MOUNTAIN SHEEP WINTER FOOD HABITS IN THE UPPER YELLOWSTONE VALLEY

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This paper describes winter food habits and forage selection by Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) in two wintering areas in the upper Yellowstone River valley. The Everts winter range (EWR) lies within Yellowstone National Park (YNP) in an area where Houston (1978) believed elk (*Cervus elaphus nelsoni*) were artificially concentrated in winter due to late season hunts and harassment on agricultural lands outside the park. The Cinnabar winter range (CWR) is located outside the boundary of YNP in an area used less heavily by elk.

STUDY AREAS

The EWR encompasses approximately 480 ha adjacent to the Gardner and Yellowstone rivers south of Gardiner, Montana. In March 1981, YNP personnel counted 190 individuals during a bighorn survey of the EWR (M. Meagher, unpubl. data). Vegetation types in which bighorns were observed included bluebunch wheatgrass (*Agropyron spicatum*), needle-and-thread (*Stipa comata*), and Idaho fescue (*Festuca idahoensis*) grasslands; sage (primarily *Artemisia tridentata*) and black greasewood (*Sarcobatus vermiculatus*) shrublands; open Douglas-fir (*Pseudotsuga menziesii*) woodland; and the vegetative mosaics associated with cliffs and draws.

Bighorns begin to congregate on the EWR during November and typically reach highest concentrations during late November and December. Most bighorns remain on the winter range into April, but concentrations in the more easily accessible areas tend to decrease through the winter. A few sheep summer on the EWR. The EWR is moderately to heavily used by elk from November through April. The extent of elk use increases with winter severity. Mule deer (*Odocoileus hemionus*) and pronghorns (*Antilocapra americana*) are also found on the EWR but in much lower numbers.

The CWR covers approximately 350 ha 10 km northwest of Gardiner on the west side of the Yellowstone River. The maximum bighorn count during the 1980–81 winter was 83 (Keat-

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ing 1982). Vegetation types in which bighorns were observed were similar to those used in the EWR with the exception of a 40-ha field of crested wheatgrass (*Agropyron cristata*) planted at the base of Cinnabar Mountain. Idaho fescue and sage (*Artemisia tridentata* and *A. arbuscula*) types were more prominent on the CWR than on the EWR.

Bighorn concentrations on the CWR are highest in late November to early January. Use of easily observable areas tends to decrease by February, but some individuals remain on Cinnabar Mountain as late as June. As in the EWR, the extent of elk use of the CWR is dictated by winter severity but is consistently lower than on the EWR. Mule deer are abundant on the CWR, and pronghorns move into the area during severe winters. Although more than half of the CWR is located on privately owned ranches, domestic livestock grazing was light or nonexistent during 1978–81.

The climates of the winter ranges are similar. Average annual precipitation and temperature during 1956–71 were approximately 275 mm and 5 C, respectively, at the Gardiner weather station (Houston 1976). Weather data for the 1980–81 winter were incomplete for the Gardiner station, but precipitation was lower than average, and temperatures during November 1980–March 1981 were approximately 5 C above the winter norm (U.S. Dep. Commerce 1980–81) making this one of the three mildest winters in 25 years (H. D. Picton, unpubl. data).

METHODS

Fecal pellets were collected during November 1980 through March 1981 on the CWR and EWR. Only pellets observed to have been produced by bighorns were collected. Fecal samples were airdried and ground to 1-mm size in a Wiley mill. Diet composition for individual samples was determined using microhistological techniques and frequency conversions described by Sparks and Malechek (1968). Twenty fields on one slide were read per sample by Kasworm. No adjustments for differential digestibility were included. Monthly means were calculated based on 10 samples per month per winter range. Reference specimens were collected on the study area.

Relative availability of forage was measured during July and August 1982. Canopy coverages of herbaceous plants and woody plants <0.5 m in height were estimated using the Daubenmire plot technique (Daubenmire 1959). Larger plots (Pfister et al. 1977) were used to estimate canopy coverage for woody plants >0.5 m in height. A single transect, consisting of 20 0.1-m^2 Daubenmire and 3 375-m^2 Pfister plots, was located at a representative site in each major physiographic type in which bighorns were commonly seen. Daubenmire plots were spaced by drawing random numbers between 25 and 45 and pacing each distance. Pfister plots were centered at the 1st, 10th, and 20th Daubenmire plots. Six transects were located in the CWR and five in the EWR. Canopy-coverage estimates for plant categories identifiable in fecal samples were calculated for each physiographic type (bench, dry slope, mesic slope, saddle, ridge, cultivated grassland) and weighted by proportionate occurrence of the type to provide an estimate of overall canopy coverage. Forested areas (other than patches in major types) were not sampled because all pellets were collected from sheep feeding in open areas, and observations indicated that use of forested areas by bighorns was light.

Diets were compared using Spearman's rank-correlation tests, Student's t tests, and analysis of variance (Steel and Torrie 1960). Similarity between winter ranges was tested using Spearman's rank-correlations for plant taxa ranked by canopy coverage. Mann-Whitney U tests (Steel and Torrie 1960), with individual transect means as sample units, were used to assess differences in total seed-plant canopy coverage, forage-class canopy coverages, and percent bare ground between winter ranges.

