Interaction of Kiang (*Equus kiang*) with Livestock in Hanley Valley of Chanthang Wildlife Sanctuary, Ladakh

Dissertation Submitted to

University of Saurashtra, Rajkot

In partial fulfilment of

Master's Degree in Wildlife Science

By

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Under the Supervision of

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June 2009

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CERTIFICATE

This is to certify that Asif Hussain of the Wildlife Institute of India has carried out original research titled "Interaction of kiang (*Equus kiang*) with livestock in Hanley valley of Eastern Ladakh" in partial fulfilment of Masters in Wildlife Science from Saurashtra University, Rajkot. These investigations were carried out under our supervision at the Wildlife Institute of India from November 2008 to June 2009. We also certify that this work has not been submitted for any other degree to any other university.

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ACKNOWLEDGEMENTS

My heartfelt gratitude for all the people and organizations, without them my study would have not been possible.

The Director, Shri P. R. Sinha and Dean (Faculty of Wildlife Science) Dr. Vinod Mathur, of Wildlife Institute of India for permitting and promoting this study in various ways at various stages.

I sincerely thank my guides Shri Qamar Qureshi, for his inputs in the form of study design and statistical analysis and Dr. G. S. Rawat for his conviction, zeal and passion for Trans-Himalayas which inspired me greatly. I extend my heartfelt gratitude to both for their pragmatic guidance and immense patience.

The Jammu and Kashmir forest and Wildlife Department was very supportive of this study. Thanks to Chief Wildlife warden, Mr Jigmet Takpa (conservator of forest), Mr Tahir Shawl (Wildlife warden Leh), regarding permissions and valuable suggestions.

The winter in Ladakh was particularly severe over the duration of the study. This study would not have been possible without the generous support extended to me by the Indian Institute of Astrophysics. I extend my sincere thanks to Professor Incharge (IIAP Bangalore) for allowing me to stay at their base camp in Hanley. A special word of thanks to Ka Angchuk Dorjee (Engineer Incharge), Ka Tashi, Ka Sonam, Ka Thubstan, Nawang, Ka Tsewang. Also I would like to thank all the staff of IIAP Hanley, Liker and Chemet for the exquisite dishes they prepared, Dorjee (Chotu) and his wife for great hospitality during my stay in Hanley Chemba, Norbu, Dorjee, Goree, Lamo and her husband. Special thanks for Kesang Angail for helping me with sample collection IIAP drivers Fouji, Skouru, big ustad, and Kiran.

I would like to thank my field assistants Nawang Dechen, Tsering dorjee (Partner), Paljoor their Indigenous knowledge of about the area was amazing.

I sincerely thank Dr. T. Phounchok Sheep Husbandar dept. Leh and their staff at Hanley for helping me with sample collections and Socio-economic surveys.

I would like to thank Dr. Parag Nigam, Namgail, Dr. Yashveer Bhatnagar, Nita shah, Dr. Raghu Chundawat, Dr. Bilal habib, Suresh, Gopi G. V. and Ashwani for helping me developing the idea of the study.

I offer my humble thanks to Mr. Karma field coordinator nature conservation foundation Mysore (NCF) for all sorts of help he provided me.

I would like to thank all the faculty at WII, especially Dr. Vasudevan, Dr. Hussain, Dr B. K. Mishra, Dr Malik and Dr. Y. V. Jhala especially Dr. V. P. Uniyal (Course Director).

I want to thank Nilanjana, from the GIS, cell for all the help with the GIS analysis, Babita (project assistant Tiger Project) for helping me out with formatting of the thesis, Manoj kumar for GIS help.

Thanks to All library staff, computer room staff, Laboratory staff especially Vinod Thakur for his help in Lab. analysis.

It was a completely different environment for me to adjust In WII as I am from a very different background and was also with almost zero knowledge about wildlife, but with the help of my batch mates I stood tall and slowly developed confidence and my classmates have a great contribution in it, so I would like to thank Sahas for helping with Birding skills, Murali for Microsoft office, Sartaj and Rekha with stats & Excel , shuniti for lovely meals at his place Sumitra as a critic, Sabita and Chandan with forestry and most importantly I would like to thank all of them for liking Tibetan food which made them come all the way to Lhasa with me.

A very warm thanks to Deep for helping me with thesis structuring and comments as well, Merwyn for again helping with thesis structuring, Abishek and moss for helping me with analysis, special thanks to Imran and Meraj for being with me all the time when i was in need of them.

Sutu, for the support and love she had given me.

I stand here today because of the unrelenting support of my family. I would like to thank my dad for developing my interest in nature and wildlife, my mom for the immense love affection that she has given me , my sisters and kaka Zakir, my cousins Murtaza and Muzafar for the support.

Lastly I would like to thank all the herders of Hanley valley for being so cooperative with me, and teaching me how tough life could be.

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Summary

Hanley Valley ((32° 41' 27" N 79° 04' 3.5") in Eastern Ladakh forms the western most extension of Tibetan plateau and has been recognized as an important biogeographic province in India (Indian Trans-Himalaya). This region harbors a rich array of wild and domestic ungulates. The area is also home to nomadic Changpa and Tibetan refugee herders. The political, social and ecological transformations have altered previous, well-established links between the pastoral population and their rangeland environment. Over the years, with growing integration of the local economy of Ladakh and with better development of cash markets, the pastoral community is fast losing its tolerance towards the kiang and it is increasingly seen as a competitor to livestock. The purpose of this study was to document this intensifying conflict between pastoralism and Kiang conservation, using resource selection functions.

Data on habitat variables were collected on 4 fixed trails of varying length (3-7 km) for kiang (with and without livestock presence) and livestock for use-availability analysis. For food habits, micro-histological method in case of kiang and bite count method in case of livestock was used. Data on activity pattern of kiang was collected to examine change in response to livestock presence. Density and encounter rates were estimated using vehicle transects (n=5) of varying lengths (5-56 km). Livestock were followed (focal animal sampling) from dawn to dusk to estimate amount of forage removed. Availability of different habitat variables was estimated using ArcGIS 9.2.

Total of 104 kiang groups before arrival of livestock and 187 kiang groups after livestock arrival to the area were recorded. Habitat use by kiang and livestock was significantly different ($\delta = 0.00016$, $p < 0.05$). Habitat use by kiang before and after livestock arrival was found to be significantly different ($\delta = 0.013$, $p <0.05$). Groups of kiang were observed (n=14) for time budget evaluation, 7 prior (640 min) and 7 (820 min) after livestock had come to the area. Activity pattern of kiang before and after livestock arrival was found to be significantly different ($\delta = 0.04$, $p <0.05$). Food preference for kiang before and after livestock arrival was not found to be significantly different. Food preference for kiang and livestock was significantly different ($\delta= 0.0000007$, $p < 0.05$). Use-availability analysis suggested differential selection for food plants. Schoener's niche overlap for food items found moderate overlap between kiang, sheep and goat (<60%) and high overlap between kiang and horse (>80%). Forage removed (kg) by sheep, goat and horse were 2.33 kg, 2.25 and 8.19 kg respectively. Total density and encounter rate for Hanley valley was 0.07 kiang/ km^2 and 0.45 kiang per km respectively.

The difference in habitat use translated into Kiang using higher elevations while livestock used middle elevations more than available. Kiang used steep slopes whereas livestock used steep as well as gentle slopes more than available. Kiang used North-West aspect more than available. Kiang used vegetation communities dominated by graminoides while sheep-goat used communities dominated by shrub and forbs. Density and encounter estimates did not show considerable increase in kiang population compared to previous studies. Hence, the perception of people of kiang overstocking in the study area appears to be misplaced. Detailed perception studies should be carried out in the whole of Changthang and herder-centered participatory programmes need to be carried out on a large scale to ensure long term conservation of kiang in eastern Ladakh.

1. INTRODUCTION

Animals are not dispersed randomly in any environment. Free ranging wild and domestic animals may exhibit extreme non-randomness in the use of the resources of the environment (Arnold and Dudzinski 1978). Habitat selection results from complex interaction of both abiotic and biotic factors including human interventions. When environmental resources are heterogeneous and patchy, both spatially and temporally, animals are likely to become strongly selective or generalist.

High animal density and heavy grazing pressures are commonly believed to reduce site selectivity.

1.1 Resourced Selection

When animals graze, they first select a location and then search for a desirable forage within the location (Kothmann 1984). The hierarchy of site selection among herbivores is usually in the following order (Senft 1987):

i. Geographical region (determined by environment, kind of animal, evolution or management)

ii. Landscape (Bounded by sociality and energy intake constraints).

iii. Plant community or terrain type (Affected by food quality and quantity)

iv. Feeding area (influenced by terrain, proximity of cover physical boundaries, animal sociality.

The final foraging decisions are selecting for ingestion the plant species, individual plant and the plant parts available within the feeding area. Competition is likely to occur when the quantity of the resources available for one species may be depleted by the presence of another in the area, i.e. when one species out-competes another.

1.1. a. Resource selection and competition

Competition between grazing animals occurs only when there is a limited supply of one or more necessities of life. Competition can be for space, water, or cover but most commonly for forage. Forage competition can vary from intense to only moderate to virtually none. In selected circumstances under mixed grazing, competition can actually be negative, i.e. synergistic in that grazing by one species enhance the quality and or quantity of grazing capacity for another. Inter specific forage competition, of course cannot occur except under mixed grazing. Dietary overlap between species is not sufficient evidence for exploitative competition, dietary overlap is important only if accompanied by spatial overlap, if shared foods are in short supply, or if one herbivore limits the access of another to a preferred forage plant species in the absence of alternative acceptable forage plant species. Diet similarity studies are only first step in accessing the competitive interaction according to Thill and Martin (1986), and they further conclude that even high diet overlap is not sufficient evidence for competition in the absence of data showing diminished animal health or reproduction.

1.2 Equid and bovid co-existence

Equids are generalist herbivores that co-exist with bovids of similar body size in many guilds of grazing herbivores in tropical ecosystems in Africa (Cumming 1982). In temperate ecosystems during the Holocene, *Equus* species apparently overlapped extensively with the steppe-living *Bison* species as well as the wild cattle of woodlands (Kurtén 1968). The ecological mechanisms that allow the co-existence in tropical and temperate ecosystems of equids and grazing bovids have been debated. Janis (1976) noted that their very different digestive systems (hindgut, ruminant) could theoretically lead them to adopt different foraging strategies, resulting in niche separation. This 'nutritional model' predicts that the efficient ruminant digestive system allows bovids such as cattle to extract more digestible dry matter than equids from medium-quality grasses (defined by their fibre content). The equid system, in contrast, should allow them to extract more than the bovids from grasses with very high fiber contents because the hindgut digestive system has a higher throughput rate. It is technically difficult to obtain accurate estimates of daily food intake and digestion for free-ranging animals (Gordon 1995), so few data are available for equids at pasture and for cattle in natural grasslands.

Information from single-species feeding trials using stalled animals shows that horses can ingest more dry forage per kg of body weight per day, and extract more nutrients than cattle on all forages (Duncan *et al.* 1990). However, at pasture the low-intake strategy of cattle may allow them to feed more selectively, and they use a wider range of plant species (Krysl *et al.* 1984). It is therefore possible that on medium-quality forages at pasture, cattle extract nutrients at a higher rate than do equids, as predicted by the nutritional model. Equids, unlike ruminants, have two sets of incisors, which could allow them to feed faster than bovids on short grass. Although zebras *Equus burchelli* are medium-tall grass feeders (Bell 1970), horses feed on grass too short for cattle in at least two European grazing systems (Gordon 1989). Further, ruminants are known to use dicotyledons, which contain more secondary metabolites than graminoids, to a greater extent than horses (Krysl *et al.* 1984). It is therefore possible that the principal mechanism of co-existence is resource partitioning by the use of different plant species, but few comparative data are available to test this hypothesis.

1.2 Resource utilization by domestic and wild ungulates in the trans-Himalaya

Several studies in the trans-Himalayan rangelands have revealed that there is a considerable overlap in resource utilization by domestic and wild ungulates. High livestock densities in rangelands in the trans-Himalaya have yielded evidence for resource competition (Mishra et al. 2001). Mishra et al. (2002) contend that rangelands of the Trans-Himalaya may be over-stocked. Further, they hypothesize that the millennia of grazing by domestic livestock in these areas may have led to the exclusion of wild herbivores in many rangelands (Mishra 2001). These findings are corroborated to different extents by a number of studies.

Based on a study in the rangelands of Spiti, (Mishra (2001) suggests that competition is the dominant interaction among herbivores of relatively low productivity systems like the Trans-Himalaya. Further evidence of this is found in other recently conducted studies. Research by Bhatnagar (1997) and Bagchi et al. (2004) reveals that Asiatic ibex (*Capra ibex sibirica*) are limited in their use of habitat and resources by livestock. Mishra et al. (2004) show evidence of competition between blue sheep or bharal (*Pseudois nayaur*) and domestic livestock, and Raghavan's (2003) study demonstrates that an overlap in the diet and habitat requirements of Ladakh urial (*Ovis orientalis vignei*) and livestock may have resulted in the former occupying sub-optimal habitats. Fairly recent research on the Tibetan argali and Tibetan gazelle in Ladakh implicate livestock for having a detrimental effect on populations of these wild ungulates. Namgail et al (2006) studied habitat shift and time budget in the argali and conclude that there is a potential for competition between these species and that livestock have a 'clear disturbance effect on argali'. Bhatnagar et al (2006) opine that livestock for being an important cause that has led to the decline of Ladakh's gazelle population.

While the above mentioned studies indicate that livestock impose resource limitation on wild ungulates in many areas, other research suggests that this is not always so. Schaller (1998) reports that competition in the Chang Tang is low; particularly where densities of both livestock and wildlife are low. Studies on summer diets (Shreshtha et al, 2005), and habitat segregation (Namgail et al. 2004) between sympatric wild ungulates indicate that in some areas within their ranges, argali and bharal co-exist without apparent competition. Negative interactions are usually avoided where animals differ in their selection of habitats, vary in selection of forage species, or differ in behavioral adaptations such as anti-predator strategies. It is often problematic to demonstrate overstocking or competition by livestock and Shrestha et al. (2005) suggest that these anthropogenic factors may not actually contribute significantly to declining trends observed in many populations of wild ungulates.

In many areas of the Trans-Himalaya, changing agro-pastoral practices, and altered patterns of utilizing natural resources, habitat fragmentation and illegal hunting have led to the decline of wild herbivore populations and their predators (Schaller, 1998, Mishra 2001).

1.5 The Kiang

During the late Pleistocene, 40000 years ago, Asian wild asses are known to have roamed as far as West Germany (Kurten, 1968). Like many other large bodied mammals, equids vanished from numerous biogeographic regions during a mass extinction about 12,000 years ago,, even though the number of species seems to have remain more or less constant (Mac faden, 1992) the range of Asian wild asses has continued to shrink ever since. The taxonomy of wild asses for whole of the Asia is still not entirely clarified (Feh et al. 2001). It is now widely accepted from morphological as well as chromosomal and mitrochondrial DNA analysis that the Tibetan wild ass or kiang (*Equus kiang*), is a species of its own (Ryder and Chemnick, 1990). The kiangs are the largest of the Asiatic wild asses. The three subspecies of kiang have geographically distinct populations (Groves 1974) and their morphology is different based on such features as skull proportions, angle of incisors, shape of rump, colour pattern, coat colour, and body size (Groves and Mazak 1967). The eastern kiang (*Equus kiang holdereri*) is the largest subspecies (142cm at shoulder), the southern kiang (*E. k. polyodon*) is the smallest (100–105cm at shoulder). The western kiang (*Equus kiang kiang*) are slightly smaller than *E. k. holdereri* and also have a darker coat (Groves 1974). The kiang has a large head, with a blunt muzzle and a convex nose. The mane is upright and relatively short. The coat is rich chestnut colour, darker brown in winter and a sleek reddish brown in late summer, moulting its woolly pelage. The summer coat is 1.5cm long and the winter coat is double the length (Groves 1974). The legs, undersides and ventral part of the nape, end of the muzzle, and the inside of the pinnae are all white. A broad, dark chocolatecoloured dorsal stripe extends from the mane to the end of the tail, which ends as a tuft of blackish brown hairs. Kiang have very slight sexual dimorphism.

Distribution

Kiang inhabits a large range in Asia and occurs in China, India, Nepal, and Pakistan, and possibly Bhutan. All three subspecies are found in China. The eastern kiang is found only in China, while the southern and western kiangs are trans-boundary species, occurring in the border areas of several countries (Shah 2002). To date, there have been few studies or population estimates conducted. All three subspecies of kiang occupy the Tibetan Plateau, which consists of vast rolling terrain, dissected by hills, snow-capped ranges, and river basins. The highlands of Tibet cover an area of 2,164,000km2 (Schaller 1998). Kiang may have been isolated on the Tibetan Plateau for several thousand years, and today, 350km separate it from the nearest *Equus hemionus* in northern Gansu and Inner Mongolia (Schaller 1998).

