlife Sanctuary, India (Mishra, 1997). The average per household loss per annum in the proposed GMWS is substantially higher than the US$ 26 per family per year in Qomolungma Nature Reserve (Jackson, 1991), and also higher than £27.6 and £29.0 per household for 1988-89 and 1989-90, respectively, reported from Manang, Nepal (Oli *et al.,* 1994). These amounts translated to a quarter of the average annual per capita income of Nepal. Nevertheless, similar studies in Africa indicated that economic loss incurred due to wild carnivore predation was insignificant (US$ 13 per household per year) compared to the losses incurred due to natural causes of livestock mortality (Butler, 2000).

Mitigating the conflict

Livestock in the villages as well as on high pastures are penned in open corrals at night. These corrals are poorly built with low walls, which are designed to keep the livestock in, rather than keeping the predators out (T.

Namgail, pers. obs.). The most decried multiple killings of sheep and goats in corrals by snow leopard could be drastically reduced, if the corrals are designed to exclude these predators. Several non-governmental organisations are already working towards this end in the region. For example, the International Snow Leopard Trust (ISLT) and the Snow Leopard Conservancy (SLC) have established new predator-proof corrals or improved existing ones in the Hemis High Altitude National Park, and continue to do so in other parts of Ladakh, which have been quite successful so far. Therefore, such corral-improvement programs should also be initiated in the proposed GMWS.

The increased depredation rates of livestock in the recent years have largely been attributed to decrease in the natural prey populations (Jackson, 1998; Mishra *et al.,* 2003). Therefore, increasing natural prey for these predators is the most desirable, although difficult proposition. Wild carnivores prefer natural prey to livestock, when the former have good populations (Quigley and Crawshaw, 1992). It is equally important to maintain a high diversity of herbivore species, so that the wild predators could shift to another wild prey in the face of a decline in the primary wild prey, rather than switching to the livestock. To this end, it is necessary to stabilize/reduce the livestock population, so that natural prey species could recover from their low numbers (Mishra *et al.,* 2003). Nevertheless, theoretically speaking, the disproportionately high livestock population, especially sheep and goats may still remain more profitable to the snow leopard and wolf in terms of energy-gain vis-à-vis searching and handling time (Begon *et al.,* 1996). Thus, protective measures and improved herding skills are also necessary to resolve the perceived conflict between pastoralists and wild carnivores.

Shepherd dogs guarding other domestic animals is an age-old concept (Coppinger and Coppinger, 1993). Dogs are presently used to guard livestock in the area, but increasing the number of these dogs to cope with a surging livestock population may have negative ramifications. For example, shepherd dogs also attack wild herbivores, such as marmot *Marmota bobak,* Tibetan woolly hare *Lepus oiostolus* (T. Namgail, pers. obs.), and also juvenile wild ungulates (Tashi Gyatso, pers. comm.), which constitute a substantial part of the snow leopard and wolf diet (Schaller *et al.,* 1988; Oli *et al.,* 1993). Such incidences of dogs attacking wildlife are also reported from elsewhere (e.g., Iverson, 1978; Kruuk and Snell, 1981; Green *et al.,* 1984; Butler *et al.,* 2004). Guarding dogs therefore may accelerate the depletion of natural prey for wild predators, which may consequently lead to increased livestock depredation by these predators (Hamlin *et al.,* 1984). Such issues must be addressed in detail in order to safeguard the future of the Trans-Himalayan endangered large carnivores such as snow leopard.

Human-wildlife conflict has become a central issue in the conservation of large carnivores across the globe (Stahl *et al.,* 2001; Mazzolli *et al.,* 2002; Polisar, *et al.,* 2003). Various measures such as compensation scheme have been explored to offset livestock losses in almost all the areas where the human-carnivore conflict is a major conservation issue (Oli *et al.,* 1994; Linnell *et al.,* 1996; Mishra, 1997; Naughton-Treves *et al.,* 2003). In the proposed GMWS, although, a compensation scheme by the government of Jammu and Kashmir is in place, operating since 1994, pastoralists are generally dissatisfied with it due largely to low compensation rates and the time and costs involved in the process (Urgyan Phuntsog, pers. comm.). Thus, the current compensation scheme, without major amendment, is least likely to resolve the human-wildlife conflict, and alternative options that could effectively resolve the conflict should be explored. The long-term survival of the large carnivores such as snow leopard hinges on the co-operation of local communities. The pastoralists who do not benefit directly from wildlife conservation could be given incentives to offset the livestock losses to large predators. Recently, we have initiated such a program in the three villages, which is aimed at enhancing living standard of the local communities on the hand and discouraging poaching and retaliatory persecution of large carnivores on the other.

