Management and Conservation Note

Dietary Overlap Between Huemul and Livestock in Los Alerces National Park, Argentina

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ABSTRACT We evaluated the potential for interspecific competition for forage between huemul (*Hippocamelus bisulcus*) and livestock in Los Alerces National Park, Argentina. We studied winter diets based on microhistological analysis of fecal samples. Huemul selected herbs and shrubs, sheep showed preference for herbs and grasses, and cattle selected grasses. As predicted for small-bodied species, huemul had a narrower dietary niche than did larger bodied cattle. Competition for forage would be more likely between huemul and sheep than between huemul and cattle. Our results might be helpful to managers in areas where domestic and wild ungulates live in sympatry in order to reduce competition, especially in wintering areas where food is scarce. (JOURNAL OF WILDLIFE MANAGEMENT 73(3):368–373; 2009)

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KEY WORDS competition, diet overlap, forage selection, *Hippocamelus bisulcus*, livestock, Patagonia.

The huemul (*Hippocamelus bisulcus*) is an endemic deer of the Andean–Patagonian forests and forest–shrub ecotones of Argentina and Chile (Cabrera and Yepes 1960). Huemul range extends from 34°S to 54°S (Díaz 2000), but most current populations have been reported to be fragmented in small and scattered clusters (Vila et al. 2006). In fact, huemul is one of the most endangered neotropical deer species (International Union for Conservation of Nature 2007). Although competition for food between livestock and huemul has long been suggested to be an important conservation issue, little evidence has been offered to support this hypothesis (Smith-Flueck 2000). Following morphophysiological feeding habits proposed by Hofmann (1989), cattle and sheep have been classified as grazers, whereas huemul has been assumed to be a concentrate selector (Smith-Flueck 2003, Galende et al. 2005). Therefore, we would not expect to find high diet overlap between huemul and livestock. In contrast to Hofmann (1989), other authors have argued that body mass plays a major role in shaping foraging strategies (Bell 1970, Jarman 1974, Demment and Van Soest 1985, Gordon and Illius 1988). An adult huemul weighs approximately 60–90 kg, not much heavier than sheep (40–60 kg), whereas cattle body mass is about 550 kg. Within this broader context we would not expect huemul–cattle competition for forage, but body size could predispose a higher food niche overlap between sheep and huemul. Furthermore, seasonal changes in forage availability often lead to increased habitat and dietary overlap when resources are limited (Jenkins and Wright 1987, Gordon and Illius 1989, Putman 1996, Mysterud 2000). Although winter diets are expected to be largely constrained by food availability in temperate habitats, foraging ecology of sympatric domestic and wild ungulates has never been studied in Patagonian forests during this season. Thus, our objective was to assess potential for interspecific competition for forage by studying diets of huemul, cattle, and sheep during winter in Los Alerces National Park, Argentina.

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STUDY AREA

We conducted our study in the westerly and southerly facing slopes (4,650 ha) of Cerro Riscoso, Los Alerces National Park (259,000 ha; Fig. 1). Elevation ranged from 500 m to 2,500 m and mean annual temperature was 8° C. Mean annual precipitation decreased abruptly from west to east, from >3,000 mm to 800 mm (Administración de Parques Nacionales 1997). Precipitation occurred mainly from April to October, with snow falling in winter (Jun to Sep).

Los Alerces National Park has been classified in 2 phytogeographical types: Sub-Antarctic and High Andean provinces (Cabrera 1971). Sub-Antarctic forests were dominated by pure or mixed stands of the conifers ciprés de la cordillera and alerce (*Austrocedrus chilensis* and *Fitzroya cupressoides*), the evergreen tree coihue (*Nothofagus dombeyi*), and the deciduous species lenga and ñire (*Nothofagus pumilio* and *Nothofagus antarctica*). The High Andean Province included a mosaic of grasses, shrubs, and forbs of limited cover.

