Conflicts between traditional pastoralism and conservation of Himalayan ibex (*Capra sibirica*) in the Trans-Himalayan mountains

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Abstract

There is recent evidence to suggest that domestic livestock deplete the density and diversity of wild herbivores in the cold deserts of the Trans-Himalaya by imposing resource limitations. To ascertain the degree and nature of threats faced by Himalayan ibex (*Capra sibirica*) from seven livestock species, we studied their resource use patterns over space, habitat and food dimensions in the pastures of Pin Valley National Park in the Spiti region of the Indian Himalaya. Species diet profiles were obtained by direct observations. We assessed the similarity in habitat use and diets of ibex and livestock using Non-Metric Multidimensional Scaling. We estimated the influence of the spatial distribution of livestock on habitat and diet choice of ibex by examining their co-occurrence patterns in cells overlaid on the pastures. The observed co-occurrence of ibex and livestock in cells was compared with null-models generated through Monte Carlo simulations. The results suggest that goats and sheep impose resource limitations on ibex and exclude them from certain pastures. In the remaining suitable habitat, ibex share forage with horses. Ibex remained relatively unaffected by other livestock such as yaks, donkeys and cattle. However, most livestock removed large amounts of forage from the pastures (nearly 250 kg of dry matter/day by certain species), thereby reducing forage availability for ibex. Pertinent conservation issues are discussed in the light of multiple-use of parks and current socio-economic transitions in the region, which call for integrating social and ecological feedback into management planning.

INTRODUCTION

All over the world, parks and reserves have become the cornerstone of biodiversity conservation. In most of the 'Third World', conservationists and managers face a litany of problems since people are dependent on park resources (Terborgh *et al.*, 2002). Multiple-use of wildlife reserves in a country such as India, which has a high human population and the world's largest livestock population (449 million head: W.R.I., 1996), is often inevitable. Pastoralism is a widespread form of resource extraction in wildlife reserves, with three-quarters of India's reserves being grazed by livestock (Kothari *et al.*, 1989). Yet the ecological impacts of livestock grazing on wildlife conservation objectives, as well as the social dynamics that influence stocking

densities and herding behaviour, are poorly understood but strongly debated (Saberwal, 1996, 1998; Mishra & Rawat, 1998). The issue of forage competition between livestock and wild herbivores, although long acknowledged as being important for conservation management (Kie *et al.*, 1991), has remained a contentious one and reviews suggest a worldwide scarcity of studies aimed at understanding it (Putman, 1996; Prins, 2000). In this paper, we evaluate the effects of livestock grazing on the conservation status of a mountain ungulate in the Trans-Himalayan cold deserts of India in the context of current social dynamics in the region.

Approximately 10% of the world's population lives in mountain areas, with livestock contributing substantially to their economy (Pun & Mares, 2000). The Trans-Himalayan region, which includes the Tibetan Plateau and the Tibetan Marginal Mountains, represents a vast rangeland system (*c.* 2.6 million km^2) that is subject to traditional and pervasive livestock grazing by the local, predominantly Buddhist, community (Handa, 1994). The wildlife of the Trans-Himalaya resides alongside a diversity of domestic livestock and includes carnivores such as snow leopard (*Uncia uncia*), wolf (*Canis lupus*), wild dog (*Cuon alpinus*) and lynx (*Lynx lynx*)

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and an assemblage of large herbivores such as the wild ass (*Equus kiang*), Tibetan argali (*Ovis ammon*), Tibetan antelope (*Pantholops hodgsoni*), Tibetan gazelle (*Procapra picticaudata*), ibex (*Capra sibirica*), urial (*Ovis vignei*) and bharal (*Pseudois nayaur*) (Schaller, 1977; Mishra, 2001). These large carnivores and mountain ungulates are all threatened and are provided with the highest protection status (Schedule I) under Indian law (Anonymous, 2002). In the 12 000 km² Spiti Valley in the Indian Trans-Himalaya, a tribal agro-pastoral society holds traditional grazing rights over the entire catchment, even though parks for wildlife conservation have been designated. Spiti is currently in a state of land use flux, as the local economy is rapidly becoming integrated with the mainstream markets (Mishra, 2000). Most of the rangelands in Spiti are overstocked, with domestic herbivores attaining up to ten times the biomass of wild herbivores (Mishra, Prins & van Wieren, 2001). Forage competition with livestock and the collateral effects of pastoralism have presumably caused local extinctions of at least four wild herbivores from Spiti (Mishra *et al.*, 2002). The extant wild ungulates include just the ibex and bharal. The Pin Valley region of Spiti has been recognised as being an important stronghold for the conservation of ibex and snow leopard and it was designated a wildlife reserve in 1987. Despite this, the entire Pin Valley catchment is grazed by a diverse livestock assemblage and the impact of livestock grazing on ibex populations, especially the issue of forage competition between them, remains unclear (Bhatnagar *et al.*, 2000).