In sum, while conceding the major limitation of the study i.e., relying only on villager's information, who tend to attribute deaths of their animals to wild carnivores, often without knowing the actual causes (although, care was taken to exclude all the cases, which the herders were unsure of the agents), we provide the first information on livestock depredation by large carnivores in the proposed GMWS. The three villages lost 7.1% of the total livestock holding, which translated to an estimated loss of *c.* US$ 185 per household per year. Goats were important in terms of numerical losses, while horses were important in terms of monetary losses. Wolf was the most important predator, followed by snow leopard. This information serves as a baseline data for monitoring further trends in livestock depredation in the area. More importantly, it may contribute in formulating conservation policy for this prospective reserve, which is likely to protect a number of endangered species with global conservation importance (Namgail, 2003).

References

Begon, M., Harper, J.L. and Townsend, C.R., 1996. *Ecology: Individuals, Populations and Communities*, pp. 945, Blackwell Scientific Publications, Oxford.

Bhatnagar, Y.V., Wangchuk, R. & Jackson, R., 1999. A survey of depredation and related wildlife-human conflicts in Hemis National Park, Ladakh, Jammu & Kashmir, India. International Snow Leopard Trust, Seattle.

Butler, J.R.A., 2000. The economic costs of wildlife predation on livestock in Gokwe communal land, Zimbabwe. *Afr. J. Ecol.* **38:** 23-30.

Butler, J.R.A., du Toit, J.T. & Bingham, J., 2004. Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbawe: threats of competition and disease to large wild carnivores. *Biol. Conserv.* **115:** 369-378.

Chundawat, R.S. & Rawat, G.S., 1994. Indian cold deserts: a status report on biodiversity. Wildlife Institute of India, Dehradun

Coppinger, L. & Coppinger, R, 1993. Dogs for herding and guarding livestock. In Grandin, T. (Ed.). Livestock Handling and Transport. CAB International, Wallingford, UK.

Green, J.S., Woodruff, R.A. and Tueller, T.T., 1984. Livestock-guarding dogs for predator control: costs, benefits and practicality. Wildl. Soc. Bull. **12:** 44-50.

Hamlin, K.L., Riley, S.J., Pyrah, D., Dood, A.R. & Mackie, R.J., 1984. Relationships among mule deer fawn mortality, coyotes and alternative prey species during summer. *J. Wildl. Manage.* **48:** 489-499.

Iverson, J.B., 1978. The impact of feral cats and dogs on populations of the West Indian rock iguana, *Cyclura carinata. Biol. Coonserv.* **14:** 63-73.

Jackson, R., 1991. *A wildlife survey of the Qomolungma Nature Preserve, Tibet Autonomous Region, People's Republic of China.* Woodlands Mountain Institute, Franklin, West Virginia.

Jackson, R., 1998. Depredation management handbook: environmentally and socially responsible livestock-predator damage control measures for Qomolangma Nature Preserve, Tibet. Pp. 18. International Snow Leopard Trust, Seattle.

Kruuk, H. & Snell, H., 1981. Prey selection by feral dogs from population of marine iguanas (*Amblyrhynchus cristatus*). *J. Appl. Ecol.* **18:** 197-204.

Linnell, J.D.C., Smith, M.E., Odden, J., Kaczensky, P. and Swenson, J.E., 1996. Strategies for the reduction of carnivore-livestock conflicts: a review. Oppdradsmelding **443:** 1-116. Norsk Institutt for Naturforskning, Norway.

Mazzolli, M., Graipel, M.E. & Dunstone, N., 2002. Mountain lion depredation in southern Brazil. *Biol. Conserv.* **105:** 43-51.

Mishra, C., 1997. Livestock depredation by large carnivores in the Indian Trans-Himalaya: conflict perceptions and conservation prospects. *Environ. Conserv.* **24:** 338-343.

Mishra, C., 2001. *High altitude survival: conflicts between pastoralism and wildlife in the Trans-Himalaya*. Ph.D. thesis, Wageningen University, the Netherlands.

Mishra, C., Allen, P., McCarthy, T., Madhusudan, M. D., Bayarjargal, A., and Prins, H. H. T. 2003. The role of incentive programs in conserving the snow leopard. *Conserv. Biol.* 17: 1512-1520.