Los Alerces National Park included 2 categories of management: National Park and National Reserve. The National Reserve was conceived as a buffer zone where regulated uses were permitted (e.g., livestock-raising and tourism; Martín and Chehébar 2001). Five rural settlements were found in Cerro Riscoso with traditional activities based on livestock-raising for subsistence (Martínez 2006). Settlers colonized the area before the National Park was created in 1937. Stocking rates have been declining since 1940 and settlers were relying on tourism as an alternative livelihood means (Martín and Chehébar 2001, Martínez 2006). Cerro Riscoso area was known for its low livestock productivity. The most productive understory of lowland *Nothofagus* forests, grasslands mainly composed by bamboo

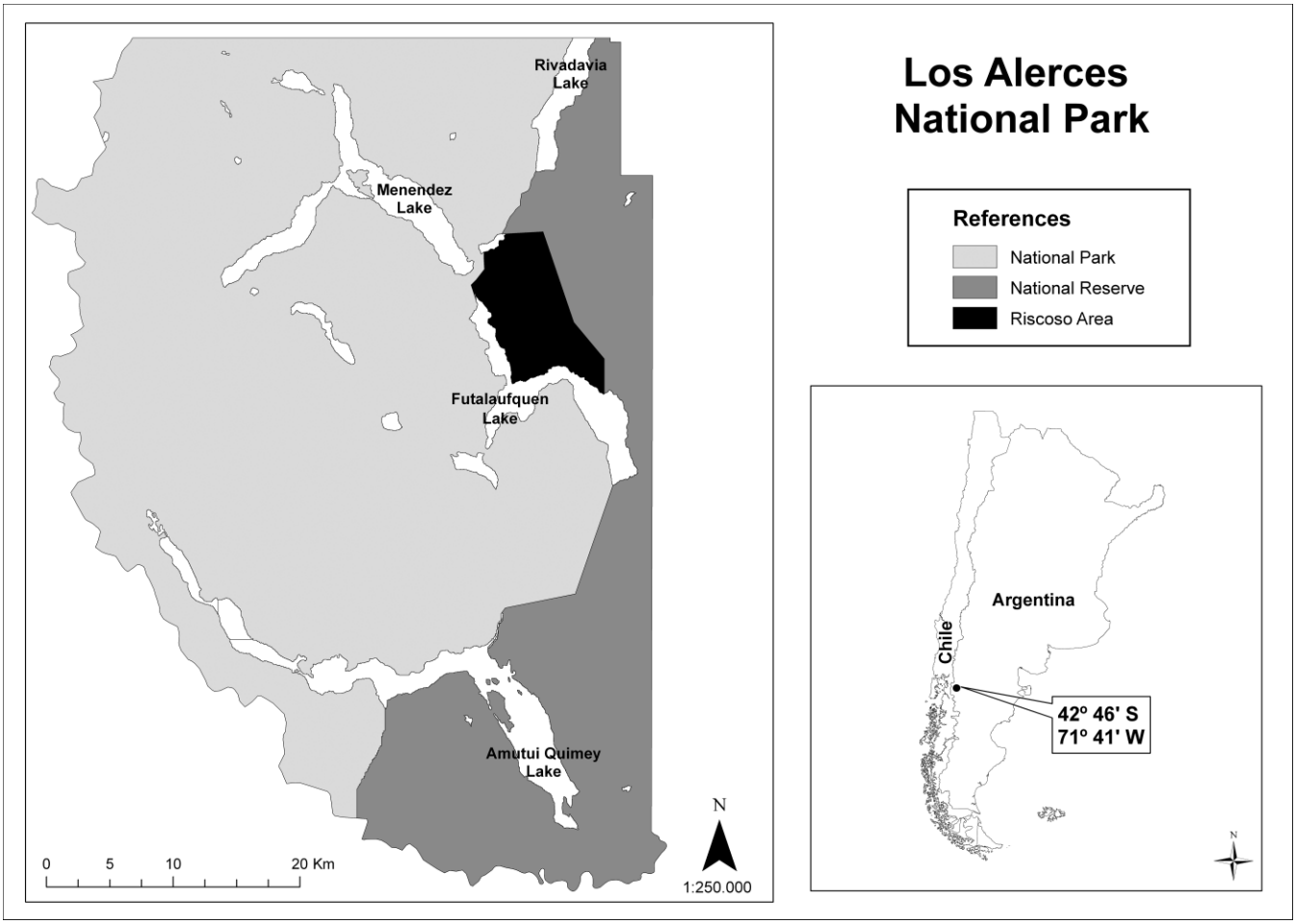

Figure 1. Location of the study area in Los Alerces National Park, Patagonia, Argentina, June–September 2003, where we studied winter diets of huemul, cattle, and sheep.

colihue (*Chusquea culeou*), had a productivity of 1,350 kg dry matter/ha, which could support 1 sheep/0.55 ha or 1 cow/3.85 ha (Martínez 2006). However, cattle and sheep densities for the complete study area were lower, 2.3 and 2.4 animals/km^2, respectively, during the study period (Martínez 2006). The grazing system was extensive and continuous. Estimated huemul density was low (0.3 deer/km^2).