The classical theory of a 'niche' emphasises the role of inter-specific competition and resource partitioning in allowing species co-existence (Hutchinson, 1959; Schoener, 1974; Giller, 1984; Goldberg & Barton, 1992; Whitfield, 2002). Competition occurs when the amount of available resources for a species is depleted due the presence of another species (Sale, 1974; Abrams, 1998). Such density dependent interactions between domestic and wild herbivores have been debated in many regions (Stover, 1985; Prins, 1992; Fleischner, 1994; Noss, 1994; Voeten & Prins, 1999; Mishra, 2001). Theoretically, species populations can grow (by consuming resources) until resource availability is reduced to the point where the population growth rate is balanced by mortality – the point of resource limitation (Huisman, 1997). When livestock are supplementary fed, their populations can continue to grow beyond this threshold – a process called overstocking (Mishra *et al.*, 2001). If there is high overlap in the habitat and forage requirements of livestock and wild herbivores, overstocking and supplementary feeding can cause competitive exclusion of the latter (Mishra *et al.*, 2002).

In this paper, we ask if the ibex faces the risk of out-competition by livestock in Pin Valley. In line with Schoener (1974), we predicted that (1) ibex and livestock would co-exist without competition if they used different habitats, (2) they would co-exist without competition if they used the same habitats but diverged in their diets and (3) livestock would out-compete ibex if they used the same habitats and had similar diets. We will evaluate these predictions by assessing the patterns of habitat use, diet and spatial co-occurrence of ibex and a diverse assemblage of livestock.

METHODS

Study area

The catchments of the Pin River form the Pin Valley National Park (PVNP, 32° N 78° E) in the Pir Panjal range of the Himalayas with altitudes ranging between 3600–5400 m (average 4420 m). The region experiences severe winters with temperatures dropping below −40°C (November–March). Spring and summer are the period of plant growth (April–August) and are relatively snow-free, leading on to autumn and a period of plant senescence during September–October. The terrain is rugged and most of the area has an inclination of between 30° and 60°. Being cold and arid, the vegetation of the region is characterised as 'dry alpine steppe' with grasses such as *Stipa*, *Festuca*, *Oryzopsis* and *Elymus*. Sedges are represented by *Carex* and *Kobresia*. Shrubs include *Rosa*, *Myricaria*, *Lonicera*, *Caragana* and *Ephedra*. Common herbs are *Lindelofia*, *Artemisia*, *Arnebia* and *Pleurospermum* (Champion & Seth, 1968; Aswal & Mehrotra, 1994). The tree layer is largely absent.

The Parahio is a major tributary of the Pin and local villagers have traditional rights over its pastures. The people keep several types of livestock including horses, donkeys, goats, sheep, yaks and cattle (including yak–cattle hybrids), which graze the pastures between April and October. Of these, only horses are used for trade, while other livestock are raised for meat, milk, hide, wool and as draught animals. Young horses (and lactating mares) are herded but adult horses and yaks are free ranging. In addition, migratory herders have traditional rights over a few pastures on which they graze goats and sheep during June–August. The other form of land-use is agriculture and local people grow several varieties of barley and pea for food and fodder (Mishra, 2001).

Increasingly, there is a trend towards growing pea as a cash crop and 89% of the families in these villages have taken up this form of income generation in the last 5 years (Bagchi *et al.*, 2002). In doing so, they allocate about a quarter of their land-holding for planting cash crops, which reduces the amount of fodder production (Mishra, 2001; Bagchi *et al.*, 2002). Since added profits impose fodder shortage, 27% of the families have given up horse rearing since they found that cash crops were four to six times more profitable. Consequently, the number of horses in these villages has shown a 37% decline during the period 1998–2002 (Bagchi *et al.*, 2002).