Namgail, T., 2003. Gya-Miru: last refuge of the Tibetan argali. *Sanctuary Asia*. **23:** 16-21.

Namgail, T., Fox, J.L. and Bhatnagar, Y.V., 2003. Sheep and shoats: friends or foes? Competitive interaction between argali and shoats (domestic sheep and goats) in a prospective Trans-Himalayan reserve. Wildlife Institute of India, Dehradun.

Naughton-Treves, L., Grossberg, R. & Treves, A., 2003. Paying for tolerance: rural citizens' attitudes toward wolf depredation and compensation. **17:** 1500-1511.

Nowell, K. & Jackson, P., 1996. Wild cats: status survey and action plan. IUCN, Gland, Switzerland.

Oli, M.K., Taylor, I.R. and Rogers, M.E., 1993. Diet of the snow leopard (*Panthera uncia*) in the Annapurna Conservation Area, Nepal. *J. Zool. (Lond.)*. **231:** 365-370.

Oli, M.K., Taylor, I.R. and Rogers, M.E., 1994. Snow leopard *Panthera uncia* predation of livestock: an assessment of local perceptions in the Annapurna Conservation Area, Nepal. *Biol. Conserv.* **68:** 63-68.
Polisar, J., Maxit, I., Scognamillo, D., Farrell, L., Sunquist, M.E. & Eisenberg, J.F., 2003. Jaguars, pumas, their prey base, and cattle ranching: ecological interpretations of a management problem. *Biol. Cons.* **109:** 297-310.
Quigley, H.B. & Crawshaw, P.G., 1992. A conservation plan for the jaguar *Panthera onca* in the Pantanal region of Brazil. *Biol. Conserv.* **61:** 149-157.
Schaller, G.B., Junrang, R. & Mingjiang, Q., 1988. Status of the snow leopard *Panthera uncia* in Qinghai and Gansu Provinces, China. *Biol. Conserv.* **45:** 179-194.
Schaller, G.B., 1998. *Wildlife of the Tibetan Steppe,* pp. 373, University of Chicago Press, Chicago.
Stahl, P., Vandel, J.M., Herrenschmidt, V. & Migot, P., 2001. The effect of removing lynx in reducing attacks on sheep in the French Jura Mountains. *Biol. Cons.* **101:** 15-22.

CHAPTER 5

SYNTHESIS: HUMAN ENDEAVOURS AND ARGALI CONSERVATION

The Trans-Himalayan rangelands, characterised by low primary productivity has a surprisingly high diversity of wild fauna including eight ungulate species including the highly endangered Tibetan argali *Ovis ammon hodgsoni.* The population of argali in Ladakh is however highly fragmented. This was largely attributed to the hunting for trophy as well as meat (Fox *et al.,* 1991). Recognising the need to conserve the species in India, the government of India imposed restriction on argali hunting. However, given the dynamic and complex nature of ecological processes, which often interact, a question was asked i.e., is argali rebounding after the ban on its hunting? If not, what other factor/s is/are hindering the recovery? Preliminary surveys of argali in various parts of Ladakh (Bhatnagar and Wangchuk, 2001; T. Namgail, Fox and Bhatnagar, unpubl. data) yielded few sightings of argali, suggesting that the species has not bounced back, and may even have declined. This set the stage for the present survey, and the study on the nature of interaction between argali and domestic shoats, which are comparable to argali in body size and associated ecological requirements.

Major conclusions

The lamb : ratio of 45 : 100 of argali indicates that the fecundity is quite low (chapter, 2). We suggest that the argali population may either have remained static or even declined, which implies that there are additional factor(s) that is counteracting the positive effects of moratorium on argali hunting. Chapter 3 shows that shoats accompanied by herders and guarding dogs relegate argali to marginal habitats, where its energy intake rate might go down. Furthermore, it was observed that argali's movement increases after the shoats' arrival in its habitat (Namgail, Fox and Bhatnagar, unpubl. data). Although faecal analysis is being carried out to assess the dietary overlap and competition, we at this juncture speculate that they compete for forage, especially during winter. Thus, we suggest that after the arrival of shoats, argali abandon the previously occupied habitats to avoid competition with the former. Shoats on their arrival occupied argali's former habitats. Alternatively, the argali might be maintaining a distance from the shoats to avoid predation on juveniles from guarding dogs, which accompanied shoat herds. The observed response by argali to the shoats may also be a result of the combination of predator and competition avoidance. In any case, we suggest that domestic shoats displace argali at least at the habitat level. This questions the long-term survival of argali in areas, where livestock population is increasing.