Population status in India

The status and distribution of kiang in Ladakh in relation to the distribution of the pastures and the pastoral community (Chang-pas) in Changthang (Ladakh) is a sensitive and a crucial issue from management perspective. In eastern Ladakh, India, Ronaldshay found that "galloping about in every direction were great herds of kiang or wild horse; and as I crossed the plains I must have seen hundreds of these ugly fiddle-headed creatures" (1902). Hunting has reduced the species to such an extend that now only about 1500 animals survive in Ladakh at a density of about 0.25/km^2 (Fox, et al., 1991). Although their range covers an area of 6,000km2 in Ladakh, kiang numbers have been greatly reduced in many areas (Fox *et al.* 1991). Jammu and Kashmir Wildlife Department Leh conducted a census in 1988 and estimated a total of 1,500 kiang, and in 1994 counted 1,518 kiang in East Ladakh (Ladakh Wildlife Department, Jammu and Kashmir State Forest Department). Approximately 1,500 to 1,600 kiang are distributed over an estimated range of 15,000km^2 in the Trans-Himalayan region with no protected areas (Chundawat and Rawat 1994). An encounter rate of 1.17 kiang/km was obtained (497 kiang in 426km) during the June 1995 survey (Shah, 1996). Survey of kiang covering 950 kms for entire Changthang in year 2002 was carried out by Wildlife Institute of India, found encounter rate of 1.302kiang/ km. A high encounter rate of 12.64 kiang/km was obtained along the Indus (278 kiang counted, Shah 1996), whilst 574 kiang were counted in a survey in July 2000, comprising an encounter rate of 0.92 kiang/km (Bhatnagar 2000).

(Bhatnagar *et. al* 2006) surveyed 365 km sin eastern Ladakh and found 0.24 animals per sq. km.

Until recently, southern kiangs were thought to be extinct (Duncan 1992). However, two surveys by Shah in 1994 and 1995 in North Sikkim (India) support their existence. They are distributed in a 200km2 area of the plateau in north Sikkim on the Indo-Tibetan border (Shah 1994, 1997). The plateau has no protected area status as it comes under army jurisdiction (Shah 1994, 1997). Very sporadic reports were available from Sikkim and no status reports on the species existed (Shah 1994). Kiang sightings were made along the Indo-Tibetan Border at an altitude between 5,100m and 5,400m An encounter rate of 0.54 kiang/km was obtained in a 138km vehicle survey in November 1994. A vehicle survey between May and June 1995 recorded an encounter rate of 0.092 kiang/km (26 kiang counted in 283km). The largest herd of kiang (n=48; foals were seen, but not counted) was observed across the border, west of Bamchola (Shah 1994). Seasonal movements across borders have caused. A vehicle survey between May and June 1995 recorded an encounter rate of 0.092 kiang/km (26 kiang counted in 283km). The largest herd of kiang (n=48; foals were seen, but not counted) was observed across the border, west of Bamchola (Shah 1994). Seasonal movements across borders have caused the indeterminate status of the subspecies (Shah 1994, 1997). In 1993, an army officer surveyed the Sikkim Plateau and gave an estimate of 90 kiangs (Maj Rao pers. comm.). In 1994, the kiang population was estimated between 74 and 120 (Shah 1994).

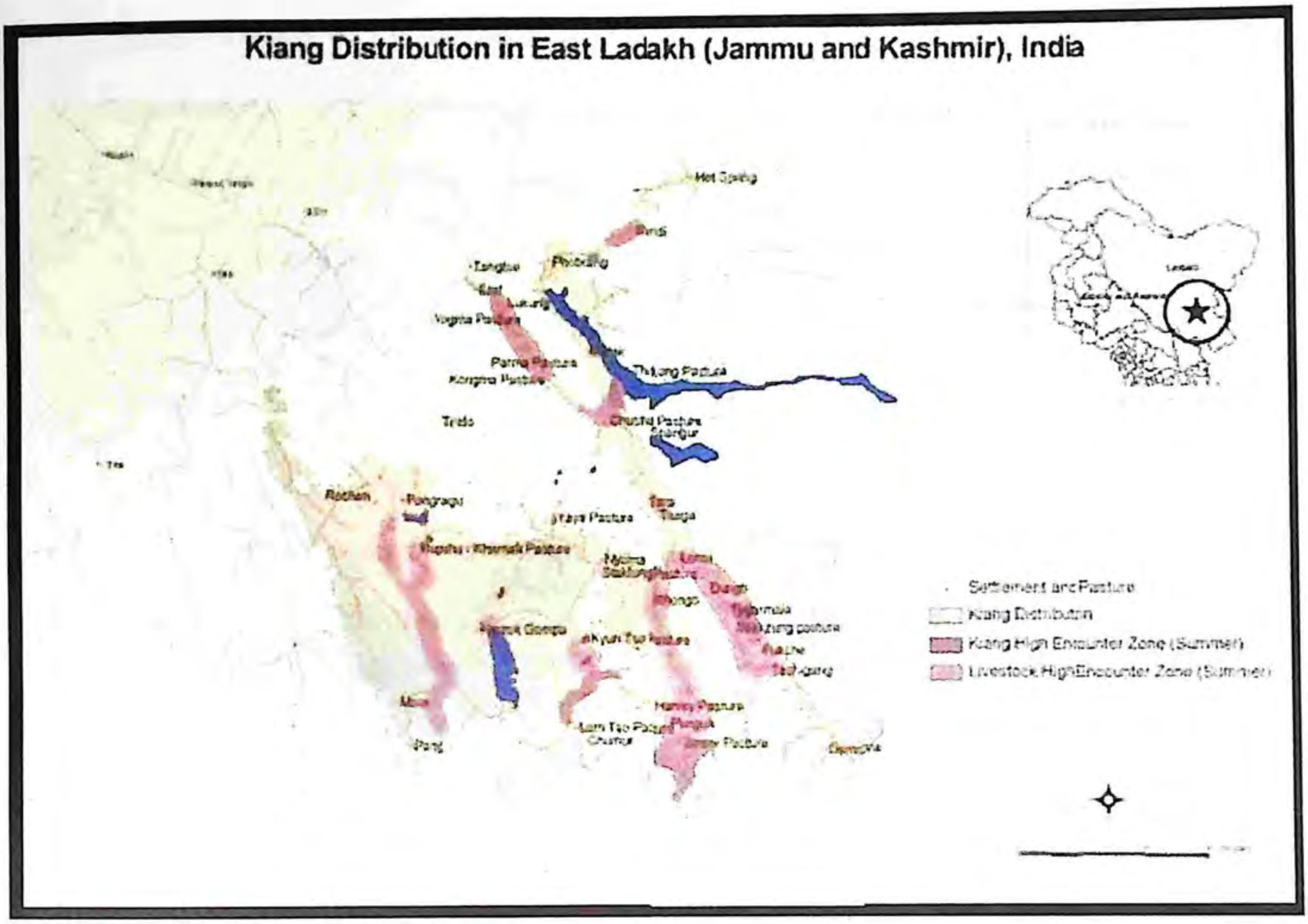


Figure 1.1 Distribution of kiang (*Equus kiang*). (source Wildlife Institute of India)

1.6 Emerging threats for kiang conservation in Ladakh

Kiang range in Ladakh covers an area of 7000 sq.km, but their number have greatly reduced in many areas (Chundawat & Qureshi 1999, Fox etal 1991). Approximately 140,000 domestic livestock (90% represented by sheep and goat and 10% by yaks and horses; Kurup 1996) compete with an estimated 5000 wild ungulates (Kitchloo 1997) in the Changtang (Ladakh). Hence there is an increased pressure on the pastureland. Jammu and Kashmir Government has encouraged nomads to keep pashmina goats for production of wool by giving incentives that will sustain their living standards. With the growing integration of the local economy of Ladakh with better development of cash markets for Pashmina , pastoral communities are fast losing their tolerance towards kiang and it is increasingly seen as competition of livestock (Fox et al 1991, Chundawat and Qureshi 1991, Shah and Qureshi 2007). Indeed, a decreasing tolerance for the species may lead in future to a worsening willingness to preserve it.

Other disturbances also arise from, 1) road networks being established for strategic reasons; 2) the State Tourist Department planning to open up new areas in the upper Indus Valley towards the Tibetan border, allowing pilgrims to visit the holy "Mount Kailash" directly from Ladakh (Pfister 1998), which would occur through the major kiang habitats in Dungti and Fukche areas.

While as increasing number of surveys has provided range and status information on kiang. We still know very little about ecology of kiang. Ecosystem analysis of habitat and forage requirements of domestic livestock and kiang is unknown. Habitat use studies are central to ecology and are necessary to develop sound management plans. In addition, information on species' requirements (e.g. forage, water, range) would be helpful to ensure that other species-specific or ecosystem management plans incorporate aspects important to kiang biology. Initial efforts should concentrate on known areas of seasonal overlap between kiang, pastoralists and their livestock.

The status and distribution of kiang in Ladakh in relation to the distribution of the pasture and the pastoral community in Changthang is sensitive and crucial issue from management perspective. Yet, with growing integration of the local economy of Ladakh with better developed cash markets, pastoral communities are fast losing their tolerance towards the kiang and it is increasingly seen as a competitor of livestock (Chundawat and Qureshi 1991,Fox et al 1991, Shah and Qureshi 2007). Ironically its relatively large population and conspicuousness are becoming concern for the continued conservation of the species. Although the species is not wronged (except driving them away from pastures by herders on horse back) in Ladakh largely due to the Buddhist beliefs of the local pastoral communities, this perceived conflict is currently one of the most serious issues being faced by the local district administration and Wildlife department, with vehement demands for compensation (Bhatnagar et al. 2006). Indeed a decreasing tolerance for the species may lead in feature to worsening willingness to preserve it.

The main aim of this study is to unravel the interaction which has intensified the conflict between pastoralist and conservation of the kiang in Ladakh. The study proposes to examine the ecological, socioeconomic aspects of Kiang-human conflict.

A preliminary survey (Asif and Namgial unpublished) have shown that Kiang and livestock share its entire range in Hanley valley. In order to co-exist these two species have to be separated spatially, temporally or at dietary level. However if there was no clear spatial separation between them the potential for competition is present.

Such competition could either lead to co-existence between the two through resource partitioning or to exploitative competition where either livestock or kiang would exclude the other species from the resources. Present study aims to find evidences for above processes.

Thus the following objectives are proposed for investigating the resource use and ecological separation between the kiang and livestock.

1.7 Objectives

1. To study the patterns of habitat selection by kiang and livestock during winter.
2. To assess forage availability and selection by kiang and livestock.

The pertinent questions with respect to these objectives are:

a. Habitat Utilization

(i) What is the availability of the habitat to wildlife populations, and how much of each habitat type is available?

(ii) Are there clear spatial or temporal differences in distribution patterns of wild and domestic ungulates on the plateau?

(iii) To what extent do habitat correlates and the presence of livestock and humans in an area influence the spatial distribution and resource utilization by wild herbivores?

2: Forage availability and utilization

(i) How similar or dissimilar is the selection and utilization of forage by domestic and wild ungulates.

(ii) What is the availability of different habitat types, cover, vegetation communities?

2. STUDY AREA

2.1 General

The study was conducted in Eastern Ladakh which lies in the Biogeographic Province 1 B of Indian Trans-Himalaya (Rodgers and Panwar 1988). This area forms the western extension of Tibetan Plateau and regarded as one of the important areas for Biodiversity Conservation in India (Rodgers et.al 2002). Also known as Changthang plateau, this zone is characterized by extremely harsh climatic conditions, low primary productivity and sparse vegetation cover. '*Chang Thang*', literally means the `northern upland' or northern plains. This tableland is one of the most astounding and physically imposing landscapes on earth and truly represents `Roof of the world'. It is spread over 4,00,000 km^2 between 33° – 36° N latitudes and 74° to 87° E longitudes. The plateau is bounded by the Zanskar, Kailash and Great Himalayan ranges on the south, Karakoram range in the west, and Kunlun and Arjin Shan in the north. On the east the plateau extends up to south-western part of Quinghai province and Xinjiang in People's Republic of China. North-western part of the plateau terminates in Aksai Chin, one of the most arid and desolate tract. A significantly large proportion of the plateau (over ca. 21,000 km^2) lies in the eastern part of Ladakh within Indian territory.

The plateau is well known for its unique geo-hydrological, biogeographic, socio-political and aesthetic values. The altitude of this landmass ranges from 4000 – 5500 m above sea level (asl), mean elevation being about 4500 m. A considerable proportion of the landmass comprises inland lake basins, characterized by alluvial fans and sandy plains. Internal drainage in some of the basins has resulted in concentration of salts and minerals over the millennia making the water bodies brackish. The plateau is fenced by high mountains and deep valleys on the south.

Administratively Indian part of Chang Thang lies in the Nyoma block of Ladakh district. At present there are four sub-units in Nyoma block *viz.*, Samad, Kharnak, Korzok and Hanle.

2.2 Palaeohistory of Changthang Plateau

The palaeo-history of the Changthang and Tibetan plateau is as interesting as its present environment. This plateau was uplifted as a result of the collision of Indian plate with Eurasia which began during middle Eocene, nearly 45 – 50 million years ago (Zhu et al., 1995). The two land masses welded along the valleys of the Yarlung Tsangpo and Indus (Wadia 1967, Valdia 2001). The northern edge of Indian plate is believed to have slid a short distance beneath the southern edge of Asia that led to great compression, folding, and thrust faulting that resulted in the uplift of Himalaya and recession of Tethys sea. Although mechanism of uplift of Tibetan plateau has been a controversial subject, most of the geologists believe that tectonic activities in the core of Asian plate led to crustal shortening, thickening and extrusion which caused thickening of the plateau. According to Molnar (1989), uplift of the plateau continued till late Miocene and during last 2-10 million years the plateau has uplifted by 1000 – 2000 m in elevation. The rise in the elevation and subsequent glaciation during Pleistocene caused drastic decline in temperature and depauperation of flora and fauna on the plateau. Re-establishment of the vegetation relied upon the flora of surrounding areas. After the plateau rose up to its present level during Quarternary period, it developed its own special plateau climate. The palynological studies indicate that for a part of Holocene there were stands of *Tamarix*, *Salix* and *Betula* in the basins of Panggong Tso, especially in protected localities with adequate moisture (Gasse et al., 1996). Trees and tall shrubs gradually vanished from the plateau by late Holocene. Influenced by the flora and fauna from the arid region of middle Asia, the present cold-steppe ecosystem was evolved. Much of this plateau was gradually colonized by hardy and grazing resistant grasses such as *Stipa purpurea, S. capillacea, S. roborowskyii*, and a large number of cold hardy cushion forming species such as *Ceratoides compacta, Salsola* spp., *Arenaria bryophylla, Thylacospermum caespitosum* and other specialized growth forms. The growing aridity and frigidity also influenced the faunal distribution. For instance, *Pantholops*, the sole endemic genus of mammals, got separated from Central Asian desert genus *Saiga* during Miocene. During Pliocene an equid *Hipparion* was a prominent member of the fauna. Other taxa such as *Ochotona* spp., *Lepus oiostolus*, *Marmota himalayan*, *Vulpes ferrilata* adapted and dispersed on the plateau. Likewise, *Tetraogallus*, a native genus of birds and a few pipits and larks specialized on the plateau.

2.3 The Hanley Valley

The intensive study was carried out in Hanley valley of Changthang wildlife Sanctuary (32° 41' 27" N 79° 04' 3.5"). This valley is flanked by Greater Himalayas in the south, Tibet in the east, Zanaskar range in north and Leh in the west. In Ladakh this area is called Anley and was previously named as Umbley. This valley had a considerable area under *Myricaria* scrub. *Myricaria* is locally called Umbu in Ladakh (hence Umbley). It is believed that some 100 years ago when people started settling and making houses in this valley, they cut most of the Myricaria for house construction. . There is also a famous monastery in Hanley which was palace of kiang Singe Namgial in 16th century.

Hanley Valley is characterized by undulating terrain interspersed with outcrops. The altitude ranges from 4400 m to 5200 m. The study area can be divided into following broad habitat types: riverine, marsh meadows, scree slopes, rocky slopes, plateau, rolling hills, alluvium fan. The area lies in the catchment of Hanley river which has its origin from Zanskar glacier in Zanskar range which meets Indus River at Loma (Figure 2.1).