METHODS

We distributed 8 transects at random on the slopes of Cerro Riscoso. Transects ran perpendicular to contour lines, starting in the valley bottom (500 m above sea level [a.s.l.]) and surpassing the tree line (1,400 m a.s.l.). We collected fecal samples of huemul, cattle, and sheep on these transects during winter 2003.

We determined the botanical composition of the diets by microhistological analysis of plant epidermal and non-epidermal fragments in feces (Sparks and Malechek 1968, Sepúlveda et al. 2004). We identified these fragments at the level of genera or species when possible. We oven-dried samples at 60° C for 48 hours, ground them to <1 mm in a Wiley-type mill, and depigmented and mounted them in glycerine-jelly (Latour and Pelliza Sbriller 1981). We mounted samples on 5 microscope slides and examined 20 fields on each slide using 100× magnification. We obtained frequencies of each species following Holechek and Gross (1982). We grouped species into 4 types according to life forms: herbs, shrubs, trees, and grasses (Poaceae, Juncaceae, and Cyperaceae).

We estimated food availability in terms of relative cover of each species using the line-intercept method, along 137 secondary transects located on 4 of the 8 main transects. Whenever possible, we randomly established 5 of these secondary transects on each contour line at 50-m elevation intervals over the principal transects. We projected plant canopies vertically on a 10-m-long tape and the measured length of the line segment for each species. We recorded projections at 2 strata, 0 m to 0.20 m and 0.20 m to 1.00 m above the ground, and assumed they reflected the feeding height of huemul, sheep, and cattle. We calculated percentage of vegetation available by including all secondary transects and both surveyed strata. Although techniques to estimate biomass are the most accurate for determining availability of forage, they are also the most time- and resource-consuming. Further, our plant community had a large number of species, plant life forms, and height strata. Thus, a great advantage of cover as a quantitative measure