Data collection

Twelve pastures were identified over a 19 km long section of the Parahio catchment and each was divided into several cells. A pasture was divided into three vertical zones (namely the lower slope, middle slope and upper

slope) and each zone was considered to be made up of two horizontal sections, so that each cell was 1–2 ha in size. When additional pastures were available along river-valleys at the base of a slope, they were considered to be separate cells.

The entire study area was systematically surveyed 26 times between April–August 2002, to record the distribution of ibex and livestock over individual cells. We considered free-ranging horses and herded horses separately, while the migratory goats and sheep were grouped into a single category. Vegetation in each cell was sampled to obtain information on ground cover by recording plant species composition and abundance using the point-intercept method (Muller-Dumbois & Ellenberg, 1974). A total of 100 points over a 50 m long line was used to record this information during peak standing biomass (late-July: Mishra, 2001). Every ground-cover category (plant species abundance, bare soil, or rock) was considered to be a separate habitat variable after arcsine transformation. Average slope, altitude and approximate distance from the nearest cliffs (escape terrain) to the centre of individual cells were all recorded, since these are important determinants for habitat selection in ibex (Bhatnagar *et al.*, 2000).

The food habits of ibex and all livestock were studied by direct observation, often with the help of telescopes and binoculars. Plant species consumed and number of bites on each species were estimated by observing individual animals. An uninterrupted sequence of 10–100 bites was considered to be a single feeding event and after 100 bites a different individual was chosen for observation. Since the accuracy of the method depends on the identification of individual plant species (Wallmo *et al.*, 1973), we grouped all grasses and sedges into just two categories since their field identification was difficult. Herb and shrub species could be identified with relative ease and were recorded separately. To get an estimate of the amount of forage consumed by livestock, we simulated bites by hand-plucking (Wallmo *et al.*, 1973) and the samples were oven-dried to obtain dry-weight. By scan sampling on foraging herds we determined the proportion of animals grazing at a given point of time and we estimated bite rates through focal sampling (Altmann, 1974). By means of field observations we also estimated the number of hours that livestock belonging to each category foraged in a day.

Data analysis

Habitat selection by ibex and livestock was analysed using Non-Metric Multidimensional Scaling (NMDS). NMDS attempts to find structure in sets of distance measures by assigning observations to specific locations in a conceptual space, such that similarities between points in this space match the given similarities as closely as possible (Clarke & Warwick, 1994; Norussis, 1997). This enables the visualisation of interspecific differences over habitat features (Clarke & Ainsworth, 1993; Bagchi, Goyal & Sankar, 2003). The response of ibex and livestock

was evaluated against habitat measurements related to vegetation, ground cover and terrain from each cell. Each habitat variable recorded in the cell was considered to be a separate dimension in niche space and the difference between group-centroids of various livestock and ibex were assessed using Euclidean distances (Bagchi *et al.*, 2003). The number of iterations was decided on the basis of Young's S-stress formula and iterations were stopped when the S-stress was less than 0.005 (Spence, 1978; Norussis, 1997). Plant species that contributed less than 2% to overall ground cover were removed from this analysis.

The diet profiles of ibex and various livestock were used to generate a matrix of percentage-utilisation of different plant species. Plants contributing less than 5% to the diet of either ibex or livestock were grouped together into one category. As with habitat variables, this was again converted into a similarity-matrix on the basis of the Euclidean distances between group-centroids to represent similarity in their diets. These two matrices were combined to obtain a geometrical representation of guild-structure and to identify species having similar resource requirements (belonging to the same guild) using NMDS, thus enabling visualisation of relative niche-positions as in Venn diagrams (Bagchi *et al.*, 2003).

The amount of forage removed by livestock was estimated for each species by multiplying the bite weight, bite rate, proportion of animals foraging and number of hours in a day spent foraging. The mean amount of forage removed in a day and 95% confidence intervals were calculated through Monte Carlo simulations (100 iterations).

We predicted that livestock species belonging to the same guild as ibex (similar habitat and diet requirements) could cause spatial exclusion of the latter. This was evaluated by analysing the relationships in spatial distribution of ibex and livestock in terms of their co-occurrence patterns across all cells. Data from all surveys were pooled to obtain a cell-wise presence–absence matrix for ibex and various livestock. Cell-based spatial co-occurrence (or, conversely, separation) between ibex and various livestock was calculated using the *C*-score index (Stone & Roberts, 1990). The index is derived from the mean number of checkerboard units/species-pair in an assemblage, calculated as:

$$C_{ij} = (r_i - S)(r_j - S)$$

Where r_i is the number of cells with species i, r_j is the number of cells with species j and S is the number of shared sites. (For an assemblage of N_s species there are $N_s(N_s - 1)/2$ species-pairs and the *C*-score is $2\Sigma\Sigma C_{ij}/N_s(N_s - 1)$).