2.3.1 Climate

Owing to sheer elevation and proximity to the outer layer of troposphere, the climate of the study area exhibits extreme temperature fluctuations. During summer the wind from the surrounding areas converge on the plateau and in winter it diverges away. This creates a special heat–island effect (Bosheng 1995). Moreover, the Himalayan range on the south creates rain shadow effect blocking most of the monsoon bearing winds. The cumulative effect of these factors has given rise to typical arid steppe or desert steppe climate. Precipitation is mainly in the form of snow. Winter temperature ranges from -5 to -30. The region is swept by cold winds and snow storms as wind velocity of 40 m/sec is not uncommon.

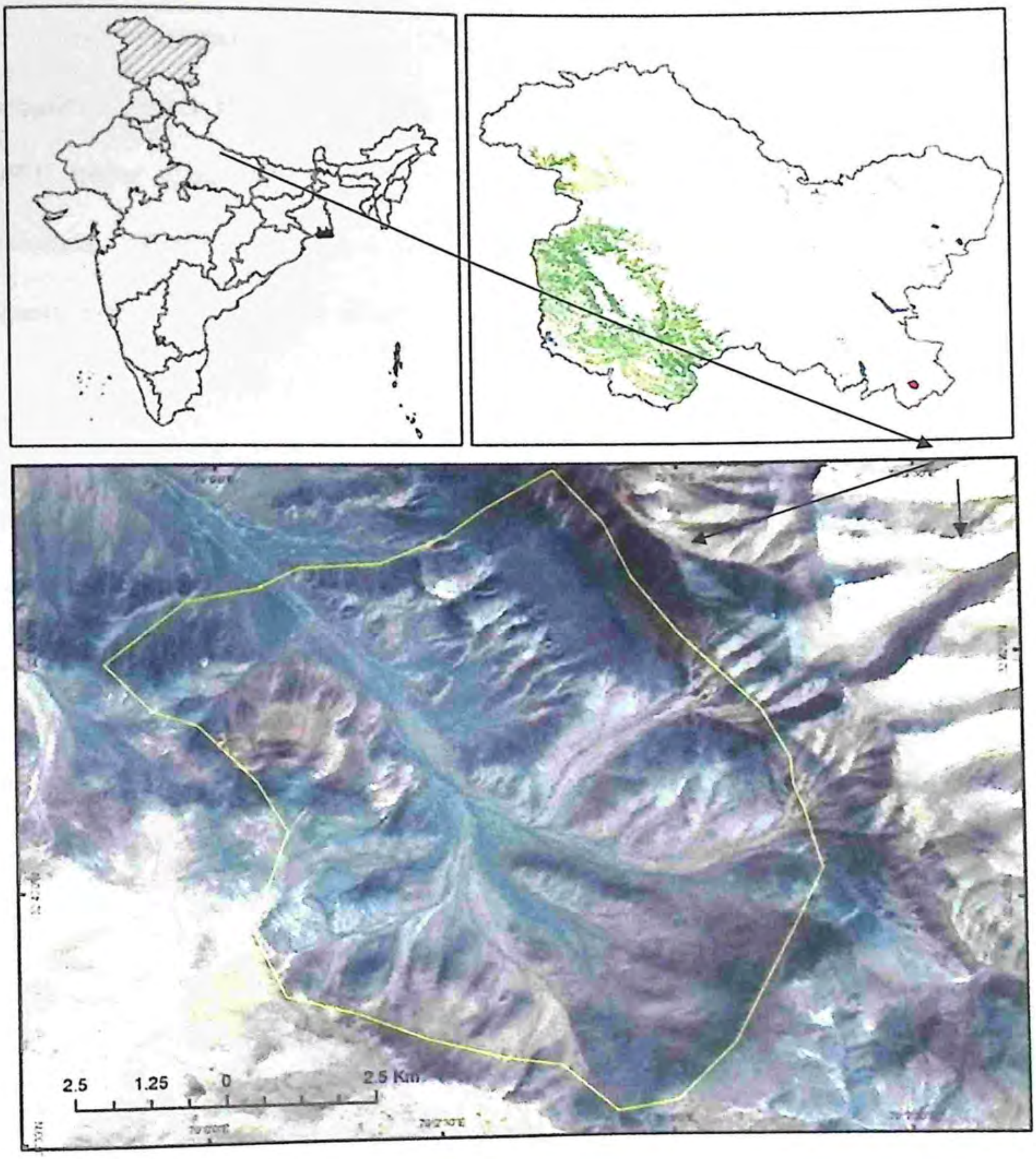


Figure. 2.1 Study area map (FCC) with study area boundary on it.

2.3.2 Vegetation

The vegetation of the Chang Thang plateau can be broadly grouped as scrub formations, desert steppe and marsh meadows. According to Rawat & Adhikari (2001) major plant associations in Indian Changthang are: *Caragana – Eurotia*, *Artemisia – Tanacetum*, *Stipa – Oxytropis - Alyssum*, and *Carex melanantha – Leymus secalinus*. Very high altitudes (>5000 m) have sparse fell-field communities with moss or cushion-like growth forms, e.g., *Thylacospermum caespitosum*, *Arenaria bryophylla*, *Androsace sarmentosa*, and a variety of lichens. Stream banks and marsh meadows around the lakes have characteristic sedge dominated vegetation represented by species of *Carex*, *Kobresia*, *Scirpus*, *Triglochin*, *Pucciniella*, *Ranunculus* and *Polygonum*. The water bodies and shallow lakes support dense growth of aquatic plants such as *Hippuris vulgaris*, *Potamogeton pectinatus*, *P. perfoliatus*, *Zannichellia palustris*, and *Ranunculus natans* (Rawat & Adhikari 2001). In addition, a large number of other communities and associations can be seen locally distributed across the gradients of soil moisture, altitude and micro-topography.

2.3.3 Fauna

The study area is rich in fauna. Notable among them are the mammals, e.g., Tibetan wild ass (*Equus kiang*), Tibetan argali or Nyan (*Ovis ammon hodgsoni*), wild yak (*Bos grunniens*), and Tibetan gazelle (*Procapra picticaudata*), The wild predators frequently encountered on the plateau include snow leopard (*Uncia uncia*), Tibetan wolf (*Canis lupus chanko*), lynx (*Felis lynx*), red fox (Vulpes vulpes), Tibetan brown bear (*Ursus arctos pruinosus*). Himalayan marmot (*Marmota bobak*), and Tibetan woolly hare (*Lepus oiostolus*), Royle's vole (*Alticola roylei*), pikas (*Ochotona roylei* and *O. curzoniae*) are among the common rodents in the meadows. As to lower vertebrates (amphibians and reptiles), the plateau environment is so severe that only a few endemic species have been able to thrive on the plateau *e.g.*, *Altrirana parkeri, Bufo tibetanus, Phrynocephalus theobaldi, P. vlangolii,* and *Thermophis baileyi* (Bosheng 1995). Inventory of lower faunal groups is far from complete. Several large birds of prey sighted regularly included the golden eagle (*Aquila chrysaetos*), the Lammergeyer (*Gypaetus barbatus)* large flocks of horned lark, Tibetan finches (*Montifringilla adamsii*). Red-billed chough (*Phrrhocorax phrrhocorax*) and raven (*Corvex corax*).

2.3.4 Local People and Landuse

The Hanley Valley has six villages (Khaldo, Pungug, Yingsoma, Naga, Bug and Shadey). There are around 1500 people in these villages including locals and Tibetan refugees. Their primary occupation is pastoralism and rear sheep, goat, yak ,horse and cow. People grow barley, sweet pea, potato and yukpa (fodder) for the livestock. Most of the land is owned by the Gompa (monastery of Hanley), and it is given to people on lease and they have to pay 10% of the produce either in the form of money or crop. The people of six villages are divided into herding units called Yulpa, Raque, Maque, Karlooq, and Dique. They got their names as they used to rear livestock of Gompa. Yulpa used to rare cows, Raque goats, Maque eves, Karlooq rams, Dique female yaks of the gompa. Now the gompa have only few livestock left due to lack of intensive management the increase in village population.

The Government of Jammu and Kashmir has notified some 7350 km^2 area of eastern Ladakh i.e., Indian Chang Thang as wildlife sanctuary. This sanctuary encompasses most of the alpine rangelands, two high altitude lakes (viz., Tso Kar and Tso Moriri) and adjacent wetlands which support a considerable number of domestic livestock as well as wildlife. Although this area has a tremendous potential to improve livestock husbandry practices (Richard 1999), concerns are being raised regarding the sustainability of these areas in the event of indefinite increase in the livestock population and intensification of land use in terms of tourism development, construction and settlements (Rawat & Adhikari 2001). At present less than 2 % of the geographical area on Indian part of Chang Thang is under cultivation. Rest of the vegetated zone is used by migratory pastoral communities i.e., *Changpa* herders as grazing ground. *Changpas* rear goats, sheep, yaks, and horses. Currently the estimated number of sheep and goats in Chang Thang is *ca.*185000 (Anon. 1998). Of this, goats and sheep account for 64 % and 36% respectively. Steady increase in the livestock population in the area is also attributed to influx of nomadic herders from Tibet during recent decades. Herders in the study area express concern about winter forage between Tibetan Ass or kiang and domestic livestock (Chundawat and Rawat 1994).

3. METHODOLOGY

3.1 Availability

Availability of habitat variable to kiang and livestock such as altitude, aspect, and slope and vegetation community were estimated using Non-Mapping Technique (Marcum and Loftsgarden, 1980). Availability of a habitat is the quantity of that habitat accessible to the population of animals during the study period (Manly *et al.*, 1993). Available slope, aspect and elevation were extracted from digital elevation model (DEM) using Arc G.I.S 9.2 by laying 300 random points on study area DEM. For vegetation community 6 vegetation types were identified in field according to their rank dominance. 30m resolution LANDSAT image of the study area was overlaid with 1X1 Km grids and all the grids were marked according to their vegetation composition. Same image was used in Arc GIS to calculate availability of habitat variables (slope, aspect, etc) using same random points (Figureure 3.1).

Cover types (barren, vegetation and rock) were estimated using point intercept method (Muller-dumbois and Ellenberg 1974). Study area was first divided into three elevation zones lower (4400-4699 m), middle (4700-4899) and upper (>4900 m). The point intercept transects (10 m 50 points) were laid in lower (n=31), middle (n=26)and higher (n=19) elevation. The type of cover at each point (every 20 cm) was noted and percent area under each cover category was calculated for each zone.

3.2 Shift in the habitat use and Activity pattern of *Equus kiang*.

3.2a Habitat use

The study was carried in Chumik catchment of Hanley valley of Changthang wildlife sanctuary-I. This study area was selected because it is a winter pasture of one of the herding unit. Study was carried out from 12 December to 10 April. Kiang was observed from four fixed trails. These trails were selected a priory with no knowledge

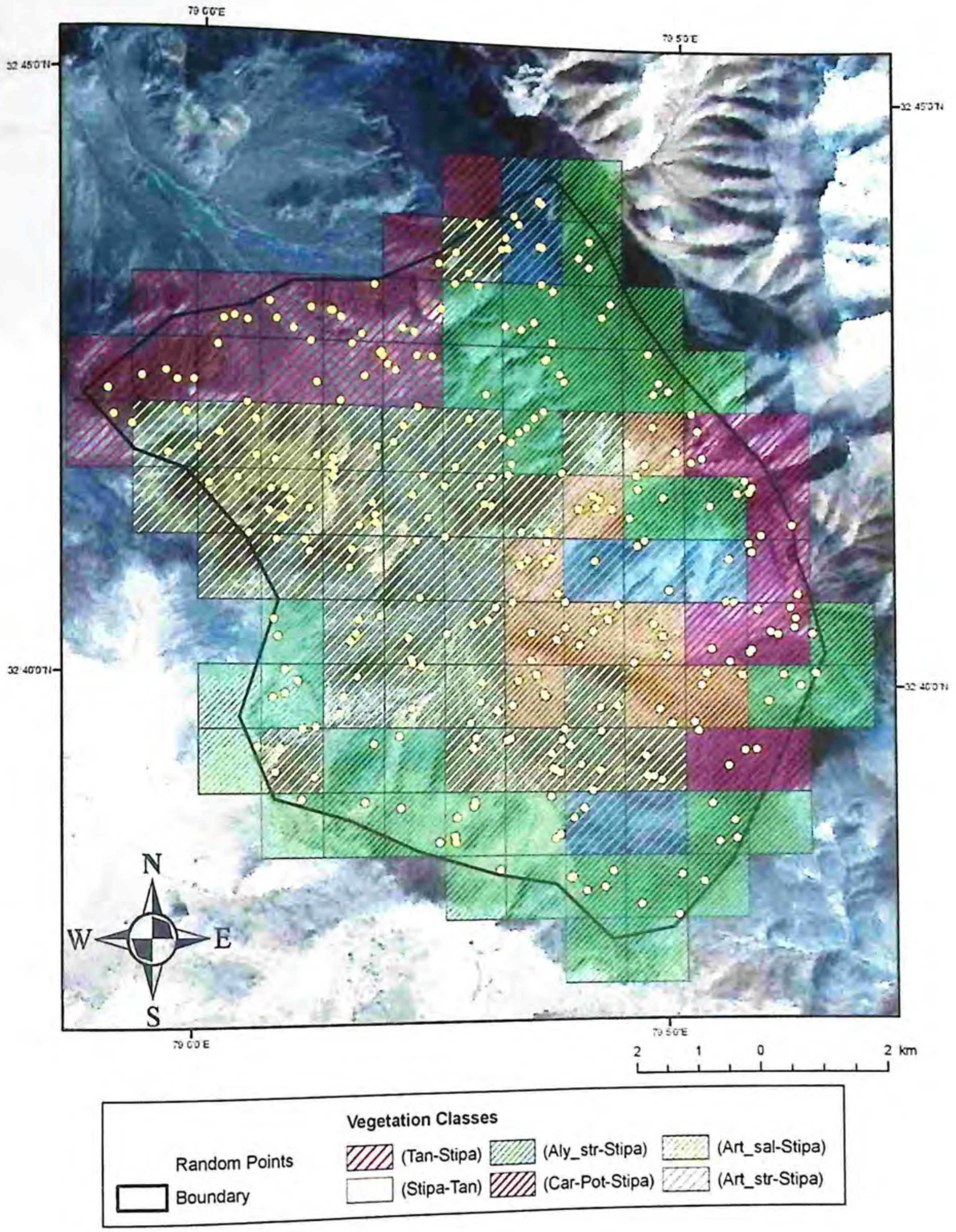


Figure 3.1 Random points overlaid on vegetation community (1x1 km) grid to estimate availability

An animal was deemed to be foraging when it fed` on a plant species or moved with its head lowered oriented towards food plant (Namgial 2006). When it stood still with its head above the shoulder, it was considered to be standing. When it moved with its head upright above its shoulders, it was deemed to be moving and resting when it was lying down. We observed groups from an average distance of 150 m, and care was taken not to disturb the animals, prior to and during the observation.

Observations on the kiang were spread across the day light hours to avoid over or underestimating behavioral activities associated time of the day, as there are diurnal patterns in the time-budget of ungulates (Schaller 1977, Rukstuhl 1988, Namgial 2006).

3.3 Habitat selection and utilization by kiang and livestock

Four monitoring trails were selected in the study area to assess the pattern of habitat use by kiang and livestock. Two out of four mere monitored on foot and two were monitored in vehicle. Data on habitat use were collected while monitoring these trails. Habitat variables like elevation slope aspect and vegetation community were recorded. Elevation was recorded using Garmin 72 GPS and DEM overlaid on FCC (false color composite). Slope was determined visually from the DEM overlaid on FCC. Aspect was recorded using shunto bearing compass. On every sighting of an animal/group (Kiang and livestock) each habitat variable was recorded. Vegetation community was determined visually.

3.4 Feeding habits

3.4a Kiang

Direct observation was used to record diet of livestock. Five individuals of sheep goat and horse were followed to the pastures. Individual animals were followed for whole day in intervals because of climatic extremes. Randomly selected animal was followed for half day then same animal was followed for next half on next day. So focal animal sampling was used at an interval of every 10 minutes and plant species being fed upon was recorded for a single bout. Bout was defined as when animal puts its head down for feeding till it raises it back. Number of Bites varied from 3-47. Animal observations were spread across study period to capture all the habitats it uses. No. of bites per/min was also recorded after every 10 minutes for sheep, goat and horse to estimate amount of biomass removed by livestock. Bite sizes of a livestock was estimated simulated by hand plucking method on different plant species (Wallmo *et al* 1973). The samples were then oven-dried to obtain dry weight.

For kiang direct observation was not possible so microhistological analysis of dung was carried out. Microhistological dung analysis is very widely used method (Todd and Hansen 1973, Green 1987) has the biggest advantage as it does not involve the sacrifice or manipulation of animals (Holechek et al. 1982). Its advantage over the feeding site method is that even species consumed in small proportions are recorded. Seven dung samples were collected randomly twice a month. Dung samples were collected in paper bags and air dried. Likewise reference samples were collected and air dried.

