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Diet of Punjab urial (*Ovis vignei punjabiensis*) in the Salt Range, Pakistan, and potential competition with domestic sheep and goats

Régime alimentaire de l'urial du Penjab (*Ovis vignei punjabiensis*) dans le Salt Range (Pakistan): compétition interspécifique potentielle avec les moutons et les chèvres domestiques

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Abstract

Food habits of Punjab urial, domestic sheep and goats in the Salt Range, northern Punjab, Pakistan, were investigated for 2 years to determine the annual diet composition of urial and to assess the potential for competition with livestock. Seasonal trends in utilization of major forage groups were similar between years. Graminoids were the dominant forage in the urial diet, averaging 67%. *Cynodon dactylon*, *Digitaria* spp. and *Eleusine compressa* were the dominant graminoids in its diet. Punjab urial and domestic sheep had very similar diets, dominated by graminoids. Of 23 genera identified in the annual diets of urial and domestic sheep, 74% were used by both species. For urial and domestic sheep the diet overlap index was $\geq$0.80 for one species of browse, two forbs and three graminoids. Domestic goats, in contrast, showed a marked preference for browse. For urial and domestic goat, the overlap index was $\geq$0.80 for three browse species, one forb and no graminoids. Browse was $<$20% in the urial diet during spring and summer, but increased in late winter. All species increased browse consumption in winter. Our results suggest a high potential for competition between urial and domestic sheep. Urial conservation may benefit from a reduction in the number of domestic livestock within its range.

Keywords: diet overlap; domestic goat; domestic sheep; Punjab urial; Salt Range.

Résumé

Pendant 2 ans, nous avons étudié le régime alimentaire de l'urial du Penjab, des moutons et des chèvres domestiques dans le Salt Range pour évaluer la compétition potentielle avec les ongulés domestiques. L'utilisation saisonnière des principaux groupes de végétaux a été identique pour les 2 années, avec une prédominance des graminées (67%) dans le régime de l'urial, notamment de *Cynodon dactylon*, *Digitaria* spp. et *Eleusine compressa*. Le régime de l'urial s'est avéré très semblable à celui des moutons, avec 74% des 23 genres consommés par les deux espèces au cours de l'année. Pour l'urial et les moutons, un indice de recouvrement du régime supérieur à 0,80 a été calculé pour six espèces végétales, dont trois graminées. Les chèvres ont montré une nette préférence pour les ligneux. Un indice de recouvrement du régime avec celui de l'urial supérieur à 0,80 a été calculé pour quatre espèces végétales, dont trois ligneuses. Les trois ongulés ont consommé plus de ligneux en hiver. Nos résultats suggèrent une potentielle compétition entre l'urial et les moutons. Une diminution du nombre des ongulés domestiques sur l'aire occupée par l'urial serait bénéfique à la conservation de cette espèce.

Mots cles: chèvres; moutons; régime alimentaire; Salt Range; urial du Penjab.

Introduction

Punjab urial (*Ovis vignei punjabiensis*, hereafter urial) is a wild sheep distributed between the Jhelum and Indus rivers in Pakistan below an altitude of 1500 m (Schaller and Mirza 1974). It is listed as endangered on the 2003 International Union for Conservation of Nature Red List. Punjab urial are listed in the Convention on International Trade in Endangered Species, Appendix II. Trophy hunting is permitted but subject to strict regulation. The subspecies is protected under the Punjab Wildlife Protection and Conservation Act of 1974.

The issue of competition between livestock and wild herbivores is contentious and a concern for both wildlife biologists and livestock operators (Vavra and Sheehy 1996, Mishra et al. 2004). An understanding of the diet of a species is of fundamental importance for its management (Martinez 2001). Knowledge of food habits and

forage preferences of wild ungulates is also necessary to understand their habitat requirements (Johnson and Smith 1980). Mountain sheep are primarily classified as grazers (Geist 1971, Schaller 1977, Krausman et al. 1999, Nichols and Bunnell 1999). Bartolome et al. (1998) suggested that domestic sheep favor grazing short herbaceous vegetation while goats prefer to browse woody vegetation. Howe et al. (1988), Bullock (1985) and Bryant et al. (1979) also reported that sheep select herbaceous species while goats select mainly woody species. Martinez (2002a) suggested that European mouflon (*Ovis gmelinii*) prefer herbaceous plants, mostly grass, compared to Spanish ibex (*Capra pyrenaica*), which consumes more woody vegetation. Therefore, we expected that urial and domestic sheep would select similar diets consisting principally of graminoids, while goats would select diets composed largely of shrubs.