The *C*-score is a measure of the tendency for species not to occur together in the same cell; larger values indicating lower average co-occurrence (greater separation) among species pairs. We assessed the significance of the observed *C*-scores through null-models where two species of a given pair were assigned to cells at random, i.e. the occurrence of one species in a cell was independent of the other. The significance of the observed *C*-scores was assessed

through Monte Carlo simulations (1000 iterations: Gotelli, 2000). Although all aspects of spatial auto-correlation can not be incorporated in randomisation algorithms (Koenig, 1999), the nature of the association between species (positive or negative trends in co-occurrence) is expected to be appropriately represented. This null-model approach is adapted from Diamond (1975) and Connor & Simberloff (1983) and has been widely debated among ecologists (for reviews, see Connor & Simberloff, 1984; Weins, 1989; Stone & Roberts, 1992; Gotelli & Graves, 1996; Gotelli, 2000). Spatial patterns can also be analyzed using alternative indices (niche-overlap indices: Albrecht & Gotelli, 2001). Analyses were carried out using spreadsheets, SPSS (Norussis, 1997), PopTools (Hood, 2002) and Ecosim (Gotelli & Entsminger, 2001) software.

Fig. 1. Relative positions of ibex and livestock in the Pin Valley over conceptual space identified using Non-Metric Multidimensional Scaling. Two habitat dimensions make up this space – altitude (*x*-axis) and distance to cliffs (*y*-axis) and different species show varied responses to these.

RESULTS

About 100 horses, 60 head of cattle, 73 yaks and 140 donkeys used the pastures. In addition there were six migratory herds of goat/sheep each consisting of 500–800 animals. Some of the livestock owned by the villagers were not brought into the Parahio catchment and grazed on other pastures.

Habitat use

NMDS identified two important dimensions that explained habitat use and differences between the habitat features selected by various livestock and ibex. The first dimension had a high loading (stimulus co-ordinate = 6.4) for the altitude of the cells and the second had a high loading for the distance to cliffs from the cells (stimulus co-ordinate = 1.2). These are represented as the X and Y axes of Fig. 1, respectively. Vegetation features such as plant species abundance and composition were only weakly loaded on either axis (stimulus co-ordinates were close to zero), suggesting that the pastures are homogenous in vegetation cover and, therefore, are not an important factor in habitat choice. Donkeys and cattle occupied pastures at lower altitudes, such as river valleys and the lower slopes and were far from cliffs. Ibex occupied higher areas (upper slopes) and were closest to cliffs. Horses, goat/sheep and yaks also occupied the middle and upper slopes and had similar habitat selection patterns to ibex. Some degree of habitat separation thus becomes evident, leading to the formation of two altitude-based guilds – the cattle and donkeys that selected for low altitude pastures and the others, including ibex, that selected for middle and upper slopes.

Diet selection

Of the 38 plant species recorded during vegetation sampling, 21 were recorded in the diet of the herbivores (ibex and livest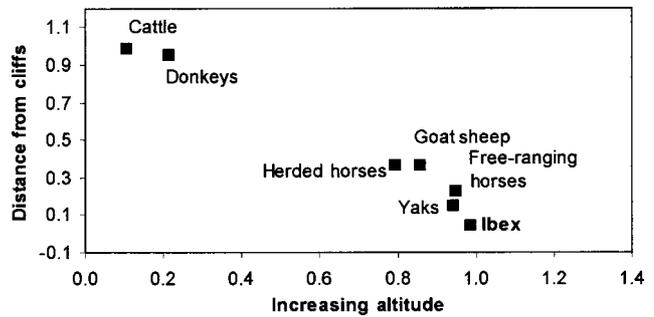ock). Of these, 10 species contributed less than 5% to their diets and were pooled together into one category. Data are from 1110 bite-counts from ibex, recorded during 62 feeding events from 17 different individuals. Of these, plant species could not be identified for 13% of bites. Similarly for livestock, the results are: free-ranging horses = 473/16/5/0; herded horses = 1244/45/11/4; cattle = 978/65/13/0.5; donkeys = 730/36/10/0; yaks = 545/53/10/0; goat/sheep = 1568/61/13/0 bite-counts, feeding events, individuals and % bites for which plant species could not be identified, respectively. The diet profiles of the species are represented in Fig. 2.