3.4b Laboratory methods

Ten composite samples were made from 28 independent samples collected over two months (December-January) without livestock and 10 from the month of (February-march) with livestock. Reference and dung samples were grinded and passed through 1 mm mesh (Sparks and Malechek 1968). Unit slide prepared method was used for each composite sample and 100 identifiable Fragments were counted at 100 X magnification (Scott and Dahl 1980). Identification of plant species was compared with known reference samples and frequency of fragments of various species were estimated.

3.5 Density of kiang

Density of kiang in Hanley valley was estimated using slow moving vehicles (10-15 Km/ hr). Four transects were selected in the whole of the valley which ranged from 5- 60 kms in length. These transects were monitored 3-4 times a month. Group size and no. of groups were recorded while moving on these transects. Area visible was estimated using view shed tool in Arc GIS 9.2.

4. ANALYSIS

4.1 Habitat selection and utilization by kiang and livestock

Data on habitat use by kiang and livestock was gathered by direct observations on fixed trails. Habitat use was characterized by resource selection function (RSFs) that are proportional to the probability of a resource being available to an animal. Design 1 with sampling protocol 'A' (Manly *et al.* 1993) was followed since individuals were not identifiable. Resource selection occurs in a hierarchical fashion from geographic range of a species, to individual home range to use of general habitat features within the home range, to selection of a particular element (food item). In this study habitat selection of Kiang and livestock within the assumed kiang group range was investigated. Hypothesis tested here is kiang and livestock (sheep, goat and horse) co-exist because of differential habitat use and preference. For determination of habitat use and selection all the habitat variables were categorized (Table 4.1). Case-wise Non-metric multi-dimensional scaling (Non parametric ordination technique) was used to reduce dimensionality of the all the habitat use data for kiang, moat (sheep and goat) and horse. Non-metric multidimensional scaling is an ordination method suited to data that are non-normal or are on arbitrary, discontinuous, or otherwise questionable scales. For this reason, NMDS should probably be used in ecology more often than it is (McCune and Grace 2002). The two axes (Individual case wise distances in ordination space) from NMDS results were used for analysis. Multi-response permutation procedure was used to test significantly the difference in these axes.

Table 4.1 Habitat variables and their descriptions.

Habitat variables	Categories	Description
Elevation	4400-4699 m	Lower elevation
	4700-4899 m	Middle elevation
	>4900 m	Higher elevation
Slope	0-10°	Very gentle slope
	11-20°	Gentle slope
	21-40°	Steep slope
	>41°	Very steep slope
Aspect	361°	Plain (software generated)
	0-90°	North-East
	91-180°	South-East
	181-270°	South-West
	271-360°	North-West
Vegetation community	*Stipa-tanaecetum*	Dominant vegetation middle and higher elevated areas
	Tanaecetun-stipa	(lower elevation) plains
	Alyssum-stipa	Forbs (higher elevated areas)
	Artemisia stracheyi-Stipa	Gentle slopes (sub-shrub)
	Artemisia salsoloides-stipa	Revirine area subshrub
	Carex-Potentilla-Stipa	Sedge area (moist area community)

Use availability analysis was used to know individual preferences for different habitat categories. To test statistically significant departures of use from availability, Marcum & Loftsgarden 1980 chi-square test of homogeneity was used. Simultaneous Bonferroni confidence interval was developed for each use vs. available habitat variable. Using Bonferroni approach, ordinary 97% confidence interval were constructed in each case. For $P_{1A} - P_{2A}$, a 97% confidence interval is:

$$(P_{1A}-P_{2A}) \pm Z_{0.985}\, [P_{1A}(1-P_{1A})/n_1 + P_{2a}(1-P_{2A})/n_2]^{0.05}$$

Where n_1 =number of points randomly distributed over the study area, P_{1A} = proportion of these points that fall in category A (proportion availability), n_2 = total no of animal sightings, P_{2A} = proportion of animals locations that fall in category a (proportion of use), $Z_{0.985}$ = 98.5th percentile for a standard normal distribution =2.71.

If 0 is not in the interval and both ends of the interval are positive, P_{1a}>P_{2A} and category A is used significantly less than in proportion to its availability. If the confidence interval includes 0 the decision will be $P_{1A}=P_{2A}$, means category is used in proportion to its availability. If 0 is not in the interval and both ends of the interval are negative, $P_{1A} < P_{2A}$ and category A is used significantly more than in proportion to its availability.

Ivlev's electivity index (Ivelev's 1961), was also used to compare use and availability as it gives good graphical view of the selection.

Ivlev's Index $E_i = (P_{2A}-P_{1A})/(P_{2A}+P_{1A})$

E_i value ranges -1to + 1 with values between 0 and +1 indicating preference, values between 0 and -1 indicating avoidance, and values equal to 0 indicating no selection.

4.2 Dietary selection and overlap for kiang, sheep, goat and horse

A matrix of diet profiles of kiang, sheep, goat and horse were developed. Likewise availability matrix was also developed. Usage and availability for evaluating Resource preference (Quade, 1979) was done to know preference or avoidance for a particular food plant. The overlap in diet was calculated using Schoener's index (Schoener 1968):

$O_{jk} = 1-1/2\ \Sigma\ [P_{ij}-P_{ik}]$

Where O_{jk} is the overlap between ungulate species j and k; P_{ij} is the proportion of species j feeding on plant species/group i; and P_{ik} is the proportion of species k feeding on plant species/group i. Overlap in diet between species j and k is complete when $O_{jk} = 1$ and is absent when $O_{jk} = 0$ (Gordon and Illius 1989). This index has been recommended by Abrahms (1980) as best overlap index of niche overlap. Schoener's index is not restricted by assumptions of competition, does not change when non-utilized resources are considered, and is not sensitive to sub-division of resource states by researchers (Abrams 1980). Quade's test was performed in RSW Statistical software. Ivelev's index was generated for different plant species to understand extent of selection. Ivelev's index for diet preference was calculated for kiang with and without livestock. Multi-response permutation procedure (MRPP) was used to test if the indices for kiang and other livestocks (sheep, goat and horse) are different or not similarly MRPP was also used to test statistically if the preferences indices are significantly similar or not.

4.3 Forage removed by livestock

The amount of forage removed by a livestock/day (sheep, goat and horse) was also estimated by multiplying bite weight, bite rate (bites/min), time spend by an animal foraging.

Forage removed/day (gms) = (bite weight gms) x (bites /min*60) x hours spent foraging.

4.4 Change in time budget, food habits and habitat shift of Kiangs.

To interpret interaction/competition studies have always been complicated because no interaction or overlap in habitat use would mean historical competition. Overlap in use would mean co-existence. To articulate any interaction a competition following three conditions should be met, a) Overlap in the use, b) Resource on which overlap is preset should be limited, c) And ultimately should affect the population dynamics that is there should be compromise with health and reproduction.

So a mere overlap does not suffice to describe an interaction as a competition, we present a case where we studied habitat use by kiang prior to and following livestock arrival to an area. Chi square test of association (contingency table) was done to know the association of kiang to habitat variables of two cases before and after habitat use of kiang.

Hypothesis tested was, H_0 : habitat use by kiang is independent of livestock presence: H_A: Habitat use by kiang is associated with livestock presence.

I observed total of 14 groups of kiang for time budget evaluation, 7 prior (640 min) and 7 (820 min) after livestock had come to the area. Multi-response permutation procedure (MRPP) was used to test statistically the difference in time budget with and without livestock to find out if the two means are from same population or not (McCune and Grace 2002). Individual activity patterns were tested separately emulating a 2-sample t-test with MRPP to find out difference with and without livestock (Mielke 1982). Ten composit dung slide samples of kiang with and 10 composit sample without livestock were analyzed. Diet and availibility profile matrix were developed and ivelev's index was calculated for every slide (use). MRPP was used to test for significant difference for these two conditions (groups).

4.5 Density of kiang

Density of kiang was estimated multiplying mean group size X mean no. of group divided by area. Area (visible area) for all the vehicle transects was estimated using view shed analysis tool of Arc-GIS 9.2. The buffer of 2, 3, 4, 5, 6 km was developed to calculate effective visible area 3 km cutoff was finally selected for analysis. As there is no logical justification this cutoff level, the only intention was for comparison, used in a previous study (Bhatnagar *et al.* 2006). Total visible area was also calculated taking all transects together so as to avoid overlap of buffers, using this visible area total density for all the transects was estimated (Figure 4.1). statistical packages SPSS 16.0 spss inc. and Blossom (U.S geo survey) was used for analysis.

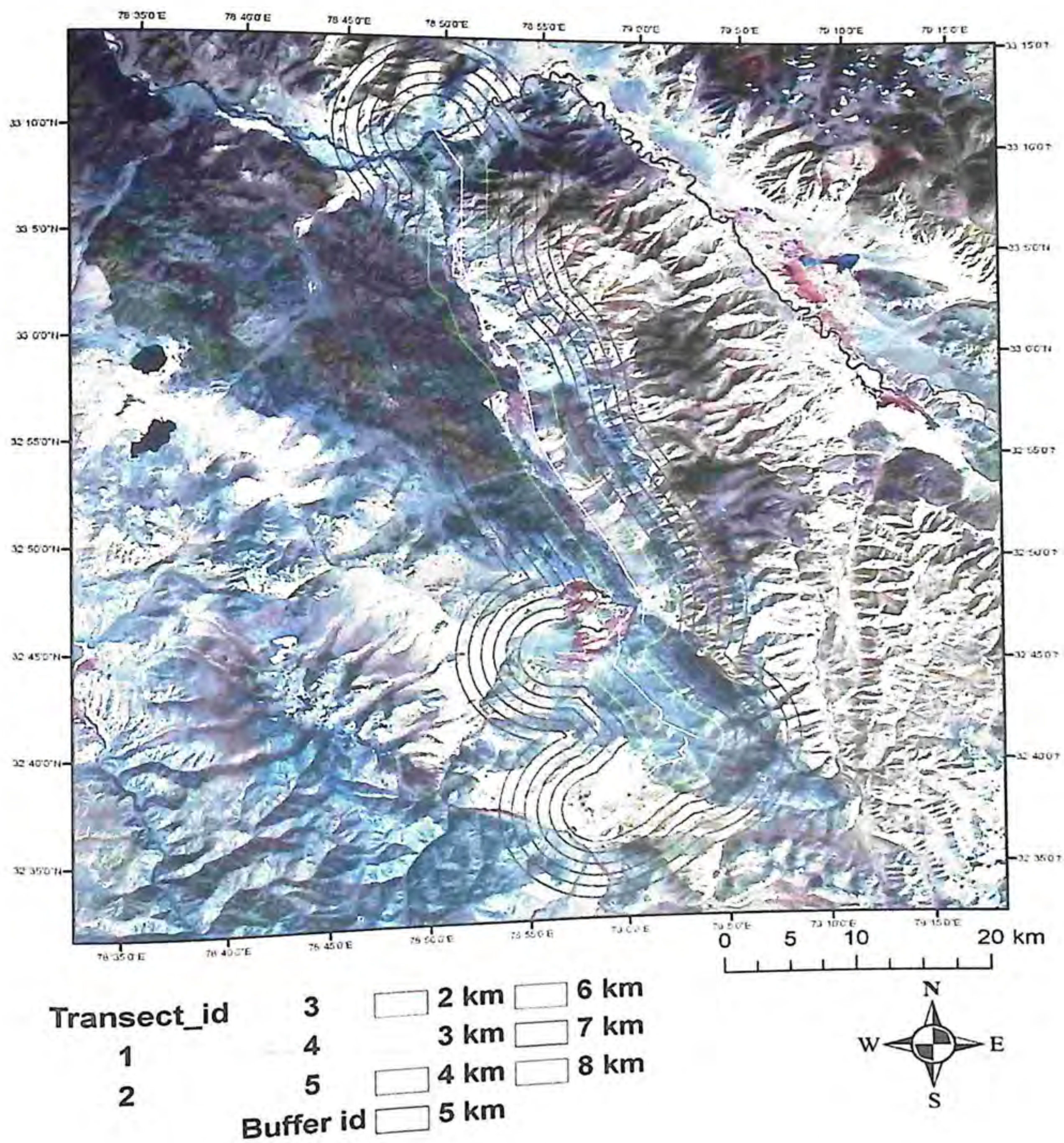


Figure. 4.1 Five vehicle transects and visible area buffers over laid on false color composite of Hanley valley.

5. RESULTS

5.1 Habitat use and selection by kiang and livestock

Non-metric multidimensional scaling identified two axes from all the habitats variables taken together for kiang, sheep & goat and horse (Stress = 0.23328, RSQ =0.78827). MRPP was significantly different (δ = 0.00016, $p < 0.05$) for the derived axes .

Use-availability analysis (Marcum & Loftsgarden 1980) was done for every variable to find out if any category was used more, less or proportion to availability.

5.1a Elevation

Kiang

Selection of the elevation categories for Kiang was found to be significant (χ^2 = 37.66, $p<0.01$). Simultaneous Bonferroni confidence interval 95% revealed elevation category 4700 m to 4899 m was used more than its availability (Table 5.1). The order of selection was 4700 – 4899 m > 4400 – 4699 m > 4900- 5100 (Figure 5.1).

Table 5.1 Preference indices for elevation categories for Kiang based on non mapping technique for habitat availability-use analysis and

Category	Available habitat		Use sample		Bonferroni CI		
elevation meters	counts	proportion	count	proportion	lower	higher	
(4400-4699)	113	0.38	52	0.29	-0.01	0.18	0
(4700-4899)	93	0.31	105	0.58	-0.37	-0.17	+
(>4900)	94	0.31	24	0.13	0.10	0.26	-
total	300	1.00	181				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Sheep and Goat

Sheep and goat were analyzed together as they were herding together in a group. For moats (Sheep and Goat) selection for elevation categories was found significant ($\chi^2 = 23.76$, $p < 0.01$) (Table 2.2). The order of selection was (4700-4899 m) > (>4900) (>4400-4699 m) (Figure 5.1).

Table 5.2 Preference indices for elevation categories for sheep and goat non mapping technique

Category	Available habitat		Use sample		Bonferroni CI		
elevation meters	counts	proportion	count	proportion	lower	higher	
(4400-4699)	113	0.38	15	0.18	0.09	0.31	-
(4700-4899)	93	0.31	50	0.60	-0.42	-0.16	+
>4900	94	0.31	19	0.23	-0.03	0.20	0
total	300	1.00	84				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Horse

Horse selection for elevation categories was significant ($\chi^2 = 29.07$, $p<0.01$) (Table 2.3). The order of selection (Ivelev's index) was category (4700 -4899 m)> (>4900 m)> (4400 – 4699 m) (Figure 5.1).

Table 5.3 Preference indices for elevation categories for Horse based on non-mapping technique

category	available habitat		use sample		Bonferroni C.I		
elevation meters	counts	proportion	count	proportion	lower	higher	
(4400-4699)	113	0.38	2	0.03	0.27	0.42	-
(4700-4899)	93	0.31	33	0.52	-0.36	-0.07	+
>4900	94	0.31	28	0.44	-0.28	0.02	0
total	300		63				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & loftsgarden) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

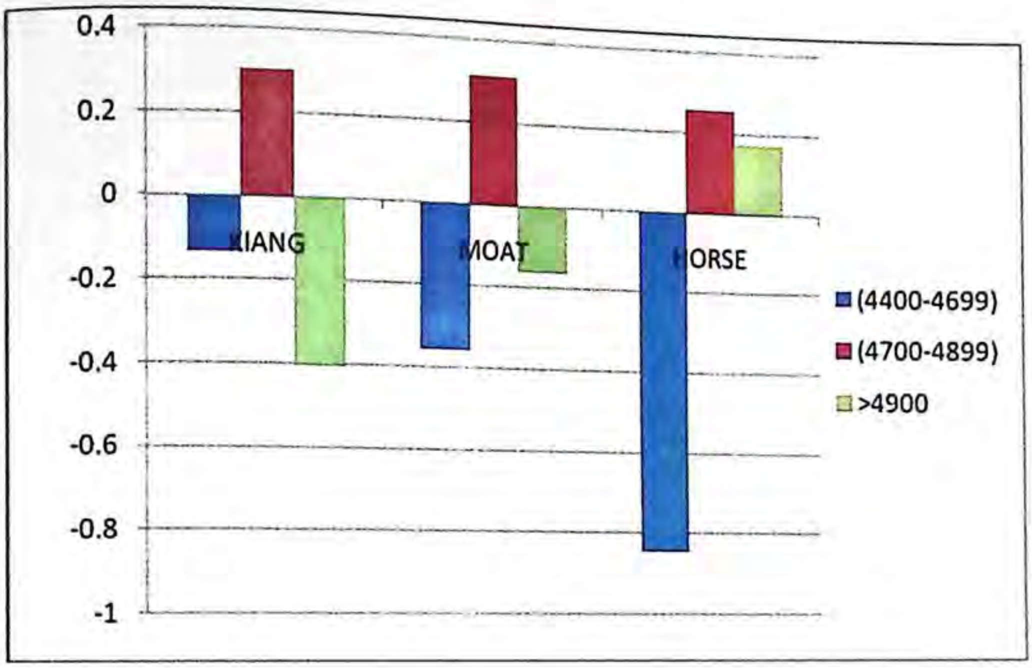


Figure 5.1 Ivelev's index for elevation categories for Kiang, Sheep & Goat and Horse

5.1b Slope

Kiang

Selection for slope categories was found significant (χ^2= 24.89, $p < 0.05$) (Table 2.4). The order of selection was slope category21-40^0 > (41^0)> (0-10^0) > (11-20^0) (Figure. 5.2).