The diet of North American mountain sheep has received considerable attention (Hansen 1971, Frisina 1974, Pitt and Wikeem 1978, Johnson and Smith 1980), but less information is available for Asian wild sheep. Mishra et al. (2004) studied feeding habits and diet overlap between livestock and bharal (*Pseudois nayaur*) in the Indian Trans-Himalaya. Feeding habits of urial were described by Aleem (1977) using visual observations. Preference for plant species was studied by Schaller (1977) in the field, and Mirza et al. (1980) in captivity. These food habit studies, however, were limited in scope and sample size, as they only dealt with urial during a single season. The seasonal diet overlap between urial and sympatric livestock has not been examined. Therefore, we studied seasonal food habits and dietary overlap of sympatric urial, domestic sheep and goats in the Salt Range to evaluate the potential for interspecific competition.

Methods

We studied urial in two areas of the Salt Range, Pakistan. The community-managed Kalabagh Game Reserve (KGR) in the western end of the Salt Range (32°52′ N, 71°39′ E) extends over approximately 137 km^2. The state-managed eastern and central section of the Salt Range (Jhelum, Chakwal and Khushab, 32°41′ N, 73°23′ E) covers approximately 3898 km^2 (Awan et al. 2004). The area has a dry sub-tropical semi-evergreen scrub forest (Roberts 1991). Average rainfall in 1961–1990 was 1239 mm in eastern and central Salt Range and 452 mm in KGR, peaking mainly in July and August. The landscape is mountainous with an average elevation of 1000 m.

Awan et al. (in press), using TWINSPAN (Hill 1979) classification, reported 10 plant communities and 131 plant species for the study area. The important plant species are *Acacia modesta*, *Olea ferruginea* and *Zizyphus* spp. Shrubs are sparse, mostly scattered *Zizyphus nummularia* and *Maytenus royleanus*, except in some ravines and on the high ridges, where *Dodonaea viscosa* is prominent. The predominant ground cover consists of grasses, importantly *Cymbopogon jwarancusa*, *Eleusine compressa*, *Heteropogon contortus*, *Aristida adscensionis*, *Cynodon dactylon* and *Saccharum* spp. KGR supports approximately 500 urial and protection against poachers has been vigorously enforced for the last 70 years by the Reserve's private owners, who employ more than 30 game guards (Awan et al. 2004). Livestock grazing within the KGR is strictly prohibited in a core area of approximately 20 km^2 with the greatest urial density, and only a few cattle and sheep are allowed in other parts of the reserve where urial occur. Human access is limited to a few unpaved roads at low elevations, where urial are rarely observed. Cutting of wood or grass is prohibited in the core urial habitat. On the contrary, in eastern and central sections of the Salt Range, law enforcement is lax, lamb captures are common and adult urial are illegally hunted. The area is also heavily grazed by cattle, domestic sheep and goats. The estimated density of livestock in the Salt Range was 119 animals/km^2, including 65 domestic goats, 15 domestic sheep and 39 cattle (Government of Pakistan 2001). Awan et al. (2004) estimated 360 urial in the Salt Range outside KGR, compared with an estimate of more than 58,470 domestic sheep, a ratio of 1:162.

People (150/km^2) commonly collect fuel wood and cut grass (Awan et al. in press). The livestock population in the Salt Range area increased 1.4-fold between 1972 and 2000, with a two-fold increase in goat population and 1.4-fold increase in cattle population, while the domestic sheep population decreased 0.7-fold (Government of Pakistan 2001). Comparatively few domestic sheep (0.23 vs. 1.07 million goats) are pastured in the Salt Range.

Punjab urial have a patchy distribution. Annual distribution patterns are similar, with some seasonal shifts in habitat use in KGR. In the other parts of the Salt Range, herds remain in one general location year-round owing to high human and livestock densities. Urial inhabit areas with rugged topography where the steep slopes are associated with escarpments, knife edges or ridges of red marl (with low vegetation cover), against which their foxy red coats are hardly visible, except at close quarters.