It appears that grasses are important for ibex, free-ranging horses and goat/sheep and that they have similar diets. Sedges form the bulk of the diet in cattle and donkeys, while herbs and shrubs are consumed in smaller amounts by all species. Yaks have a mixed diet, depending heavily on grasses and *Aconogonum* (Fig. 2). *Per capita* forage removal rates (dry weights) were highest for horses, followed by donkeys, yaks, goat/sheep and cattle (Table 1). The animals consumed forage equivalent to 2–3% of their body weight/day. Presumably, being large-bodied hind-gut fermenters, horses consumed relatively more forage than others, closely followed by donkeys. The animals generally do not forage at night due to cold and windy conditions but, given the possibility of occasional nocturnal feeding, our results perhaps under-estimate forage consumption.

Guild structure and resource partitioning

The relative separation between ibex and various livestock over habitat and dietary dimensions is represented in Fig. 3. It appears that a species-pair that is similar in habitat use is also similar in diet. Ibex, free-ranging horses and goat/sheep show low levels of differentiation in habitat use as well as in diet. In the absence of any differentiation, a distinct guild composed of ibex, goat/sheep and free-ranging horses appears and interactions within this guild would be potentially competitive.
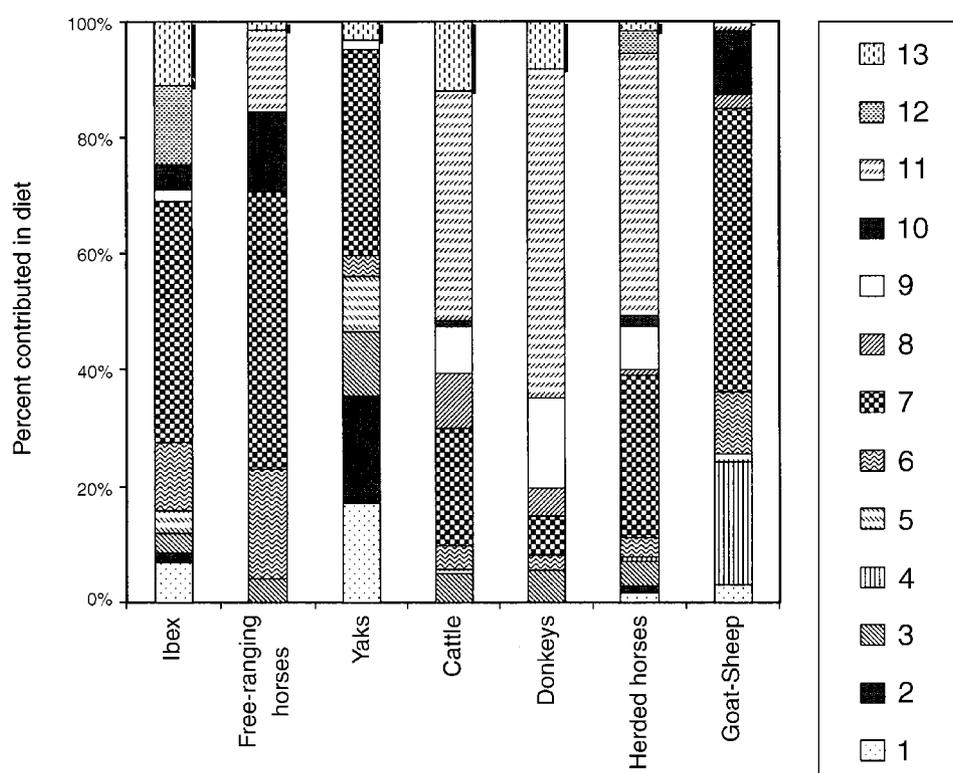
Fig. 2. Diet profile of ibex and various livestock represented as percentage contribution of different plant species (1–13) in their diets. Plants species represented are: 1, *Aconogonum molle*; 2, *Artemisia maritima*; 3, *Astragalus prostratus*; 4, *Astragalus candolleanus*; 5, *Bupleurum falcatum*; 6, *Cicer microphyllum*; 7, grasses; 8, *Hyssopus officinalis*; 9, *Lindelofia* sp.; 10, *Nepeta podostachys*; 11, Sedges; 12, Unidentified; 13, Other species. Nomenclature is taken from Aswal & Mehrotra (1994).