Table 5.4 Preference indices for slope categories for Kiang based on non mapping technique

Category	Available habitat		Use sample		Bonferroni C.I.		
slope in degrees	counts	proportion	count	proportion	lower	higher	
(0-10°) I	150	0.50	101	0.56	-0.16	0.04	0
(11-20°) II	130	0.43	46	0.26	0.08	0.27	-
(21-40°) III	12	0.04	23	0.13	-0.15	-0.03	+
(>41°) IV	8	0.03	10	0.06	-0.07	0.01	0
total	300		180				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Sheep and Goat

Chi-square goodness of fit was significant for slope categories (χ^2=40.54, p<0.01) (Table 2.5). The order of selection was category (21-40^0) > (>41^0) > (0-10^0) > (11-20^0) (Figure 5.2).

Table 5.5 Preference indices for slope categories for Sheep and Goat based on non mapping technique

Slope degree	Available habitat		use sample		Bonferroni C.I		
	counts	proportion	count	proportion	lower	higher	
0-10°	150	0.50	34	0.40	-0.04	0.23	0
11-20°	130	0.43	23	0.27	0.04	0.28	-
21-40°	12	0.04	18	0.21	-0.27	-0.07	+
>41°	8	0.03	9	0.11	-0.16	0.00	0
total	300	1	84				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Horse

Selection for slope categories by horse was found to be significant (χ^2 = 14.77, p< 0.05 (Table 2.6). The order of selection was category (21-40^0) > (>41^0) > (0-10^0) > (11-20^0) (Figure 5.2).

Table 5.6 Preference indices for slope categories for Horse based on non mapping technique

Slope in degrees	Available habitat		Use sample				
	counts	proportion	count	proportion	lower	higher	
(0-10°)	150	0.50	36	0.57	-0.221	0.078	0
(11-20°)	130	0.43	15	0.24	0.063	0.327	-
(21-40°)	12	0.04	8	0.13	-0.181	0.007	0
(>41°)	8	0.03	4	0.06	-0.106	0.033	0
total	300		63				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

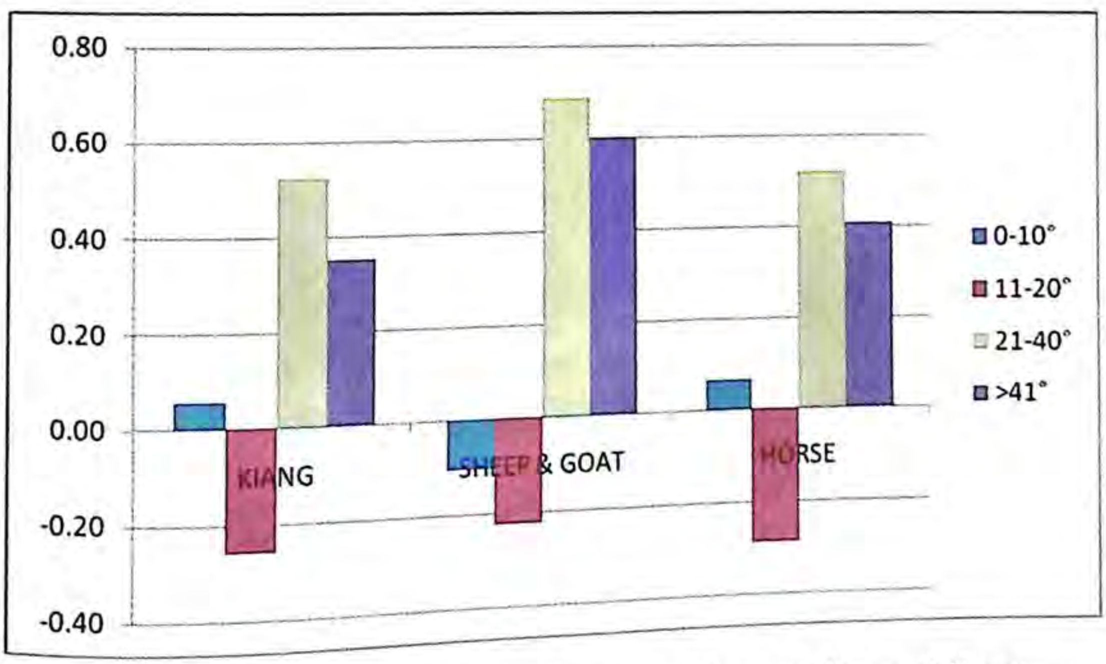


Figure 5.2 Showing ivelev's index for Kiang, Sheep & Goat and Horse.

5.1c Aspect

Kiang

Selection for aspect categories was significant ($\chi^2 = 50.05$, $P < 0.05$) for (Table 2.7). The order of selection for slope categories was NW > SE > SW > NO ASPECT > NE (Figure 5.3).

Table 5.7 Preference indices for Aspect categories for Kiang based on non mapping technique

Aspect degree	Available habitat		Use available		Bonferroni C.I		
	counts	proportion	count	proportion	lower	higher	
(0-90°) NE	96	0.32	29	0.16	0.08	0.24	-
(91-180°) SE	22	0.07	20	0.11	-0.10	0.02	0
(181-270°) SW	96	0.32	50	0.28	-0.05	0.14	0
(271-360°)NW	24	0.08	55	0.30	-0.31	-0.14	+
(361°) NO aspect	62	0.21	27	0.15	-0.02	0.13	0
total	300		181				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Sheep and Goat

Selection for aspect categories was significant ($\chi^2 = 4.910$, $p > 0.05$ (Table 2.8). The order of selection (Ivelev's index) was SW > NE > NW >SE >No aspect (Figure 5.3)

Table 5.8 Preference indices for Aspect categories for Sheep and Goat based on non mapping technique

Aspect degree	Available habitat		Use sample		Bonferroni C.I		
	counts	proportion	count	proportion	lower	higher	
(0-90°) NE	96	0.32	29	0.35	-0.15	0.10	0
(91-180°) SE	22	0.07	4	0.05	-0.03	0.09	0
(181-270°) SW	96	0.32	35	0.42	-0.23	0.03	0
(271-360°)NW	24	0.08	5	0.06	-0.05	0.09	0
NO aspect	62	0.21	11	0.13	-0.02	0.17	0
total	300		84				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Horse

Selection of aspect categories by horse was significant ($\chi^2 = 35.1$, $p < 0.01$) (Table 5.8). The order of selection was NW>SW>NE>SE>NO ASPECT.

Table 5.9 Preference indices for Aspect categories for Horse based on non mapping technique

Aspect degree	Available habitat		Use sample		Bonferroni C.I		
	counts	proportion	count	Proportion	lower	higher	
(0-90°) NE	96	0.32	11	0.17	0.03	0.26	-
(91-180°) SE	22	0.07	2	0.03	-0.02	0.10	0
(181-270°) SW	96	0.32	34	0.54	-0.37	-0.07	+
(271-360°)NW	24	0.08	15	0.24	-0.28	-0.04	+
(361°)	62	0.21	1	0.02	0.13	0.25	-
total	300		63	1			

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

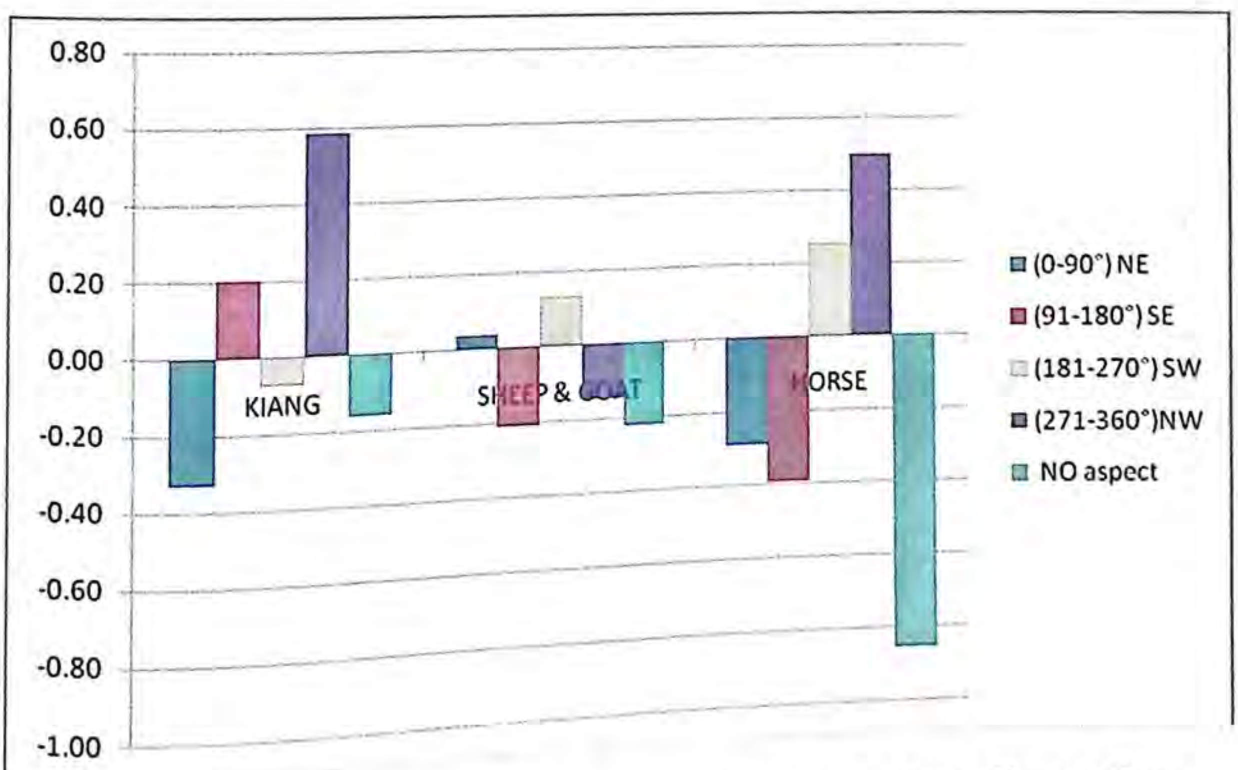


Figure 5.3 Ivelev's index for different aspect categories for Kiang, Sheep & Goat and Horse

5.1. d Vegetation community

Kiang

Selection for vegetation communities was significantly ($\chi^2 = 34.71$, $p < 0.05$). (Table 5.9). The order of selection was category III>VI>II>II=IV>V (Figure 4).

Table 5.10 Preference indices for vegetation community categories for Kiang based on non mapping technique

Vegetation community	Available habitat		Use sample		Bonferroni C.I.		
	counts	proportion	count	proportion	lower	higher	
I (Alyssum-stipa)	77	0.26	46	0.25	-0.09	0.09	0
II(Art-sal, Stipa)	42	0.14	11	0.06	0.02	0.14	-
III (Art-str,Stipa)	17	0.06	9	0.05	-0.04	0.05	0
IV (stipa-tan)	101	0.34	102	0.56	-0.33	-0.13	+
V (tan-Stipa)	38	0.13	10	0.06	0.02	0.13	-
VI (Carex, Pot, Stipa)	25	0.08	3	0.02	0.03	0.11	-
	300		181				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Sheep & Goat

Chi-square analysis for difference in vegetation community selection was significantly ($\chi^2 = 18.29$, $p < 0.05$ (table 5.9). The order of selection was category III > IV> VI > V > I > II (Figure 4).

Table 5.11 Preference indices for vegetation community categories for Sheep and Goat based non mapping technique

Vegetation community	available habitat		Use sample		Bonferroni C.I.		
	counts	proportion	count	proportion	lower	higher	
I (Aly-Stipa)	77	0.26	18	0.21	-0.07	0.15	0
II (Art-sal, stipa)	42	0.14	10	0.12	-0.07	0.11	0
III (Art-stry, stipa)	17	0.06	16	0.19	-0.23	-0.04	+
IV (Stipa-Tan)	101	0.34	30	0.36	-0.15	0.11	0
V (Tan-Stipa)	38	0.13	8	0.10	-0.05	0.11	0
VI (Car-Pot-Stiap)	25	0.08	2	0.02	0.01	0.11	-
	300		84				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

Horse

Selection of vegetation community for horse was significantly different (χ^2 = 27.47, $p < 0.05$ (Table 2.10). Order of selection was IV > VI > II >V > I > III (Figure 4).

Table 5.12 Preference indices for vegetation community categories for Horse based on non mapping technique

Vegetation community	Available habitat		Use sample		Bonferroni C.I		
	counts	proportion	count	proportion	lower	higher	
I (Aly, Stipa)	77	0.26	3	0.05	0.13	0.29	-
II(Art-sal, Stipa)	42	0.14	12	0.19	-0.17	0.07	0
III (Art-str, Stipa)	17	0.06	2	0.03	-0.03	0.08	0
IV(stipa-tan)	101	0.34	37	0.59	-0.40	-0.10	+
V (tan-stipa	38	0.13	1	0.02	0.06	0.16	-
VI (Car, Pot, Stipa)	25	0.08	8	0.13	-0.14	0.05	0
	300		63				

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, '+' used more than available, 0 means proportional use and (-) used less than available)

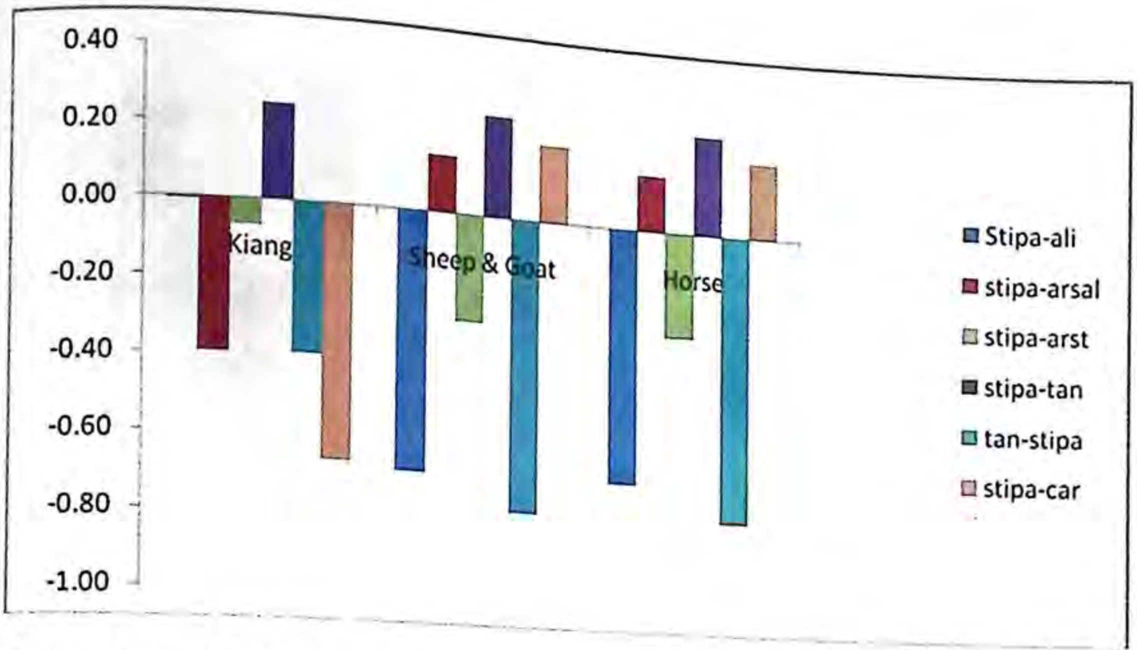


Figure 5.4 Ivelev's index of vegetation communities for Kiang, Sheep & Goat and Horse

Table 5.13 Preference indices for different habitat categories for Horse based on Marcum and Loftsgarden (1980) non mapping technique

Habitat categories	SHEEP & GOAT	HORSE	KIANG
ELEVATION 1 (4400 -4699 m)	-*	-*	0
ELEVATION 2 (4700 -4899 m)	+*	+*	–*
ELEVATION 3 (> 4900 m)	0	0	+*
SLOPE 1 (0 - 10°)	0	0	0
SLOPE 2 (11 - 20°)	-*	-*	-*
SLOPE 3 (21 -40°)	+*	0	+*
SLOPE 4 (>41°)	0	0	0
ASPECT 1 NE (0 90°)	0	-*	-*
ASPECT 2 SE (91 -180°)	0	0	0
ASPECT 3 SW (181 -270°)	0	+*	0
ASPECT 4 NW (271 - 360°)	0	+*	+*
ASPECT 5 NO aspect	0	-*	0
VEGTATION COM 1 (Stipa-*Alyssum*)	0	-*	0
VEGTATION COM 2 (Stipa-Art. sal)	0	0	-*
VEGTATION COM 3 (Stipa-Art. stachy)	+*	0	0
VEGTATION COM 4 (Stipa-Tanecetum)	0	+*	+*
VEGTATION COM 5 (Tanecetum-Stipa)	0	-*	-*
VEGTATION COM 6 (Stipa-Carex)	-*	0	-*

(95 % Bonferroni confidence interval were constructed for all categories (Marcum & Loftsgarden 1980) where as, (+*) used significantly more than available, 0 means proportional use and (-*) used significantly less than available)

5.2 Shift in habitat use and Activity pattern (Temporal segregation)

Observations were spread across one and half month for kiang without livestock and 2 and half month during livestock. There were 105 and 181 observations on kiang before and during livestock respectively. Habitat use variables (Table 4.1) were subjected to NMDS (ordination) which identified two axes (individual distances in ordination space). MRPP was found to be significantly different ($\delta = 0.013$, $p < 0.05$) for these two axes.