Diet selection by urial

Direct observations of plants eaten in the KGR were made using five (3 females and 2 males) human-habituated urial in the core area of the reserve, where domestic livestock are not allowed, following procedures recommended by Frisina (1974), Pitt and Wikeem (1978) and Johnson and Smith (1980). The group fed almost exclusively on natural food. All observations of feeding were made from a distance of $<$20 m. Animals could be approached up to $\pm$5 m, but could not be handled.

Data were recorded as the number of bites (interactions) per plant species. Each bite was considered to represent one instance of use for a plant species (Frisina 1974). At all feeding sites (defined as locations where urial were actually observed feeding) at least 100 bites were recorded (Johnson and Smith 1980).

Feeding observations were made for 5 consecutive days during each season from fall 2000 to summer 2002. Foraging observations were supplemented with fecal analysis of wild urial from the entire Salt Range.

Microhistological analysis

Fecal pellets of urial and domestic sheep and goat were collected in the middle of spring, summer, autumn and winter 2000–2001 (Pereira et al. 2003). The diets of urial and domestic sheep and goat were determined for the entire year through fecal analysis of plant epidermal cells found in feces (Hansen 1971, Martinez 2002b), identified by comparison with reference plants collected in the study area (Johnson and Smith 1980).

Fresh fecal pellets were sprinkled with table salt to prevent decomposition. Each sample consisted of two pellets per individual. Ten samples were collected from urial and five from domestic sheep and goats in each season, producing a composite sample of 40 fecal pellets for urial and 20 for sheep and goats for each season. Feces were oven-dried at 50°C for 24 h. Each sample was crushed and homogenized separately, treated with nitric acid and washed in boiling water following Martinez (2002b). Fecal pellet contents were washed over a 0.5-mm sieve and separated into fragments (Jiang et al. 2002).

For each composite sample, a sub-sample was used for microhistological analysis to estimate the relative density of forage fragments, which provides a good approximation of the relative amount of each plant eaten (Johnson and Smith 1980). A template was used to regulate the amount of material deposited on each sample slide. Five microscopic slides for each of the three ungulate species were prepared for each seasonal sample and 20 slide fields read per slide, for a total of 100 fields per sample per season. A microscope with a 100× objective lens was used to identify plant species or genera based on epidermal characteristics (Holechek and Gross 1982). At each location (field) in the slide, plant species present were recorded. The percentage frequency of each identified plant species was converted to density of particles per microscope field (Dearden et al. 1975). The relative density of fragments was then obtained from the frequency figures as:

$$\text{Density} = \ln [1-(F/100)],$$

where ln is the natural logarithm and F is the frequency (%), and

$$\text{Relative density} = \frac{\text{Density of fragments per species}}{\text{Sum of the denisty of fragments for all species}} \times 100.$$

Plant fragments were grouped into functional categories: graminoids (grasses and sedges), forbs (herbaceous annuals), or browse (woody shrubs and trees) (Jiang et al. 2002, Brown and Yde 1988).

Diet overlap

The degree of diet overlap between urial and domestic sheep and goats was assessed following Bartolome et al. (1998) as: overlap of a plant species i in the diets of urial D_{iu}, and domestic sheep D_{is}. The resulting index, L_i, ranged from 0 to 1:

$$L_i = 1-[D_{iu}-D_{is}]/[D_{iu}+D_{is}].$$

The overlap between diets of urial and domestic sheep, L was:

$$L = 1-\sum_i[D_{iu}-D_{is}]/\sum_i[D_{iu}+D_{is}]$$

Overlap between urial D_{iu} and goat D_{ig} was calculated similarly.

A reference collection was made from the foraging areas in all seasons. Plants were blended for 2 min at high speed with hot water (Hansen 1971). The contents of the blender were poured into a 0.1-mm-mesh screen and washed. Reference slides were made directly from this material, following the procedure described for fecal samples. Each plant species was identified in fecal samples when a fragment was observed that matched a reference slide. The dietary components in the microhistological analysis at the generic level were identified according to Cooperrider et al. (1980). However, in most cases only one species of each of the major genera in the diet was consumed. Seasonal variations in diets of the three species were compared with a χ^2 test following García-González and Cuartas (1992).

Results

Urial foraged in virtually all plant communities, although seasonal use varied. Forage availability appeared to be a primary determinant of community selection, and areas with dense tree cover were clearly least utilized. Of 131 species available, a maximum of 52 species occurred in the diet of urial, domestic sheep and goats (Table 1). A total of 26 plant genera (13 grasses, 7 forbs and 6 shrub/trees) were identified in the diets of wild urial, domestic sheep and goats (Table 2). Goats ate more browse than either urial or domestic sheep in all seasons ($\chi^2=52.74$, $p<0.05$). Urial and domestic sheep maintained a high proportion of grasses in their diet during all seasons, despite low availability.