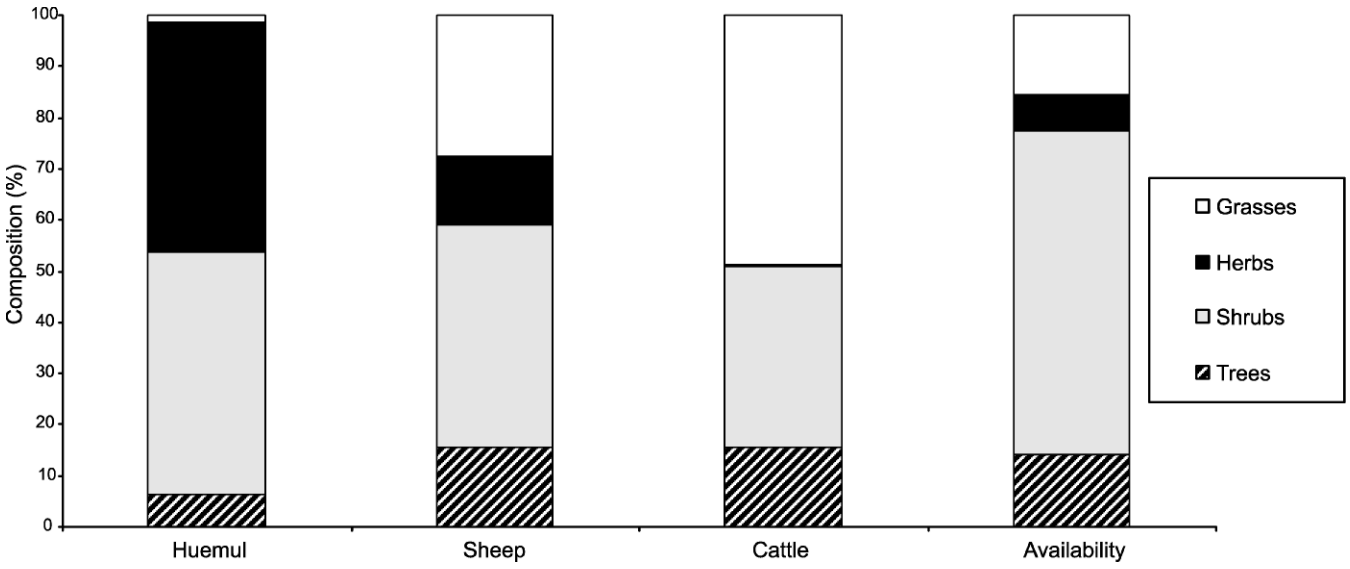

Figure 2. Composition (%) of grasses, herbs, shrubs, and trees available and consumed by huemul, sheep, and cattle in winter at Los Alerces National Park, Argentina, June–September 2003.

was that we evaluated nearly all plant life forms by the same parameter and, therefore, in comparable terms as was suggested by Mueller-Dombois and Ellenberg (1974).

We measured the niche breadth using Levins' normalized index (Krebs 1989). We used Ivlev's electivity index (Krebs 1989) to evaluate forage selection. We analyzed diet overlap between species using the simplified Morisita index (Krebs 1989). We also evaluated dietary separation among the 3 species using correspondence analysis. We analyzed differences in the proportion of plant categories or individual key species across herbivore species using a Kruskal–Wallis *H*-test. We defined key plant species as those representing $\geq$10.0% of the diet in $\geq$1 sample.

RESULTS

We identified 77 available plant species. Shrub cover was higher than that of other life forms (63.3% of total cover; Fig. 2). Main shrub species available were *Berberis* spp. (10.1%) and codocoipu (*Myoschilos oblongum*; 9.8%), whereas mutisia (*Mutisia* spp.), *Maytenus* spp., chaura (*Gaultheria mucronata*), espino negro (*Colletia hystrix*), and chacay (*Discaria* sp.) accounted for 5.0% to 7.0% of cover each. *Nothofagus* spp. showed the highest tree cover (7.7% of total cover), mainly coihue (*N. dombeyi*). Cover of herb and grass species generally accounted for <3.0% of food availability; only pasto de mallín (*Poa pratensis*) accounted for >5%.

We recorded 33 (43.0%) of 77 plant species identified in huemul diet. Cattle fed on 19 species, whereas sheep diet was composed of 35 species. We found only 9 species eaten exclusively by huemul, whereas 5 and 13 species were eaten exclusively by cattle and sheep, respectively. We observed the lowest value of Levins' normalized index in huemul (0.23), whereas sheep showed the highest niche breadth (0.40) and that of cattle was intermediate (0.35).

Huemul diet was largely dominated by shrubs and herbs (Fig. 2). Cattle and sheep ate mainly shrubs and grasses, but sheep showed a more balanced diet composition (Fig. 2). Percentage of shrubs, herbs, and grasses was different among diets of the 3 ungulates (shrubs $H = 13.5$, $P < 0.01$; herbs $H = 15.2$, $P < 0.01$; and grasses $H = 16.7$, $P < 0.01$). In contrast, percentage of trees in diets was not different across species ($H = 4.4$, $P > 0.05$).

Huemul predominantly fed on *Muehlenbeckia chilensis*, *G. mucronata*, laura (*Schinus patagonicus*) and *Maytenus* spp., and the hemiparasitic herb barba del ángel (*Misodendrum* sp.; Table 1). These 5 species comprised 74.3% of huemul diet. Only *Berberis* spp. and *P. pratensis* showed a frequency >10.0% in the diet of sheep (Table 1). The most important forage items for cattle were *Berberis* spp. and 2 grasses, bamboo colihue (*C. culeou*) and ratonera (*Hierocloe* sp.; Table 1), accounting for 58.5% of cattle diet. Percentage of *S. patagonicus*, *G. mucronata*, *Misodendrum* sp., and *M. chilensis* in the diet of huemul was greater than in domestic species diets, whereas percentage of *Berberis* spp., *Discaria* sp., rosa mosqueta (*Rosa rubiginosa*), *C. culeou*, *Hierocloe* sp., *P. pratensis*, and coirón amargo (*Stipa speciosa*) was lesser in huemul than in livestock diets (Table 1).