Four different variables were categorized and analyzed by chi-square test of association.

5.2. a Elevation

Chi-square test of association for elevation categories was significantly different ($\chi^2 = 27.90$, $p < 0.05$), thus indicating shift in use of elevation in response to disturbance (livestock and herders).

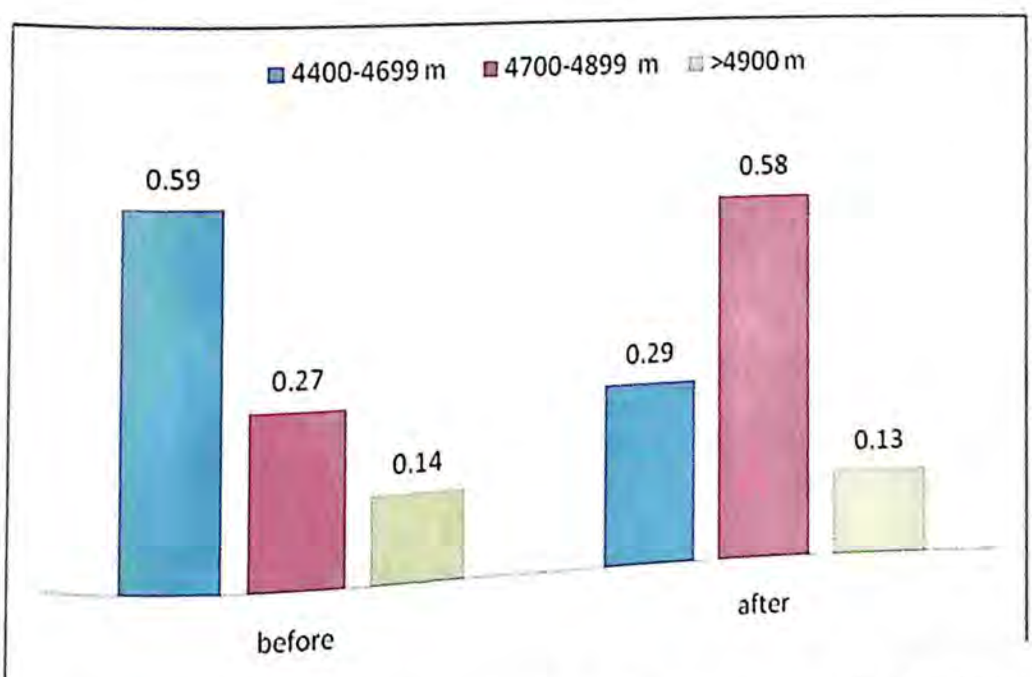


Figure 5.5. Proportion elevation used by Kiang before and after livestock coming to area.

Kiang was found to be positively associated with elevation category 4400-4699 m as proportion of use exceeds the proportion of expected before (without livestock), negatively associated with elevation category 4700-4899 m as proportion of use lowers the expected use and there was no association for elevation category >4900 m as there was no significant difference for this category (Figure 5).

5.2.b Slope

Chi-square test of association for slope categories was significantly different ($\chi^2 = 16.49$, $p < 0.05$), thus indicating shift in use of slope in response to disturbance (livestock and herders).

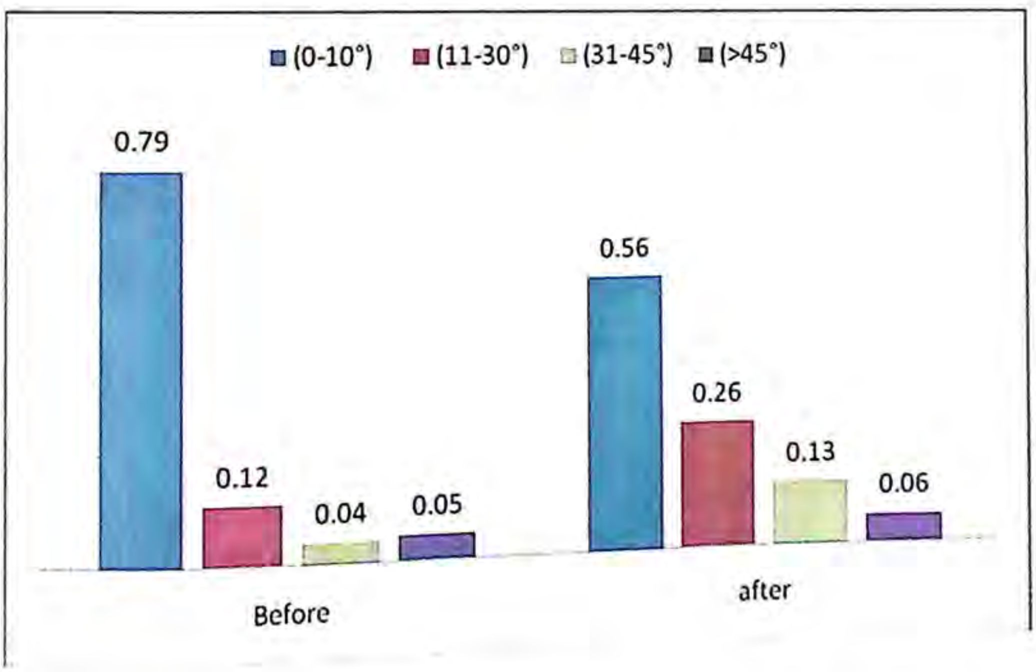


Figure 5.6 Proportion slope use by Kiang before and after livestock arrival.

Kiang was found to be positively associated to slope category $0\text{-}10^0$ as proportion of use exceeds the proportion expected, negatively associated with category $11\text{-}30^0$ & $31\text{-}45^0$ as observed use is lower than expected use, no association with category $>45^0$ as there is no difference in proportion use and expected without disturbance (livestock and herders). But there is marked shift in associations as they are coerced to use categories (11-30^0 & 31-45^0) which they tend to avoid, and avoided category 0-10^0 which they preferred (Figure 6).

5.2.c Aspect

Chi-square test of association for slope categories was significantly different ($\chi^2 = 27.28$, $p < 0.05$), thus indicating shift in aspect use in response to disturbance (livestock and herders).

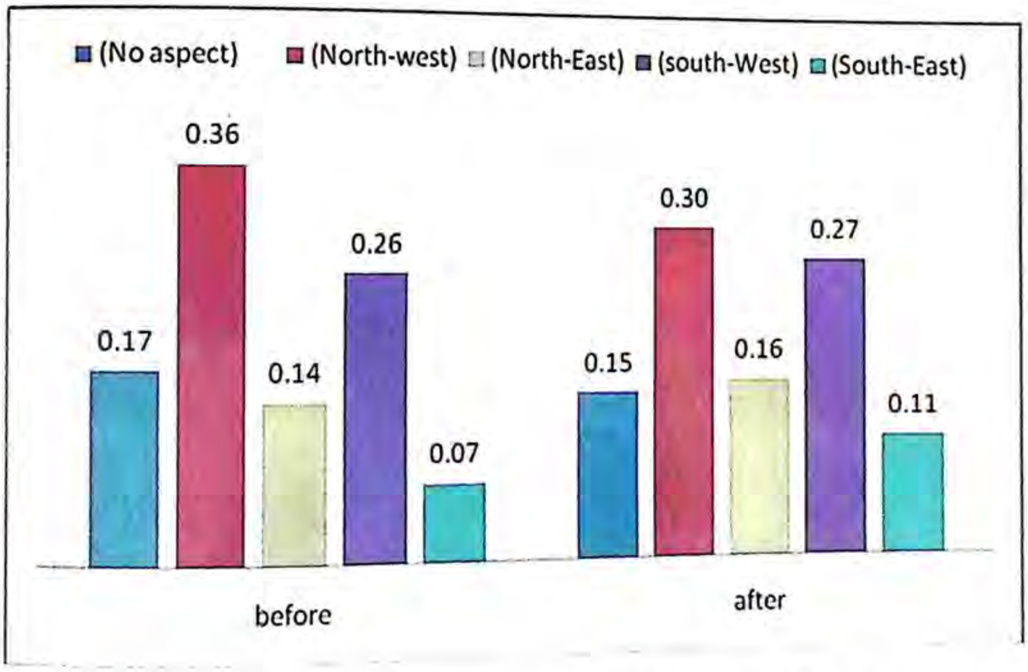


Figure 5.7 Proportion aspect use by Kiang before and after livestock arrival.

Aspect category south west is positively associated with kiang as observed used exceeds expected but decreases as disturbance factor comes into play, rest all categories there is no major shift like south east category is negatively associated but its use is little affected by the livestock presence (Figure. 7).

5.2.d Vegetation communities

Chi-square test of association for slope categories was significantly different ($\chi^2 = 17.062$, $p < 0.05$), thus indicating shift in vegetation community use by kiang in response to disturbance (livestock and herders).

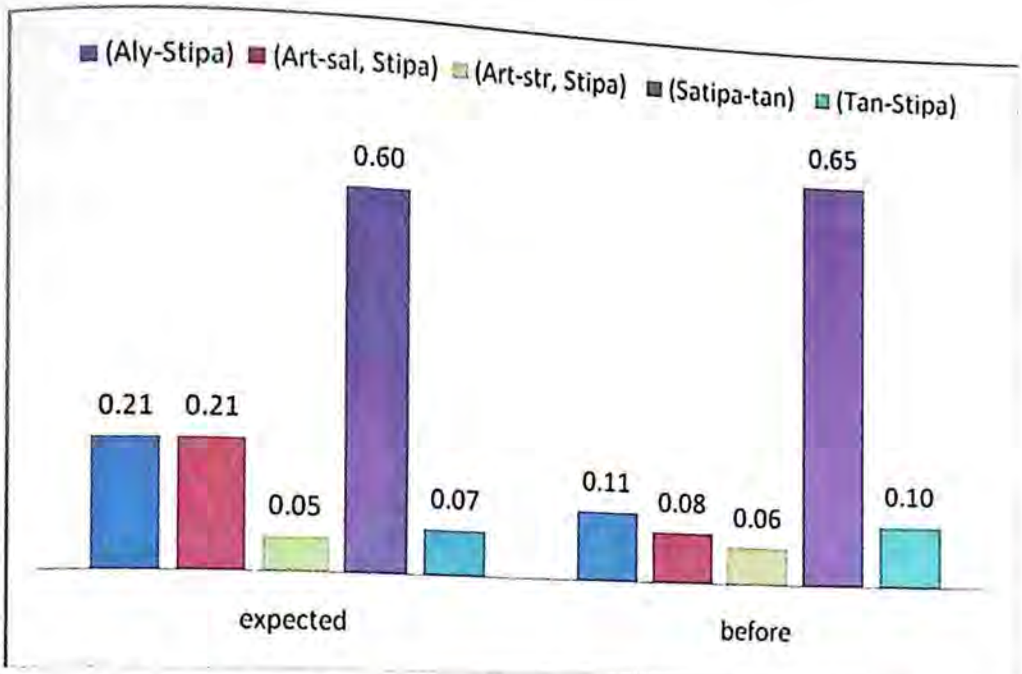


Figure 5.8 Proportion vegetation community use by Kiang before and after livestock arrival.

Vegetation community (*Alyssum-Stipa*) and (*Artemisia salsoloides-Stipa)* were negatively associated with Kiang as observed use before decreases expected use. Categories (*Stipa-Tanaecetum*), (*Artemisia stracheyi-Stipa*) and (*Tanacetum-Stipa*) were positively associated with Kiang. (*Alyssum-Stipa*) is being more used than expected and (*Stipa-Tanaecetum*) is used less than expected in after treatment in after treatment (Figure 8).

5.2.2 Change in food habits and time budget of kiang with and without livestock.

Multi-response permutation procedure (MRPP) was not significantly different (δ= 0.96, $P > 0.05$) for preference indices (Ivelev's index) of different plant species for kiang with and without livestock.

MRPP was used to test for difference in the activity pattern of kiang before and after livestock arrival. The proportion of animals engaged in various behavioral patterns (feeding, standing, moving and resting) was found to be significant ($\delta = 0.03$, $p < 0.05$). Emulative 2-sample MRPP t-test was used to test for difference in individual behavioral variables taking grouping variable before and after (Mielke 1986). Individual activity patterns, standing (before and after) and resting (before and after) were not significantly different ($\delta = 0.163$, $p > 0.05$) and ($\delta = 0.925$, $p > 0.05$) respectively. Feeding (before and after) and movement (before and after) was found to be significantly different ($\delta = 0.20$, $p < 0.05$) and ($\delta = 0.4$, $p < 0.05$) respectively).

5.3 Winter diets of Kiang (*Equus kiang kiang*), Sheep, Goat and Horse

Total of 10 slides from composite dung samples without livestock and 10 slides with livestock were analyzed. For livestock 5 individuals from each species were analyzed. Quade's method was used to compute the percent use of each plant species by each animal and the percent of each plant available to each animal and F statistic was used to find the selection for food types.