Urial diet: direct observation

A total of 44 plant species were eaten by urial. Annual use of the three major forage groups did not vary between years, as the diet consisted of 65% and 69% graminoids, 17% and 19% forbs and 16% browse in the 2 years. Data for the 2 years were therefore pooled for further analysis.

Graminoids were the dominant forage in all four seasons, averaging 67% of the diet (Table 3). *Cynodon dactylon*, *Digitaria* spp. and *Eleusine compressa* were the dominant graminoids in the diet. Browse comprised <20% of the diet during spring and summer, but increased in late winter.

Forb consumption increased gradually in spring, peaked in summer and declined in fall (Table 3), in accordance with the annual growth and development of herbaceous forage. Browse intake varied seasonally, as determined by direct feeding observations ($\chi^2=15.28$, $p<0.05$).

Table 1 Plant species occurring in seasonal diets of Punjab urial, domestic sheep and goats for both visual observations and fecal samples from fall 2000 to summer 2002.

Grasses	Forbs	Shrubs and trees
Aristida adscensionis	*Aerva javanica**	*Acacia hydaspica**
Cenchrus ciliaris	*Asparagus adscendens*	*Acacia modesta*
Cenchrus pennisetiformis	*Boerhaavia procumbens**	*Capparis decidua*
Heteropogon contortus	*Chenopodium murale**	*Grewia tenax*
Chloris digitata	*Crotolaria* sp.	*Grewia villosa*
Chrysopogon serrulatus	*Cyperus rotundus*	*Olea ferruginea*
Cymbopogon jwarancusa	*Indigofera linifolia*	*Prosopis cineraria**
Cynodon dactylon	*Medicago laciniata*	*Salvadora oleoides*
Dactyloctenium aegyptium	*Medicago polymorpha*	*Solanum incanum*
Desmostachya bipinnata	*Polygala* sp.	*Withania coagulans*
Dicanthium annulatum	*Portulaca* sp.*	*Ziziphus mauritiana*
Dicanthium foveolatum	*Rhynchosia minima*	*Ziziphus nummularia*
Digitaria bicornis	*Trianthema portulacastrum*	
Digitaria ciliaris	*Tribulus terrestris*	
Eleusine compressa	*Trichodesma indica*	
Eragrostis poaeoides		
Hordeum vulgare		
*Imperata cylindrica**		
Ochthochloa compressa		
Panicum sp.		
Paspalidium flavidum		
Poa annua		
*Saccharum munja**		
Saccharum spontaneum		
Setaria glauca		

*Not observed to be eaten by urial.

Urial diet: fecal analysis

A total of 21 plant genera were identified in urial fecal samples. These included 63% grasses, 18% forbs and 19% browse. Grasses dominated the urial diet. Ten grass genera with >2% relative density occurred in the diet of urial throughout the year, while six forb and five browse genera were identified in pellet samples during different seasons (Table 2). Grass, grass-like plants and forb intake did not differ seasonally, while browse intake differed significantly (χ^2=16.14, $p<0.05$). Urial ate the greatest variety of species in spring and least in winter. The dominant grass genera in the diet of urial were *Cynodon*, *Paspalidium*, *Digitaria* and *Eleusine*. Dominant forbs included *Medicago*, *Polygala* and *Tribulus*, while dominant browse included *Acacia*, *Grewia*, *Olea* and *Ziziphus*. *Olea ferruginea* seeds found in fecal pellets of urial in winter indicated that fallen fruits were also consumed. Urial apparently fed more on forbs than domestic sheep and goats did.

Potential dietary overlap

Domestic sheep consumed 16 plant genera (Table 2), including 72% grasses, 13% forbs and 15% browse. A higher proportion of grasses and forbs were found in the diet of sheep during spring than in summer. The relative densities of browse in the sheep diet were lower during spring and summer and higher in winter.

A total of 16 plant genera were identified in the goat diet, which comprised 69% browse, 22% grasses and 9% forbs (Table 2). In fall, the goat diet contained over 78% browse, including *Acacia*, *Ziziphus*, *Olea*, *Grewia*, *Maytenus* and *Solanum*. Goats were mostly browsers in all seasons.