Diet compositions of huemul, sheep, and cattle were not similar to relative availability of forage categories (Fig. 3). Huemul selected herbs and shrubs and avoided grasses and trees. In contrast, cattle selected grasses and avoided herbs, whereas sheep preferred herbs and grasses.

Dietary overlap between cattle and sheep diets (simplified Morisita index = 0.55) was greater compared with diet overlap between huemul and sheep (0.31). We found the lowest dietary overlap between huemul and cattle (0.11). Accordingly, we obtained a clear separation between huemul and cattle diets in the first factorial plane of the correspondence analysis, which explained 93% of variance (Fig. 4). Huemul diet was dominated by shrubs and herbs, whereas cattle fed mainly on grasses. Sheep did not show

Table 1. Mean percentage and standard error of key plant species in the winter diet of huemul ($n = 8$), sheep ($n = 5$), and cattle ($n = 7$) in Los Alerces National Park, Argentina, June–September 2003.

		Huemul		Sheep		Cattle			
Families	**Species**	$\bar{x}$	**SE**	$\bar{x}$	**SE**	$\bar{x}$	**SE**	***H*-test**	***P***
Trees									
Fagaceae	*Nothofagus* spp.	3.45	1.84	3.44	1.85	7.46	2.51	2.39	>0.05
Proteaceae	*Lomatia hirsuta*	1.53	1.04	5.75	2.80	5.58	3.34	1.93	>0.05
Shrubs									
Anacardiaceae	*Schinus patagonicus*	13.35	3.23	3.20	2.06	0.00	0.00	9.60	<0.01
Apiaceae	*Azorella* sp.	0.00	0.00	4.48	4.48	0.12	0.12	1.57	>0.05
Asteraceae	*Chilliotrichium rosmarinifolium*	0.00	0.00	0.00	0.00	2.71	1.76	3.91	>0.05
Berberidaceae	*Berberis* spp.	0.78	0.46	15.85	3.91	18.10	2.34	13.39	<0.01
Celastraceae	*Maytenus* spp.	12.75	3.36	8.09	3.62	4.46	2.88	3.46	>0.05
Ericaceae	*Gaultheria mucronata*	14.33	2.34	2.35	1.44	0.00	0.00	12.66	<0.01
Monimiaceae	*Laureliopsis philippiana*	1.77	1.33	0.00	0.00	0.00	0.00	4.99	>0.05
Polygonaceae	*Muehlenbeckia chilensis*	19.11	1.22	0.00	0.00	0.00	0.00	17.47	<0.01
Rhamnaceae	*Discaria* sp.	0.62	0.44	2.42	1.19	8.43	1.93	9.44	<0.01
Rosaceae	*Rosa rubiginosa*	2.90	2.15	5.19	2.66	0.00	0.00	7.35	<0.05
Herbs									
Misodendraceae	*Misodendrum* sp.	14.79	3.67	2.70	2.54	0.00	0.00	11.75	<0.01
Unidentified	Unidentified sp.	2.86	1.86	0.04	0.04	0.04	0.04	1.75	>0.05
Grasses									
Poaceae	*Chusquea culeou*	1.01	0.46	7.22	1.38	21.61	1.20	16.73	<0.01
	Hierocloe sp.	0.00	0.00	0.00	0.00	18.83	1.24	17.90	<0.01
	Holcus lanatus	0.35	0.17	5.07	2.11	0.00	0.00	6.05	>0.05
	Poa pratensis	0.03	0.03	10.17	1.64	0.00	0.00	16.43	<0.01
	Stipa speciosa	0.00	0.00	0.00	0.00	6.54	1.83	14.52	<0.01

any clearly predominant life form in their diet, but it was closer to cattle diet than to huemul diet.

DISCUSSION

The endangered huemul in Los Alerces National Park had a diet dominated by shrubs and herbs in winter. Similar winter diets were previously reported in Nahuel Huapi National Park (Galende et al. 2005) and in Chillán (Colomes 1978). Diet of huemul was more similar to sheep than to cattle, suggesting that competition would be more likely between huemul and sheep than huemul and cattle. Although spatial and seasonal replication limitations of our data do not provide conclusive evidence, our results offer the first data available on winter dietary overlap among sympatric huemul, cattle, and sheep, a first step towards understanding potential competition among them.