5.3a Kiang

Food plant selection by kiang was significantly different with ($F_{7, 63,} = 21.04$, $p < 0.0001$) and without ($F_{7, 63} = 19.6$, $p < 0.0001$) livestock. Weighted-ranking test statistics for use of different food plants was significant for period without livestock was (*Stipa* > *Artemisia stachy* > *Oxytropis microcarpa* > *Artmesia salsoloides* > *Others* > *Carex malenantha* > *Alyssum sp.* > *tanecetum*) and with livestock was (*Stipa sp.* > *Oxytropis microcarpa* > *Others* > *Artmesia stachy* > *Artmesia salsoides* > *Carex melanantha* > *Tanecetum* > *Alyssum sp.)*

5.3b Sheep, Goat and Horse

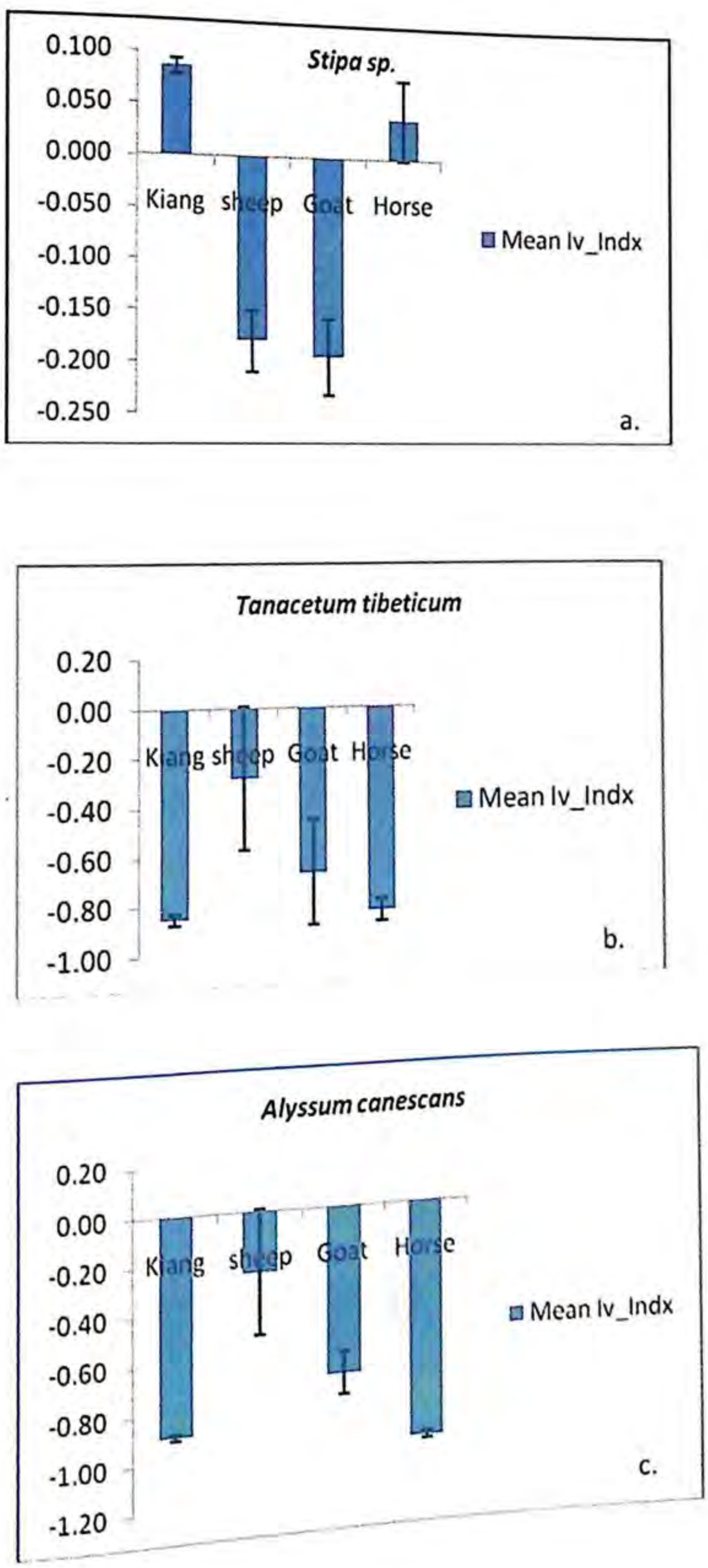
Food plant selection for sheep, goat and horse was significantly different ($F_{7, 28} = 3.5$, $P < 0.05$), ($F_{7, 28} = 4.48$, $p < 0.05$) and ($F_{7, 28,} = 3.76$, p, 0.05) respectively). Weighted-ranking test statistics for use of different food plants was significant for sheep (*Carex malanantha* > *Artemisia stachy* > *Artemesia salsoides* > *Tanecetum* >

Alyssum > Oxytropis microcarpa > Others > Stiap sp), goat (*Artemesia satchy > Alyssum > Carex malantha > Artemisia salsoloides > Oxytropis microcarpa > Tanecetum > others > Satipa sp.)* and horse (*Artemesia stachy > Oxytropis microcarpa > Artemisia salsoides > Stipa sp. > Tanecetum > Others > Carex maanentha > Alyssum cana*).

5.3c Forage selection

Ivelev's index was generated for all the food species to compare across Kiang, sheep, goat and horse (Figure 9). MRPP was significantly different (δ = 0.0000007, $p < 0.05$) taking all indexes of all forage plants together for kiang, sheep, goat and horse. MRPP for individual plant preference (indexes) were also significantly different Stipa (δ =0.00001, $p < 0.05$), Tanaecetum tibeticum (δ = 0.031 $p < 0.05$), Alyssum (δ = 0.00036, $p < 0.05$), Carex malanentha (δ = 0.00035), Artemisia stracheyi (0.00095, $p < 0.05$), Artemisia salsoloides (δ = 0.00007, $p < 0.05$), others (δ = 0.0020, $p < 0.05$) and Oxytropis (δ = 0.05, $p < 0.05$).

Kiang and horse selected *Stipa sp.* while as sheep and goat tend to avoid it (9. a). *Tanacetum tibeticum* was avoided by every animal but Kiang and horse avoided it 56% more tan sheep and 17% more tan goat while as kiang (85%) and horse (84%) had similar avoidance for it (Figure 9. b). *Alyssum canescans* was avoided by every animal species but Kiang avoided it 64 % more than sheep and 20 % more than goat while as 8% less than horse (Figure 9. c). *Carex malantha* was avoided by kiang, goat and horse while as sheep showed selection for it. Kiang avoided it 49 % more than the goat while horse showed 100% avoidance for it (Figure 9. d). Sheep showed selection for *Artemisia stracheyi* while as kiang, goat and horse avoided it. Kiang avoided it 64% and 25% more than horse respectively (Figure 9. e). Sheep selected *Artemisia salsoloides* while kiang, goat and horse avoided it. Kiang avoided it 40% more than goat while as it was avoided 100% by horse (Figure 9. F). All the animals avoided *Oxytropis microphylla*, kiang avoided it 18% and 5% more than sheep and horse respectively, while as horse avoided it 5% more than kiang (Figure 9.g).



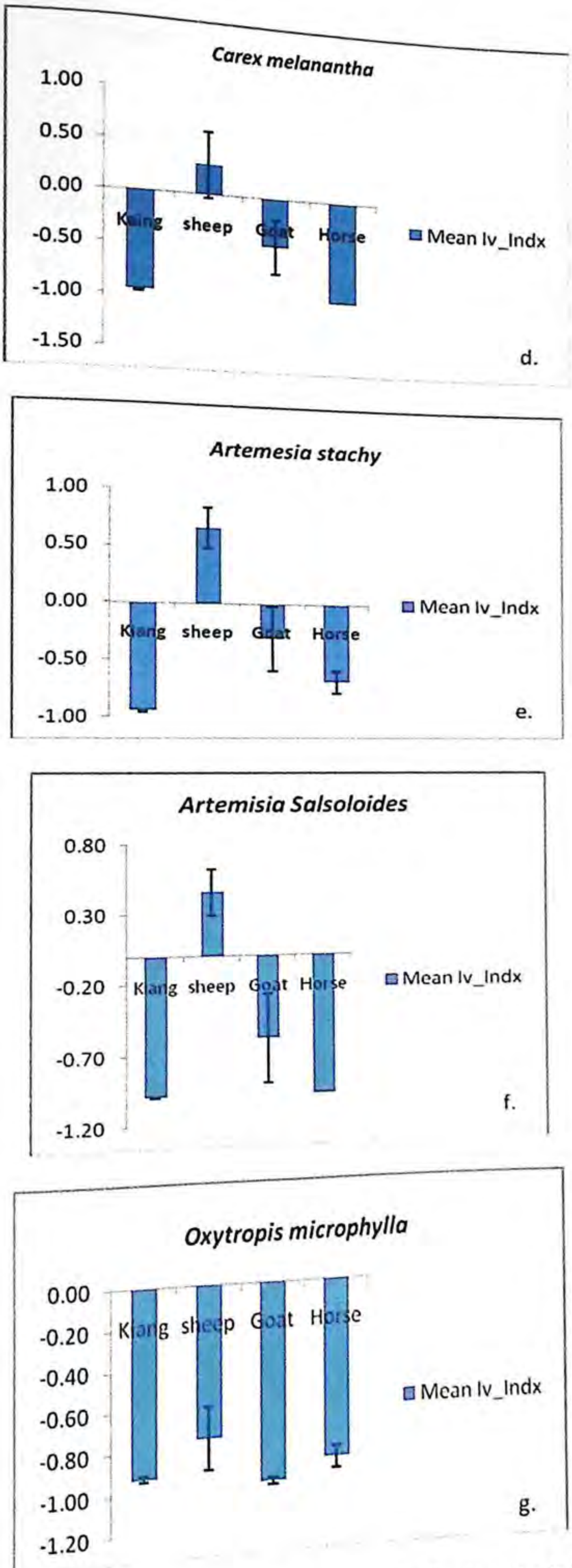


Figure 9. a-g Forage plant association as selection (Ivelev's index) for different plant species for kiang, sheep, goat and horse.

5.3.d Diet overlap and biomass removal

Schoener's diet over between kiang and sheep was 58%, kiang and goat was 57% and between kiang and horse was 82% (table 2.12). Forage removed per animal per day is given in table 2.13. Mean bite weight (grams) of horse, sheep and goat were 1.04±0.20, 0.31±0.08 and 0.31±0.08 respectively. Mean bite rates of horse, sheep and goat were 14.54 (±1.26), 15.35 (±0.95) and 14.66 (±0.83) respectively. Bite rate was multiplied by 60 to convert it into bites per hour. Forage removal (kg) by horse, sheep and goat were 8.19 kg, 2.33 kg and 2.25 kg respectively. All the values were divided by 1000 to convert it into kg.

Table: 5.14 Percent overlap (Schoener's niche overlap index) between kiang and other ungulates.

	Kiang	Sheep	Goat	Horse
Kiang		58%	57%	82%
Sheep			91%	69%
Goat				68%

Table 5.15 Average bite weights, bite rate, activity hours and forage removal by horse sheep and goat in Henley valley of eastern Ladakh.

	Horse (mean±S.E)	Sheep (mean±S.E)	Goat (mean±S.E)
bite wt gms (W)	1.04 (±0.20)	0.31 (±0.08)	0.32 (±0.08)
bite/min (M)	14.54 (±1.26)	15.35 (±0.95)	14.66 (±0.83)
activity hrs (A)	9.00	8.00	8.00
Forage removed (F) (gms)	8196.06	2335.66	2251.78

(*60 used to convert it into bites per hour)

F (grams) = Wx(Mx60*) xA,

5.4 Density of kiang in Hanley valley

Densities and encounter rates were estimated for five transects of varying length also Total density and encounter rates were estimated (Table 2.14).

Table 5.16 Transect lengths, visible area (view shed analysis), density and encounter rates of kiang in Hanley valley

Transect	Transect length (km)	Visible area (km^2)	DENSITY (km^{-2})	ENC_RATE (km^{-1})
Loma-Hanley	56	259.04	0.13	0.59
Kosep-Chumik	13.31	98.418	0.19	1.88
Khuloons	5.7	54.966	0.86	5.67
Bug-shadey	8.1	67.7	0.03	0.39
Kalat tar tar	5.15	34.97	1.87	17.98
Total	88.26	497.18	0.07	0.45

6. DISCUSSION

6.1 Habitat use and separation between kiang and livestock

Kiang showed complete separation with other livestock on the basic of preference for habitat categories. Elevation was divided in to three categories as lower middle and higher elevation zones. Kiang used higher elevation zones more than available while as sheep, goat and horse used it proportion to its availability. Kiang used middle elevation zone less than available while as sheep, goat and horse showed used it more than available. Kiang used Lower elevation zone in proportion to availability but sheep, goat and horse avoided it. So present investigation revealed significant difference in use of different elevations on an altitudinal gradient, thereby decreasing the possibility of a competitive interaction.

Like wise slope were also divided into four categories very gentle, gentle, steep and very steep. Kiang and sheep-goat both used steep slopes more than available and horse avoided it. Very gentle slope was found to be principle habitat category for kiang (56 %), sheep& goat (40 %) and horse (57 %) (Table....). Habitat separation has been considered as the most common mode of resource portioning in animals (Schoener, 1976). Predation as a factor for resource portioning has been extensively studied in other taxa (Mittelbach, 1984) but it is poorly understood in ungulate communities. Predation may lead to habitat portioning provided the species are safe from predator in different habitats (Repasky, 1996). Only predator known to kiangs are wolves as I observed three times wolf attacking kiang and twice wolf succeeded and in all three cases kiangs were on steep slope also every time wolf attacked from below and made it run up hill. So unlike other mountain ungulates distance from cliff forms an important factor for resource portioning among ungulate guilds as a escape cover (Namgail *et. al.* 2004, Bagchi *et. a.l* 2004, Raghvan 2003). I found slope to be an important factor for escape cover for kiangs although there was no clear separation between Kiang and Sheep-goat on the basic of slope as there was overlap. Kiang and horse use slope differentially, as horses are not affected by livestock presence.

Aspect forms an important factor in habitat use because of differential vegetation response to aspects and also a crucial factor for as it is directly related to climatic extremes (Morrison *et. al.* 1992). Aspect was divided into five different categories. Kiang used north-west aspect more than availability while as horse used north-west and south-west aspect more than availability. Selection of north-west aspect and avoidance for north-east could be due to mechanism to protect itself from chilling wind blowing at very high speed from south-west aspect towards north-east aspect. Study on white tailed deer in south Texas also showed that Weather variables influenced habitat use during winter, but not during other seasons (Beier and Mccullough 1990).

Sympatric ungulates tend to use different vegetation communities (Gordon, 1989). A very different functioning of their digestive tracts, mouth anatomy between kiang and sheep-goat would lead to fundamentally different pattern of use of different plant species hence different vegetation communities. I expected kiang and horse to be using similar vegetation communities as being from same genus. Kiang and horse used community dominated by grass and shrub more than availability. Sheep-goat communities dominated by grass and forbs more than availability.

Despite the fact that kiangs were separated from livestock but concluding the interaction studies has always been tricky job as evidence of separation would mean no competetion or historical competition which had shaped the interaction as non competitive by using different resources. Hence separation of these ungulates on temporal scale helps us to understand resource portioning in much details.

6.2 Shift in activity pattern, diet and habitat use of kiang to livestock presence

A study addressing the issue of resource partioning over a period on spatial scale is not sufficient to conclude; hence these issues also should be addressed on temporal scale as well. So keeping this in mind habitat use was studied with and without livestock presence to know how kiang responds to livestock presence. Kiangs continued using the same catchment but started to move out of the study area during late winter which may be due to the fact that the decline in the forage availability and increase in direct disturbance due to human presence. Kiang showed marked change in their habitat use in response to livestock presence in the area. Similar results were obtained by other researches on white tailed deer (Cohen *et al.*1989, Beier and Mccullough, 1990) where white tailed deer shifted its habitat use in response to the presence of cattle. Namgail and others (2006) also found out that Argali shifted to areas with less vegetation cover and to steeper habitats in response to livestock presence. During the present investigation I also found kiang got shifted to higher elevations, Aspects with low vegetation cover and steep slopes where predation risk was high.

Diet preferences of kiang did not change or were similar even if their habitat use got shifted. Kiangs activity budget was also changed due to livestock presence, as foraging time decreased and movement increased significantly such an change can be attributed towards livestock grazing and collateral herding activities. These conditions can be more aggravated as forage availability reduces in winter. Such conditions may led to lower the fitness level of the animal which ultimately can have effect on reproductive performance due to energy constraints associated with decreasing foraging opportunities in marginal sites, thereby reducing fecundity (Clutton-brock *et al.* 1982).

6.3 Diet selection and overlap between kiang and livestock

Information on diet selection and overlap in resource use is central to understanding of interspecific exploitation competition and resource portioning (Mysterud, 2000). A high level of resource use overlap has often been use to infer the completion is occurring. However it is the density of individuals relative to the resource base (space and time) that determines the strength of competitive interactions, and not resource use overlap per se (Abrams 1980). A high degree of overlap may indicate the absence of completion permitting the sharing of common resource (Gordon and Illius 1998; Putman 1996). It has been argued that it is pertinent to describe resource overlap both the times of a year when resources are abundant and when they are scarce, and infer the existence of completion, if and when overlap declines in lean season (Gordon and Illius 1989). In the present investigation I studied the diet selection and overlap during winter when both wild and domestic ungulates share same pastures. Kiang showed a very high selection for grasses (84%), and very low for forbs (5%) and sub shrubs (7%). Selection of forbs was different with and without livestock presence which was probably because of differential availability of forbs and sub shrubs in shifted habitat. Sheep and goat selected sub shrubs and forbs more than grass. Horse also showed selection for sub shrubs and grasses. Selection of grasses by kiang was expected as kiang being a purely grazer. But selection of sub shrubs to forbs can be attributed towards the presence of high level of volatile oils as they lack mechanism to reduce toxic effect (Hanley 1892; white *et al.* 1982). Sheep, goat and horse diet also had kiang dung (7%), (5%) and (5%) respectively which was observed first time and hence some level of direct facilitation was observed by kiang to livestock.

Forage plant wise selection by different ungulates revealed same results that Kiang and horse avoided all forbs and shrubs and selected grasses. While as sheep being a mix feeder showed selection for shrubs. Goat being a more grazer than sheep also avoided shrubs and forbs. Selection of one particular shrub by a horse was because of horses being restricted to one particular sub-catchment where the availability of that particular shrub was very high as compared to over-all availability.