Spatial distribution of ibex and livestock

A total of 76 cells was recognised in the 12 pastures of the study area. During the surveys ($n = 26$), ibex were seen 24 times over 22 cells in eight out of the 12 pastures. Similarly, the results for livestock are: free-ranging horses = 29/11/4; herded horses = 32/17/5; cattle = 34/11/5; donkeys = 38/12/5; yaks = 34/17/7; goat/sheep = 31/13/4 sightings, cells and pastures, respectively. Given the similarity in habitat-use and diet, we expected ibex to

show a negative association with free-ranging horses and goat/sheep, i.e. ibex would be spatially excluded by them.

However, C-scores indicated that ibex had the highest spatial overlap with free-ranging horses (80), followed by yaks (176), cattle (180), donkeys (200), herded horses (204) and least with goat/sheep (286). These results are illustrated in Table 2. On the basis of the simulated null-models, the co-occurrence between ibex and free-ranging horses was found to be greater than expected by random chance ($P < 0.05$: Table 2). This suggests a positive

Table 1. Average body weight, bite rate, bite weight, proportion foraging, hours foraged per day and forage removed of livestock in Pin Valley

	Body weight[†] (kg)	Bite rate (R) (mean ± S.E.)	Bite weight (W) (mean ± S.E.)	Proportion of animals foraging (P) (mean ± S.E.)	Hours foraged/day (H)	Forage removed (F) (mean, 95% CI) where F = R × W × P × H
Cattle	190–220	13.47 (±0.55)	0.96 (±0.10)	44 (±4)	7–8	2.3 (0.8–3.8)
Donkeys	90	31.00 (±2.44)	0.55 (±0.05)	45 (±8)	8–9	4.0 (1.3–7.7)
Horses	248	28.94 (±1.27)	1.29 (±0.12)	54 (±2)	7–8	4.7 (1.9–8.5)
Goat/sheep	34–35	22.98 (±1.47)	0.43 (±0.05)	68 (±3)	6–7	2.8 (0.9–8.4)
Yaks	298	14.53 (±0.49)	1.70 (±0.15)	45 (±6)	8–9	3.0 (1.8–5.6)

[†] Body weights are adapted from Mishra (2001).

Abbreviations used: CI, confidence intervals.

Units used: Bite rate = number/min; bite weight = g dry matter/bite; proportion foraging = % feeding at any given time; forage removed = kg of dry weight/day.

Table 2. Pair-wise co-occurrence patterns of ibex and various livestock compared using C-scores from the null-model

Species-pair	Ibex	Free-ranging horses	Goat/sheep	Yaks	Herded horses	Donkeys	Cattle
Ibex	0	80[+]	286[−]	176	204	200	180
Free-ranging horses		0	143[−]	91	160	132	121
Goat/sheep			0	96	140	156	143
Yaks				0	256	204[−]	187[−]
Herded horses					0	126	112
Donkeys						0	10[+]

Higher scores indicate lower co-occurrence between a species-pair. Significant differences between the observed score and the simulated scores are marked by superscripts. The sign of the superscript denotes negative/positive association between the species-pair.
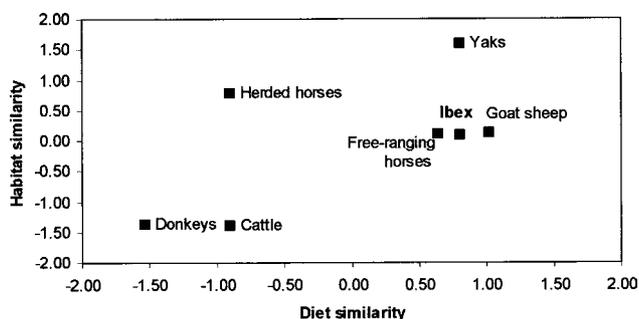
Fig. 3. Guild structure in the herbivore assemblage in terms of habitat and food dimensions. The x and y-axes represent Euclidean distance between a species-pair in conceptual habitat and dietary dimensions, respectively, as created using Non-Metric Multidimensional Scaling.

association between ibex and free-ranging horses, i.e. they have a tendency to co-occur. However, as expected, there was a negative association between ibex and goat/sheep, i.e. they have similar habitat and diet requirements but do not use the same areas ($P < 0.05$). This suggests that ibex are excluded from pastures due to the presence of goat/sheep and not due to the presence of free-ranging horses. Spatial distribution of ibex was not influenced by any other livestock ($P > 0.05$).