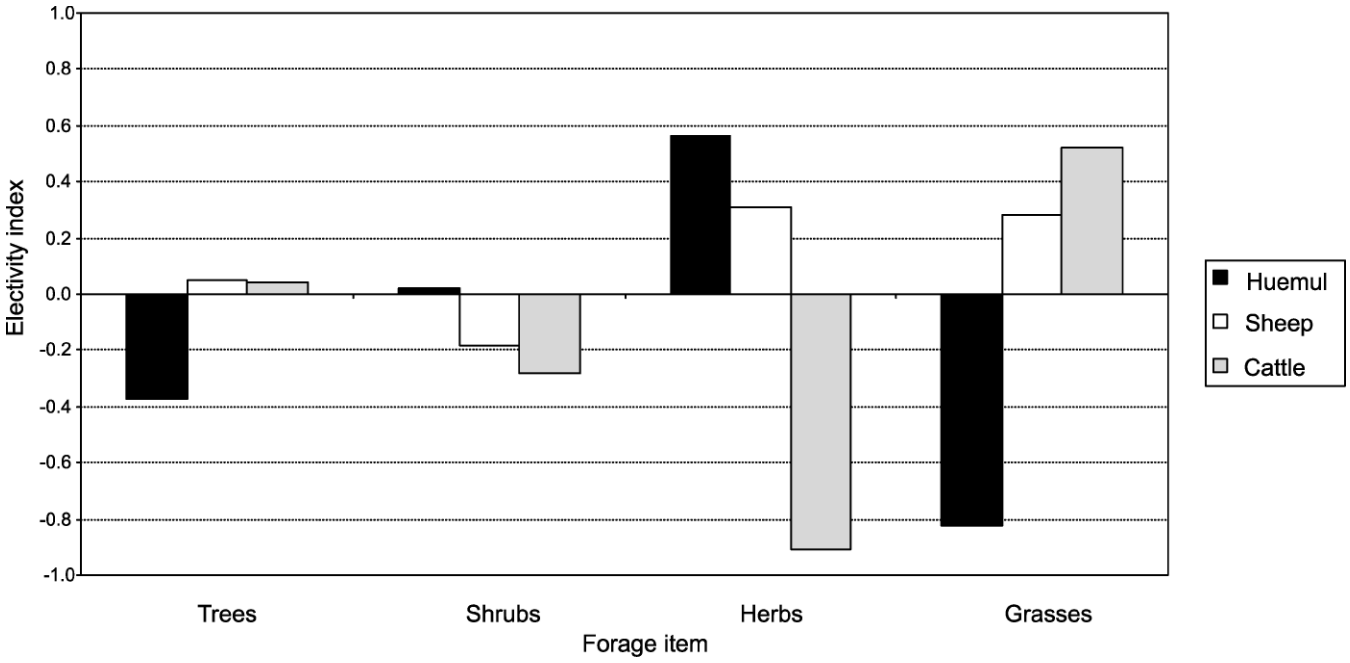

Figure 3. Ivlev's electivity indices for huemul, domestic sheep, and cattle forage selection in Los Alerces National Park, Argentina, June–September 2003. Electivity varies from −1.0 (avoidance) to +1.0 (selection), and values of zero indicate that forage items were used in proportion to their availability.

As predicted, cattle, sheep, and huemul included perennial shrubs and trees in winter diets. Cattle diets mainly composed of grasses have been reported in Patagonia (Pelliza et al. 1997, 2001), but in Los Alerces cattle also included high proportions of shrubs in their diet. The shrub-dominated diet of sheep we observed in these forest habitats differed from typical results described for the steppes. Sheep diets in arid Patagonia were associated with a grazer and intermediate selective strategy (Pelliza et al. 1997, 2001; Baldi et al. 2004). The high proportion of evergreen shrubs and trees in sheep winter diets may indicate that it is the only food of high quality that remains available in Patagonian forests.