Dietary overlap was greater between domestic sheep and urial than between domestic goats and urial. Of 23 genera identified in the annual diets of urial and domestic sheep, 74% were used in common. For urial and domestic sheep, the overlap index was $\geq$0.80 for one species of browse, two forbs and three graminoids. For urial and domestic goat, the overlap index was $\geq$0.80 for three browse species, one forb and no graminoids (Figure 1). Diet overlap between urial and livestock at the genera level was >0.70 and >0.60 for sheep and goat, respectively.

All three ungulates may compete for browse in late fall and early winter. In late winter, when grass availability was lowest, domestic sheep consumed less browse and did not shift primarily from dry grass, which still contributed 69% of their diet (Table 3). Urial, however, reduced grass content to <60% and ate 30% browse. In winter, goats continued to select higher levels of browse than other species.

Discussion

The diets of urial and domestic sheep were dominated by grasses, confirming that these ungulates are primarily grazers. The dominance of tree/shrub species in the diet of goats confirms that they prefer browse. The predominance of grasses and grass-like plants in the diet of urial in the Salt Range is consistent with that reported for other mountain sheep (Shackleton et al. 1999, Brown and Yde 1988). Tarango et al. (2002), however, reported lower consumption of grasses (4.5%), and greater use of succulents (17.8%), browse (45.7%), and forbs (32.0%) by desert bighorn sheep in an area with low graminoid avail-

Table 2 Relative density (mean±SD) of major (>2%) plant genera found in seasonal diets determined by microhistological analysis of fecal samples in the Salt Range, Pakistan 2000–2001.

Plant genus	Relative density (%)											
	Spring			Summer			Fall			Winter		
	U	DS	G	U	DS	G	U	DS	G	U	DS	G
Grasses	63	76	23	71	70	26	60	71	16	58	69	19
Aristida	–	2±1	–	–	2±1	–	–	–	–	–	2±1	–
Cenchrus	3±1	–	–	–	–	–	4±2	–	2±1	–	–	–
Chrysopogon	2±1	–	–	–	–	–	–	–	–	–	–	–
Cymbopogon	–	3±1	–	–	3±1	–	2±1	7±2	3±1	3±1	6±1	4±1
Cynodon	17±4	14±3	3±1	19±4	13±3	–	14±4	9±3	–	20±3	11±2	–
Dactyloctenium	5±3	–	–	2±1		–	–	–	–	6±2	–	–
Digitaria	9±3	7±2	–	8±4	5±3	3±1	6±2	–	2±1	–	–	–
Dichanthium	2±1	–	–	3±1		–	–	–	–	2±1	–	–
Eleusine	10±2	7±1	–	5±2	–	–	4±1	3±1	–	6±2	4±1	–
Hordeum	7±1	3±1	4±1	–	–	–	–	–	–	–	–	–
Paspalidium	–	4±1	5±2	18±2	11±4	5±2	8±1	2±1	–	–	–	–
Setaria	2±1	–	–	–	–	4±1	3±1	6±3	–	–	5±1	2±1
Saccharum	–	3±1	–	–	2±0	–	–	2±1	3±1	–	3±1	4±1
Forbs	24	14	10	21	18	12	16	9	6	12	10	5
Asparagus	3±1	2±1	–	2±1	–	–	–	–	2±1	–	–	–
Chenopodium	–	–	2±1	–	–	2±1	–	–	–	–	–	2±1
Crotolaria	–	–	–	3±1	–	–	2±1	–	–	2±1	–	–
Indigofera	4±1	–	–	–	2±1	–	–	2±1	–	–	–	–
Medicago	6±2	5±2	3±1	4±3	4±1	–	4±2	–	–	2±1	–	–
Polygala	4±2	–	–	–	–	–	–	–	–	–	–	–
Tribulus	–	2±1	–	7±2	–	4±2	2±1	–	2±1	–	2±1	–
Shrubs and trees	13	10	67	8	12	62	30	20	78	24	21	76
Acacia	5±1	4±1	–	–	2±1	17±3	9±3	2±1	12±3	12±2	–	15±3
Grewia	3±1	–	–	2±1	–	4±2	–	–	2±1	–	–	4±2
Maytenus	–	–	6±3	–	–	–		–	–		–	9±2
Olea	–	–	–	–	–	4±1	5±2	–	8±1	6±2	–	8±1
Solanum	–	–	11±2	2±1	–	–	–	–	3±1	–	–	–
Ziziphus	3±1	2±1	18±3	2±1	2±1	13±4	2±1	–	9±4	3±1	2±1	11±4

U, urial; DS, domestic sheep; G, goat.

ability, indicating that sheep are not obligatory grazers. Different sheep have different foraging habits (Pfister et al. 1988), even though their nutritional requirements and digestive systems are very similar (Bartolome et al. 1998).