There was moderate niche overlap between kiang and sheep (58%), kiang and goat (57%) and very high overlap between kiang and horse (82%). Although difference in feeding type tended to predict degree of diet overlap, where body mass did not, the weak predictive power of both these niche axes may imply that several niche axes need to be taken into account to successfully predict ungulate diet (Hanley and brady 1982). Resource use overlap between the domestic ungulates was generally high (>60%).

6.4 Forage removal by livestock

It is technically difficult to obtain accurate estimates of daily food intake and digestion for free-ranging animals (Gordon 1995), so few data are available for horses at pasture and for cattle in natural grasslands. In my present investigation I found sheep and goat removed or consumed similar amount of forage while as horse consumed much higher amount than sheep and goat. Information from single-species feeding trials using stalled animals shows that horses can ingest more (2.5 % of their body weight) dry forage per kg of body weight per day, and extract more nutrients than cattle on all forages (Duncan *et al.* 1990), while as sheep and goat can take 3-5 %

of their body weight. However, at pasture the low-intake strategy of sheep and goat may allow them to feed more selectively, and they use a wider range of plant species (Krysl *et al.* 1984). My results from sheep and goat were in concordance other studies but showed disparity for horse results (Bagchi *et al,* 2003), this could be reason because the earlier study took place during spring and summer season when pasture quality is usually high as amount of forage removed by an animal depends on pasture quality. It is therefore possible that on poor-quality forages at pasture, sheep and goat (quality) extract nutrients at a higher rate than do horses (quantity).

6.5 Density of kiang in Hanley valley

Kiang has a total estimated range of approximately 7400 km^2. Kiang range in Ladakh has reduced in many areas (Chundawat & Qureshi 1999, Fox *et. al* 1991). Of my entire vehicle transects Kalak Tar-tar had highest density and encounter rate of kiang which was little higher than earlier survey (Shah & Qureshi 2002). The reason of such higher density and encounter rates could be because kiangs congregate in large numbers on Kalak Tar-tar plateau personal communication with local herders and also this plateau remains livestock free and is only grazed by livestock during late winter and early spring. Transect loma to Hanley had encounter rate of 0.59 kiangs per km which was in concordance with the encounter rates reported by (Shah and Qureshi 2002). Total density and encounter rates are not comparable as all earlier studies covered almost whole of the Changthang and I only surveyed Hanley. With my limited information it seems that the population of kiang in Hanley valley has not increased, on interaction with local herders It was realized the their perception about pasture quality and kiang was influenced by many factors like decrease and erratic regime of rain and snowfall in the valley since many years, influx of Tibetan refugees and sharing of ancestral pastures with them and occupation of some areas of

Changthang by China and restricting the local Changpa herders to small areas had aggravated the present scenario. Further detailed survey should be conducted for whole of the Changthang to know their perception towards the pasture quality and conservation of kiang.

Reference

Abrams P. (1980). some comments on measuring niche overlap. Ecology , 44-49.

Altman, J. (1974) Observational study of behavior: sampling methods. Behavior 49: 227-267.

ANON. (1998) Statistical Handbook, Govt. of Jammu & Kashmir, District Leh 1996-97. Directorate of Economics and Statistics. District Statistical Evaluation Agency, LAHDC, Leh.

Arnold, G. W., and Dudzinski. (1978) Ethology of free ranging domestic animals. Elsevier, New York. 198 p.

Bagchi, S., Mishra, C., and Bhatnagar, Y.V. (2004) Conflicts between traditional pastoralism and conservation of Himalayan ibex (*Capra siberica)* in the Trans-Himalayan Mountains. Animal Conservation, 7:121-128.

Beier, P., & Mccullough, R. (1990). factors influencing activity patterns and habitat use. Wildlife monographs , 1-50.

Bell R. (1970) The use of herb layer by grazing ungulates in the Serengeti. In Watson A (ed) Animal population in relation to their food resources. Blackwell, Oxford, pp 111-113.

Bhatnagar, Y.V. (1997)Ranging and Habitat Utilization by the Himalayan Ibex (*Capra ibex siberica*) in Pin Valley National Park. PhD. Thesis, Saurashtra University.

Bhatnagar, Y.V. (2000). Status Survey of large Mammals in Eastern Ladakh and Nubra. In. Conserving Biodiversity in the Indian Trans-Himalaya: new initiatives of Field Conservation in Ladakh. Annual Technical Report.

Wildlife Institute of India, U.S Fish & Willdlife Services and International Snow Leopard Trust.

Bhatnagar, Y. V., Wangchuk, R., Prins, H. H. T., Van Wieren, S. E., and Mishra, C. (2006). Perceived Conflicts Between Pastoralism and Conservation of the Kiang Equus kiang in the Ladakh Trans-Himalaya, India. Environmental Management 38:934-941.

Bosheng, L. (1995) Biodiversity of Qinghai – Tibetan Plateau and its conservation. Discussion Paper, Series No. MNR 95/3, ICIMOD, Kathmandu, Nepal.

Chundawat R. and Qureshi Q. (1991) Planning wildlife conservation in leh and kargil districts of Ladakh, Jammu and Kashmir. Wildlife Institute of India, Dehradun.

Chundawat, R.S. and Rawat, G.S. (1994) Indian Cold Desert: A Status Report on Biodiversity. Wildlife Institute of India, Dehra Dun.

Chundawat, R. and Qureshi, Q. (1999) Snow leopard intensive management study report. Wildlife institute of India, Dehradun.

Clutton-Brock T.H., Guiness F.E., Albon S.D. (1982) Red deer: behaviour and ecology of two sexes. University of Chicago Press, Chicago

Cohen W. E, Drawe D.L., Bryant F. C., Bradley L. C (1989) Observations on white tailed deer and habitat response to livestock grazing in south Texas. J Range Manage 42:361-365.

Cumming, D.H.M. (1982) The influence of large herbivores on savanna structure in Africa. Ecology of Tropical Savannas (eds B.J. Huntley & B.H. Walker), pp. 217–244. Springer-Verlag, Berlin, Germany.

Duncan, P. (1992) Horses and Grasses: The nutritional ecology of Equids and their impact on the Camargue Springer-Verlag Inc., New York.

Duncan, P., Foose, T. J., Gordon, I., Gakahu, C. G. and Lloyd, M. (1990) Comparative nutrient extraction from forages by grazing bovids and equids: a test of the nutritional model of equid/bovid competition and coexistence. - Oecologia 84: 411-418.

Feh, C., Munkhtuya, B., Enkhbold, S. and Sukhbaatar, T. (2001) Ecology and social structure of the Gobi khulan Equus heminous subsp. In the Gobi B National Park, Mongolia. Biological conservation pp, 51-61.

Fox J. L., C. Nurbu, R. S. Chundawat. (1991) The mountain ungulates of Ladakh, India. Biological Conservation 58:167–190.

Gasse, F., J.. Fontes, E. Campo, and K. Wei. (1996) Holocene environmental changes in Bangong Co (Western Tibet). Part – 4: Discussion and conclusions. Palaeogeography, Palaeoclimatology, Palaeoecology 120: 79 – 92.

Gordon I. J. (1989) Animal based techniques for grazing ecology research. Small ruminant research 16: 203-214.

Gordon, I. J. (1989). Vegetation community selection by ungulates on the Isle of Rhum. III. Determinants of vegetation community selection. Journal of applied ecology 26: 65-79.

Gordon, I.J. & Illius, A.W. (1989) Resource partitioning by ungulates on the Isle of Rhum. Oecologia, 79:383–389.

Gordon, I.J. (1995) Animal-based techniques for grazing ecology research. Small Ruminants Research, 16:203–214.

Groves, C., Mazak, V., (1967) On some taxonomic problems of Asiatic wild asses; with the description of a new subspecies Perrissodactyla; Equidae. Z. f. Saugetierkunde 21, 321-355.

Groves, C. P. (1974) Horses, asses, and zebras in the wild. Ralph Curtis Books, Hollywood, Florida, 192 pp.

Hanley, T. A. (1997) A nutritional view of understanding and complexity in problem of diet selection by deer (Cervidae). Oikos 79: 209-218.

Hanley, T. A. and Brady W. W. (1977). Seasonal fluctuations in nutrient content of feral burro forages, Lower colarado river valley, Arizona. J. Range Manage. 30: 370-373.

Holechek, J. L. (1982) Sample preparation technique for microhistological analysis. J. Range Manage. 35: 267-268.

Ivlev, J. S. (1961) Experimental ecology of the feeding fishes. New Haven,C T: Yale University Press.

Janis, C. (1976) The evolutionary strategy of Equidae and the origin of rumen and Cecal digestion. Evolution (Lawrence, Kans.) 30:757-774.

Kitchloo, N.A (1997) Unified Ecosystem Management Plan for the Changtang Wilderness Area, Dept. of Wildlife Protection, Jammu & Kashmir Govt. Srinagar.

Kothmann, M. (1984) Concepts and principles underlying grazing system: A Discussant paper. In Natl. res. Council/Natl. Acad. Sci. "Developing Strategies for rangeland management". Westview press, Boulder, Colorado, pp. 903-916.

Krysl, L. J., Hubbert, M., Sowell, B., Plumb, G., Jewett, T., Smith, M., Waggoner, J. 1984. horse and cattle grazing in the Wyoming Red Desert. I. Food habits and dietry overlap. J. Range mgt. 37: 72-76.

Kurtén, B. (1968) Pleistocene Mammals of Europe. Weidenfeld & Nicholson, London, UK

MacFadden, B., (1992) fossil horses. Systematics, Paleobiology and evolution of the family Equidae. Cambridge University press, Cambridge.

Machlis L, Dodd PWD, Fentress JC (1985) The pooling fallacy: problems arising when individuals contribute more than one observation to the data set. Z Tierpsychol 68:201–214

Manly, B., McDonald, L., and Thomas, D. (1993) Resource selection by animals. Statistical design and analysis from field studies. Chapman and Hall, London

Marcum, C. L., Loftsfarden D. O. (1980). A non mapping technique for studying habitat preferences. Journal of Wildlife Management, 964-968.

McCune, B. and Grace, B. J. (2002). MRPP(Multi-response permutation procedures) and related techniques. In B. a. McCune, Analysis of ecological communities (pp. 188-197). chapel Hill, North carolina: Deke University.

Mielke, P. W., 1982. An extended class of permutation techniques for matched pairs. Communication in statistics part A-theory and methods 11: 1197-1207.

Mishra, C. (2001). High altitude survival: conflicts between pastoralism and wildlife in the Trans-Himalaya. Doctoral thesis, Wageningen Univ., The Netherlands

Mishra, C, Prins, H.H.T., Van Weiren, S.E., and Ketner, P (2001) Resource competition in a Trans Himalayan herbivore assemblage; diet overall and its demographic consequences. Pages 73-94 in High Altitude Survival; Conflicts between Pastoralism and wildlife in the Trans Himalaya. Mishra, C. Doctoral Thesis. Wageningen University, The Netherlands.

Mishra, C., Prins, H.H.T , and van Wieren, S.E. (2002a) Overstocking in the trans-Himalayan rangelands of India. Environmental Conservation, 28

Mishra, C., van Wieren, P., Heitkonig, I.M.A., and Prins, H.H.T. (2002b) A theoretical analysis for competitive exclusion in a Trans-Himalayan large-herbivore assemblage. Animal Conservation, 5, 251-258

Mishra, C., van Wieren, S.E., Kenter, P., Heitkonig, I.M.A., and Prins, H.H.T. 2004. Competition between domestic livestock and wild bharal (*Pseudois nayaur)* in the Indian Trans-Himalaya. Journal of Applied Ecology, 41, 344-354.

Mittelbach, G. G. (1984). Predation and resourse partining in two sunfishes (Centraarchidae). Ecology, 65, 499-513.

Molnar, P. (1989). the geological evolution of the tibetan plateau. American Scientist , 77: 350-360.

Morrison, M. L., Marcot, B. G., Mannan, R. W. (2002). Wildlife habitat relationship concepts and applications. University of Wisconsin press.

Muller-Dombois, D., and Ellenberg, H. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.

Mysterud, A., 1998. The relative role of body size and feeding type on activity time of temperate ruminants. Oecologia, 113, 442-446.

Namgail, T., Bhatnagar, Y. V., Mishra C., Bagchi, S. (2007). Pastoral Nomads of the Indian Changtanhg: production system, Landuse and Sioecnomic Changes. Hum Ecol

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

Pfister, O.(2004) Birds & mammals of Ladakh. Oxford Publishers, New Delhi

Putman, R. J. (1996). Competition and resource partitioning in temperate ungulate assemblies. London, UK: Chapman and Hall

Quade, D. (1979) Using weighted ranking in the analysis of complete blocks with additive block effects. J. Am. Stat. Assoc. 74:680-683.

Raghavan, B. (2003) Interactions between Livestock and Ladakh Urial (*Ovis vignei vignei*). M.Sc Dissertation, Wildlife Institute of India, Dehradun

Rawat, G. S. and Adhikari, B. S. (2001). Vegetation characteristics and patterns of Livestock grazing in Changthang plateau, Eastern Ladakh. Katmandu, Nepal.: ICMOD.

Repasky, R. R. (1996) Using vigilance behaviour to test whether predation promotes habitat portioning. Ecology, 77:1880-1887

Richard, C. (1999) Rangelands and Livestock as a niche opportunity for Ladakh. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Rodgers, W. A. and Panwar, H. S. . (1988). Planning a protected area network for India. Dehradun: Wildlife institute of India. Vol I & vol II.

Rukstuhl, K.E.(1998) Foraging behaviour and sexual segregation in bighorn sheep. Animal Behaviour 56:99–106

Ryder, 0. and Chemnick, L. (1990) Chromosomal and molecular evolution in Asiatic Wild Asses. Genetica 83: 67–72.

Schaller GB (1977) Mountain monarchs: wild sheep and goats of the Himalaya. University of Chicago Press, Chicago

Schaller, G. B. (1998). Wildlife of Tibetan Steppe. Chicago: The University of Chicago press.

Schoener,T . W. (1968). The Anolis lizardso f Bimini:R esourcep artitioningin a complexf auna. Ecology, 49: 704-726

Schoener, T. W. (1972). Resource partitioning in ecological communities. Science 185: 27–39.

Scott, G. and Dahl (1980). Key to selected plant species of Texas using plant fragments. Occasional papers, the museum, Texas tech University, No. 64. 37 pp.

Senft, R. L. (1987) domestic herbivore foraging tactics and landscape pattern. USDA, for. Ser. Gen. Tech. Rep. INT-222:137-140

Shah, N. (1996) Status and distribution of Western kiang (Equus kiang kiang) in Changthang Plateau, Ladakh, India. Report M.S. Univ. of Baroda and Gujrat Nature Conservation Society, Baroda, Gujrat.

Shah, N. (2002) Status and action plan for the Kiang (Equus kiang kiang). Pages 72–81 in P. D. Moehlman (ed.), Equids: Zebras, asses, and horses status survey and conservation

Shah, N. (1994) Status survey of southern kiang (*Equus kiang polyodon)* in Sikkim. Maharaja Sayajirao University. Baroda, India.

Shah, N. (1997) Status and Distribution of southern kiang *(Equus kiang polyodon)* in North Sikkim, India. Phase II Report, Zoological Society for Consevation of species and population, Munchen and M.S.University, Baroda, Gujarat.India.

Shrestha, R., Wegge, P., and Koirala, R.A. (2005) Summer diets of wild and domestic ungulates in the Nepal Himalaya. Journal of Zoology, 266: 111-119.

Sparks, D. R. and Malechek (1968). Estimate percentage diets using microscope technique, Journal of Applied Ecology, 4:83-111.

Thill, R. E., and Martin A. (1986) Deer and cattle overlap on Louisana pine-bluestem range. Journal of Wildlife Management. 50: 707-713

Todd, J. W. and Hansen (1973). Plant fragments in the feces of bighorns as an indicator of food habits. Journal of Wildlife Management. 37: 362-366.

Valdia, K. S. (2001). Himalaya: Emergence and Evolution. India: University press limited

Wadia, D. 1967. Geology of India. London, MacMillan.

Wallmo, O. C., Gill, R. B., Carpenter, L. H. & Reichert, D. W. (1973). Accuracy of field estimates of deer food habits, Journal of Wildlife Management. 37: 556–562.

White, G.C., Anderson, D.R., Burnham, K.P., Otis, D.L., (1982) Capture-recapture Removal Methods for Sampling Closed Population. Los Almos National Laboratory Publication LA-8787- NERP, Los Alamos.a

Wilderness Area, Dept. of Wildlife Protection, Jammu & Kashmir Govt. Srinagar.

Zhu, L., Owens, T.J. and Randall, G. E. (1995). lateral variation in crustrual srtucture of the northern Tibetan plateau infered from Teleseismic reciever function. Seismological society of America 85:1531-1540.