In our study area, seasonal data on diet were only available for cattle. Cattle increase proportion of trees in their diet from autumn to spring, whereas shrub consumption increases in winter and spring (L. Borrelli, Instituto Nacional de Tecnología Agropecuaria, unpublished data). Estimated canopy coverage of life-form types differs across seasons. Available cover of tree and shrub species is higher during cold rather than warm season, whereas coverage of herbs and grasses is higher in spring–summer than autumn–winter (L. Martínez, Administración de Parques Nacionales, unpublished data). Low-lying perennial herbs were largely unavailable under snow during winter, and the proportion of available woody evergreen species was higher in winter than summer. Similarly, Jenkins and Wright (1987) showed that white-tailed deer and elk consume more browse when snow covers their preferred forages during harsh winters. Food availability also determines the increase of trees and shrubs consumed by roe deer in winter (Cornelis et al. 1999).

Body size differences among the 3 studied ungulates may explain their dietary relationships. Smaller animals have proportionally higher energetic requirements relative to their body mass than do larger animals (Bell 1970, Jarman 1974). Conversely, larger species should be capable of digesting more fibrous foods. Moreover, species of intermediate body mass consume important proportions of both browse and grass. Although huemul have an intermediate body size, they consume large amounts of shrubs and herbs and avoid grasses. In contrast, cattle are well-adapted to forage on grasses. Thus, as predicted for small-bodied species, huemul are highly selective and have a narrower dietary niche than larger bodied cattle. As predicted by previous classifications for intermediate feeders, sheep include high proportions of grasses and shrubs in their diet and also show the highest niche breadth compared to huemul and cattle.

Species with similar body sizes are expected to present interspecific competition under food-limiting conditions (Schoener 1974, Belovsky 1986, de Boer and Prins 1990). Consequently, dietary niche separation between huemul and cattle should be much more pronounced than between huemul and sheep, consistent with our expectations. However, we observed the highest diet overlap for cattle and sheep, contrary to our predictions.

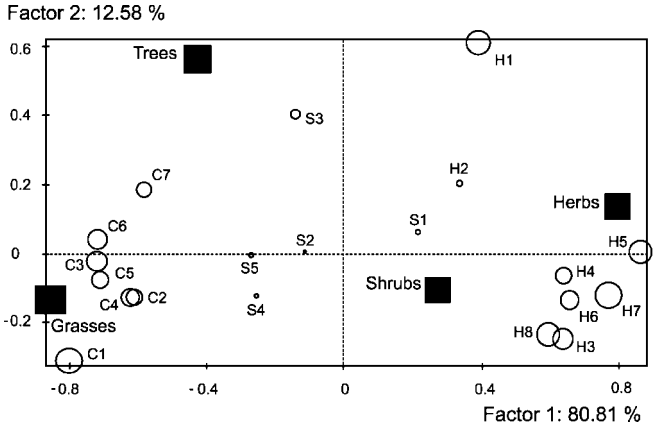

Figure 4. Correspondence analysis of winter diet composition data from huemul (H), cattle (C), and sheep (S) samples (circles) in Los Alerces National Park, Argentina, June–September 2003, expressed in 4 life forms (grasses, herbs, shrubs, and trees). Size of circles and squares indicates degree of contribution to conformation of the axes.

Although diet composition and diet overlap of sympatric ungulates provides insight into potential competition, food resource partitioning is only one dimension of niche separation (Schoener 1974). An understanding of habitat selection will provide another dimension to evaluate competitive displacement or coexistence between huemul and livestock. Moreover, there are other mechanisms that could potentially result in interference competition, such as behavioral intolerance of huemul to livestock accompanied by people and dogs. All these factors need to be investigated in future research on huemul–exotic ungulates interaction.

Management Implications

The Cerro Riscoso was declared a Critical Area to protect the existing huemul subpopulation in 2000. Current management policy tends to adjust stocking rates, distribution, and management of livestock to increase compatibility with huemul (Martínez 2006). To minimize potential competition for food in winter, we recommend managers ensure wintering areas free of livestock for huemul. Wintering areas for cattle should be concentrated in lowland areas that maintain high biomass of bamboo colihue, the most important species in their diet, adjusting their stocking rate to the productivity of these habitats. Our findings show that dietary overlap was greater between huemul and sheep, suggesting that alternative economic activities be promoted and implemented to gradually remove sheep from the area.

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