Seasonal variations in the diet of the three ungulates are mainly explained by seasonal changes in vegetation. Similar findings were reported by García-González and Cuartas (1992). Ungulates eat more graminoids and forbs during spring and summer, when their availability is greater (Buchanan et al. 1972, Bryant et al. 1979, Mishra et al. 2004). Gabriela et al. (1996) suggested that sheep consume more shrubs in fall and winter when grasses were less available or less nutritive. In fall and winter, the diet of urial and domestic sheep also shifts to browse and this apparently increases similarity in the diet of all three ungulates.

Urial, domestic sheep and goats generally exhibited similar seasonal trends in the percentage of grass in their diet. Competition for grasses appeared to be potentially greatest between urial and domestic sheep.

In our study, the importance of individual taxa in the annual diet and seasonal shifts in diet composition were related to both palatability and availability factors. Schaller (1977) reported that *Cymbopogon jwarancusa* was avoided by urial. In our study, consumption of this species was not recorded in the spring and summer diet, but contributed >5% in the winter, when other annual grass species and forbs were scarce. From Table 3 it is apparent that given similar opportunities for choice, urial, domestic sheep and goats select similar species, but in different proportions. Bartolome et al. (1998) suggested that these dietary differences result from differences in foraging behavior.

Overlap

The three ungulate species showed much variation and high overlap in their use of some plant species, mainly those that dominate the diet in different seasons, such as *Acacia modesta*, *Ziziphus* spp., *Medicago* spp., *Eleusine compressa*, *Cynodon dactylon* and *Digitaria* spp. (Figure 1). Mishra et al. (2004) reported high diet overlap between livestock and bharal (*Pseudois nayaur)* in the Indian Trans-Himalaya.

The selection of similar plant species may indicate a possibility of competition, but this in itself is not evidence of competition (Squires 1982). Urial switched to browse during the dry period, but domestic sheep did not. Grasses and forbs contributed only a small amount to the diet of goats. Squires (1982) emphasized this small difference in diet selection and suggested that where dietary overlap occurs, separation could develop during critical periods of the year. Some evidence is provided in the present study, because in periods of sufficient forage

Table 3 Seasonal food habits of Punjab urial, determined from direct feeding observations, in the Salt Range, Pakistan from fall 2000 to summer 2002.

	Percentage of seasonal diet (%)				
	Spring	Summer	Fall	Winter	Mean
Total bites (n)	6700	7480	6800	7200	
Grasses					
Aristida sp.	–	1.4	–	1	
Cenchrus sp.	2	1.5	4	1	
Cymbopogon jwarancusa	–	–	2	3	
Cynodon dactylon	22	15.6	19	21	
Dactyloctenium sp.	4	2	–	5	
Dichanthium annulatum	2	3	5	2	
Digitaria sp.	13.5	11.5	7	–	
Eleusine compressa	11	9	8	6	
Hordeum murienum	9	–	–	–	
Ochthochloa compressa	1.5	–	–	1	
Paspalidium flavidum	–	21	5	–	
Setaria glauca	–	2	4	3	
Other grasses and grass-like spp.	4	5	12	16	
Total grasses	69	72	66	59	67
Forbs					
Asparagus adscendens	1.5	1.5	1.5	1.5	
Crotolaria sp.	3	2	–	–	
Fagonia indica	–	1.5	1.5	2	
Indigofera linifolia	2	4	1.3	1.5	
Medicago sp.	4	–	1.2	–	
Phyllanthus niruri	1.5	2	–	–	
Polygala sp.	2	2	1	2	
Tribulus tristris	3	1.5	2	–	
Unknown forbs	3	7.5	7	8	
Total forbs	20	22	14	15	18
Shrubs and trees					
Acacia modesta	4.5	1.6	6.5	12.5	
Capparis decidua	1.5	1.5	1.5	1.5	
Grewia tenax	1.5	–	2.5	2	
Grewia villosa	–	1.5	–	–	
Olea ferruginea	–	–	3.5	6.5	
Salvadora oleoides	–	–	1.5	–	
Solanum incanum	1.5	–	–	–	
Solanum nigrum	–	–	1.5	–	
Withania coagulens	–	–	–	1.5	
Ziziphus mauritiana	–	–	1.5	–	
Ziziphus nummularia	2	1.4	1.5	2	
Total shrubs and trees	11	6	20	26	16