Since cell sizes were variable (1–2 ha), this could potentially influence the co-occurrence patterns for ibex, with a greater probability of occurrence in larger cells located on lower slopes (e.g. those used by donkeys). However Table 2 reveals that ibex are influenced by the species using the slightly smaller cells located on the upper slopes (horses and goat/sheep) and, thereby, suggests that variable cell size did not influence the observed patterns.

DISCUSSION

Competition between ibex and livestock

The results on guild structure suggest that ibex, free-ranging horses and goat/sheep utilise the same habitat properties and do not differentiate in their diets. Such differentiation is necessary for facilitating co-existence (Schoener, 1974; Harris & Miller, 1995; Bagchi *et al.*, 2003) and, in its absence, high levels of resource-use similarity could imply competition between species (Sale, 1974; Voeten & Prins, 1999). Given that livestock in the study area are maintained at high densities through supplementary winter-feeding (Mishra *et al.*, 2001) they can also out-compete ibex. This argument was supported by the analysis of the spatial distribution of animals, where ibex showed a significant negative association with goat/sheep. The alternative possibility of ibex excluding goat/sheep is unreasonable since they are greatly outnumbered (there being *c.* 184 ibex in the area: C. Mishra, unpublished results). However, the tendency of ibex and free-ranging horses to co-occur was not in line with our predictions. One reason might be a facilitative interaction between these two species, but our data are unable to confirm this. Both theoretical (Van de Koppel & Prins, 1998) and empirical evidence (Vesey-Fitzgerald, 1960; Bell, 1971; McNaughton, 1976; Gordon, 1998) suggest that facilitation is an important form of interaction in high productivity systems, while competition is the dominant interaction amongst herbivores of relatively low productivity systems such as the Trans-Himalaya (Mishra, 2001). Further investigations might provide useful insights.

Whether or not livestock exclude ibex from an area should be determined by two factors – the amount of forage removed by livestock and the level of disturbance caused by their presence. By simple calculations from the data in Table 1, a herd of 500–800 goat/sheep is estimated to remove *c.* 233 kg of forage (mean dry weight) from a pasture in a day. Since most pastures do not exceed 10 ha in size, such rates of forage removal are high considering that the above-ground standing biomass of these pastures is among the lowest in the world (mean graminoid biomass, including grasses and sedges, has been estimated at 170 kg/ha in another area of Spiti: Mishra, 2001). The high numbers of goats and sheep grazing together and removing substantial forage biomass, together with the fact that they are always accompanied by shepherds and dogs, render the pastures inaccessible for ibex. However, free-ranging horses are not accompanied by people, they usually graze in smaller numbers (*c.* 10–40) and remove a relatively lower biomass of forage (*c.* 130 kg/day, mean dry weight). This perhaps explains why horses (unlike goat/sheep), do not exclude ibex spatially from pastures but rather 'share' the remaining suitable habitat with them.

Conservation issues in a social context

Our study demonstrates that migratory goat/sheep impose resource-limitation on ibex and such multiple-use is not compatible with ibex conservation in Pin Valley. Johnsingh *et al.* (1999) have expressed similar concerns in the context of possible threats of disease transmission and pasture degradation caused by large migratory herds. Thus, addressing the issue of migratory grazing must become an urgent concern of conservation management in Pin Valley. Resident livestock, however, currently do not impose serious resource limitations on ibex since most species show habitat separation, while horses are relatively few and are declining in number. But, it needs to be kept in mind that agro-pastoral practices in the region are constantly changing (Mishra, 2000, 2001) and future alterations in herding practices (causing a shift in habitat use by livestock) could become important conservation concerns since most livestock have a relatively high diet similarity with ibex and remove large amounts of forage from the pastures.

This form of human-dependency on fast-depleting natural resources has made it necessary for ecology to be integrated with an understanding of the social dynamics that influence the status of the resources (Reynolds & Mace, 1999; Bradshaw & Bekoff, 2000). Mangel *et al.* (1996) and Folke (1996) emphasised the need for a trans-disciplinary conservation approach where human and ecological systems are seen in unison, with feedback across scales in time and space. Given the importance of livestock in the local economy of Pin Valley and the dynamism in land use and herding practices, there is a need for close monitoring of the livestock populations and herding practices and for social feedback to be constantly incorporated into conservation planning.

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