Multiple-land use and argali conservation

On the arid and marginal land, where any other exploitation pattern is not profitable, livestock husbandry is the best option for the people of this region. Thus livestock production is the mainstay of their economy. Nevertheless, they cultivate barley, green peas and some vegetable in the few summer months. The agricultural by-products are used for supplementary feeding to livestock during severe winters. Some farmers even grow green peas exclusively for fodder production (T. Namgail, pers. obs.). Thus, agriculture also complements the livestock production, and supplementary feeding offsets the density-dependent resource limitation on the rangelands. Enhanced agricultural production, therefore, may also indirectly affect the argali population.

Livestock consists of yaks, horses, shoats, few cows and donkeys. As per the local herders, yaks have increased in recent years. This is probably a result of minimal demand of labour for yak rearing, as they could be left untended in the high pastures, sometimes even during winter. Nevertheless, the increased threat from wolf has concerned the pastoralists over the years. Thus, the trend may reverse toward more shoats, which are tended in the high pastures, and more importantly have high demand in the *Pashimna* and meat market. Such a trend may increase the level of competition between these stocks and the argali. Moreover an increase in shoat population may increase the demand for guarding dogs, thereby increasing the predation pressure on argali. These issues need to be addressed thoroughly to safeguard the small population of argali in India.

Other anthropogenic threats to argali

In the name of development, lot of inexorable construction activities are currently going on in the area, which could seriously damage the ecological set-up. For example, a road under construction from Rumtse to Tiri Village traverses prime argali habitat in GMWS. The completion of this road may pose serious threat to the long-term survival of argali. Furthermore, there is an unconfirmed report that people of Gya Village are planning to build a motorable road to the Tsabra catchment to smoothen the transport of manure from the corrals, which may endanger the remnant population of argali, which probably use the catchment as winter habitat.

Management implications

The high density of argali observed in the proposed Gya-Miru Wildlife Sanctuary during the survey, which is the first intensive survey of argali in Ladakh, indicates that the area could serve as a potential reserve to conserve the relic population of argali in India. Therefore, we suggest that the area should be declared and gazetted as a sanctuary or a 'community reserve' (Anon. 2003) to conserve the argali. The conservation laws for the reserve should be formulated in accordance with the interest of the local people, unlike in some other protected areas in the region, where the failure is complete in harmonising human and wildlife (see Appendix II for specific recommendations).

The displacement of argali by shoats from its preferred habitats demands immediate attention from argali conservationists. Given such displacement and the rampant escalation in shoats' population (Anon., 2002), the long-term survival of argali in India is questionable. Such increase in livestock population may impose resource limitation on argali, and may also increase the number of guarding dogs in the area, thereby increasing the predation pressure. Therefore, the livestock population needs to be stabilised in the area, and herders should be discouraged from using more than one herding dog per shoat herd.

Finally, argali and other wildlife could be flourished if the pastoral community gets convinced that a multi-pronged economic system is healthier than a one-dimensional (pastoral) economy. The pastoralists should be encouraged to explore alternative sources of income such as wildlife ecotourism. This is challenging, especially in this agro-pastoral community living on marginal lands, using methods honed over centuries. They might consider any deviation dangerous to the economy that leave little margin for risk. Nevertheless, it can be accomplished if the right effort is made at the right time.

References

Anonymous, 2002. Annual Report for 2001-2002. Sheep Husbandry Department, Leh.

Anonymous, 2003. The Wild Life (Protection) Act 1972 (as amended upto 2003). Wildlife Trust of India, New Delhi.

Bhatnagar, Y.V. & R. Wangchuk, 2001. *Status Survey of Large Mammals in Eastern Ladakh & Nubra.* In Anon. 2001. *Conservation Biodiversity in the Trans-Himalaya: New Initiatives for Field Conservation in Ladakh.* First Annual Technical Report (1999-2000). Wildlife Institute of India, Dehra Dun, India

Fox, J.L., C. Nurbu & R.S. Chundawat, 1991. Tibetan argali (*Ovis ammon hodgsoni*) establish a new population. *Mammalia* **55:** 448-451.

Mishra, C., S.E. Van Wieren, I.M.A. Heitkonig, & H.H.T. Prins, 2002. A theoretical analysis of competitive exclusion in a Trans-Himalayan large-herbivore assemblage. *Anim. Cons.* **5:** 251-258.