there was greater overlap in the diets of urial, domestic sheep and goats, but in the critical winter period diet separation became apparent. However, urial and domestic goat diets seemed to converge in the critical period of winter, when both consumed much browse. The year-round preference for grass by domestic sheep increased pressure on a resource that was already in low supply during winter, possibly decreasing the amount of grass available for urial.

Domestic sheep and goats appear behaviorally dominant to urial, probably because domestic sheep and goats are more numerous and displace them from preferred sites. Of 44 interactions observed between urial, domestic sheep and goats, 78% resulted in a urial moving away, 7% resulted in a slight to moderate flight reaction by livestock, while 15% were neutral. Because the density of domestic sheep is much lower in the KGR core area and on high ridges, despite dietary overlap, the potential for competition between urial and domestic sheep is low in those small refuges. Domestic sheep may compete with urial primarily for the higher-protein forbs and grasses, while goats likely compete with urial for the more stable drought-resistant browse. The potential for forage competition is higher throughout the year between urial and domestic sheep than between goats and urial. In some areas where domestic sheep numbers are high, a reduction in their number may enhance forage availability for urial.

In addition to having a high dietary overlap with urial, domestic sheep and goat are also a source of disease transmission to urial (Awan et al. 2005). The high potential for competition between urial, domestic sheep and goat suggests that the presence of these domestic animals in high number may depress the urial population. It is unlikely that the amount of available plant material is limiting for urial in the Salt Range, as suggested by Harris and Pletscher (2002) for argali sheep (*Ovis ammon*). However, as for argali, urial may have difficulty obtaining

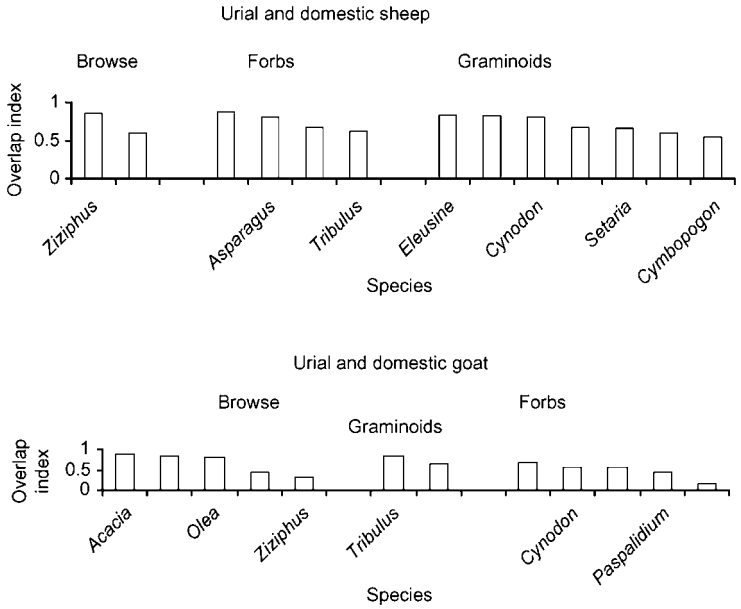

Figure 1 Plant species overlap between the diets of urial, domestic sheep and goats in the Salt Range, Pakistan.

diets with optimal mixtures of energy and protein because of the high levels of livestock grazing.

It appears that there is potential for competition between domestic sheep and urial throughout the year, and between urial and domestic goat during the critical winter period, when urial tend to include more browse in their diet, perhaps due to low availability of graminoids and forbs. Additional research is needed to determine the magnitude of competition between urial and livestock.

Recommendations

Domestic sheep and goats should be restricted to small portions of the urial habitat during the critical winter and early spring periods to reduce the potential for competition. An appropriate management system such as rotational grazing for domestic livestock should also be considered to reduce the potential for competition. It is essential that the forest department consider competition for food resources when establishing the number of grazing permits for livestock to the local community.

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