Although potential changes in forage production between 1980 and 1982 and inconsistency of correlations between forage production and canopy coverage (Brown 1954) limited the strength of our plant availability index, we used Spearman's rank-correlation tests to obtain an overview of the relationship between diet and plant abundance. We justified this approach on three bases: (1) data in Houston (1982) suggest that relative ranks of perennial plant species in the study area changed little over a 2–3-year period; (2) our mid- to late-summer measurements ensured that annual plants, potentially a major source of annual variation in forage production, were desiccated so their contribution to canopy coverage was minimal; and (3) the simple physical structures of plant communities in the study area (>90% of the vegetation was <0.5 in height) minimized the

Table 1. Summary of food items making up ≥1% of the overall winter diets of bighorns associated with the Cinnabar winter range (CWR) and the Everts winter range (EWR) based on microhistological analysis of fecal samples. Monthly percentages (with standard deviations in parentheses) are based on 10 fecal samples/winter range. Winter percentages are cumulative values based on 50 samples/winter range.

Food item	CWR						EWR					
	Nov	Dec	Jan	Feb	Mar	Winter	Nov	Dec	Jan	Feb	Mar	Winter
Graminoids												
Agropyron sp.	21 (4)	32 (7)	24 (9)	22 (6)	21 (10)	24 (8)	15 (7)	26 (6)	18 (6)	17 (6)	27 (7)	20 (7)
Bromus sp.	6 (3)	1 (1)	3 (3)	4 (2)	2 (2)	3 (3)	4 (3)	8 (6)	2 (2)	4 (3)	12 (5)	6 (5)
Carex sp.	1 (2)		5 (2)	4 (3)	1 (1)	2 (2)	tr[a]	2 (2)	12 (5)	5 (3)	5 (3)	5 (5)
Festuca sp.	10 (3)	8 (4)	3 (3)	4 (3)	5 (4)	6 (4)	4 (3)	3 (2)	3 (3)	1 (2)	1 (1)	3 (2)
Koeleria cristata	7 (4)	10 (5)	6 (3)	10 (5)	10 (5)	9 (5)	5 (4)	15 (4)	8 (3)	7 (6)	11 (3)	9 (5)
Stipa sp.	3 (3)	1 (1)	2 (2)	4 (2)	3 (3)	2 (3)	5 (3)	16 (7)	7 (4)	9 (5)	12 (4)	10 (6)
Identifiable minor grasses[b]	1 (2)	tr	tr	tr	tr	1 (2)		tr		1 (1)	tr	tr
Unidentifiable grasses	8 (1)	4 (1)	5 (2)	8 (2)	7 (2)	6 (2)	6 (2)	8 (2)	7 (2)	6 (2)	5 (3)	6 (2)
Total graminoids	59 (10)	56 (12)	48 (15)	56 (10)	50 (20)	54 (14)	39 (13)	77 (9)	57 (10)	49 (14)	73 (9)	59 (18)
Forbs												
Phlox sp.	2 (2)	tr	1 (1)	2 (1)	3 (3)	2 (2)	1 (1)	5 (3)	2 (2)	1 (1)	2 (2)	2 (2)
Identifiable minor forbs[c]	tr	1 (2)	1 (1)	2 (3)	1 (1)	1 (2)	1 (1)	1 (1)	1 (1)	2 (2)	2 (2)	1 (2)
Unidentifiable forbs	8 (2)	tr	3 (2)	5 (2)	2 (1)	4 (3)	2 (2)	3 (2)	2 (2)	2 (2)	9 (1)	4 (3)
Total forbs	10 (3)	2 (4)	5 (3)	9 (5)	6 (4)	6 (5)	4 (3)	8 (2)	5 (3)	5 (3)	13 (4)	7 (5)
Shrubs and trees												
Artemisia sp. (excluding *A. frigida*)	16 (11)	21 (8)	27 (13)	30 (7)	29 (15)	25 (12)	4 (2)	4 (3)	11 (8)	8 (5)	6 (4)	6 (5)
Eurotia lanata	6 (8)	13 (10)	18 (12)	2 (3)	tr	8 (10)	41 (9)	7 (6)	26 (9)	28 (13)	1 (2)	20 (17)
Chrysothamnus nauseosus	4 (3)	1 (2)		2 (3)	10 (8)	3 (5)	5 (3)	3 (4)		7 (6)	4 (3)	4 (4)
Juniperus sp.	1 (1)	1 (2)	tr	tr	4 (9)	1 (4)						
Pseudotsuga menziesii	1 (1)	2 (3)	1 (2)	1 (1)	1 (1)	1 (2)	2 (1)	tr	1 (2)	1 (1)	2 (2)	1 (2)
Identifiable minor shrubs and trees[d]	1 (1)	3 (2)	tr	1 (1)	1 (2)	1 (2)	1 (2)	2 (2)	1 (1)	2 (1)	1 (1)	1 (2)
Unidentifiable browse	3 (2)	2 (2)	1 (1)	1 (1)	1 (1)	2 (2)	5 (2)	1 (1)	2 (2)	1 (1)	1 (1)	2 (2)
Total shrubs and trees	31 (13)	42 (12)	48 (14)	38 (7)	45 (7)	41 (14)	58 (12)	17 (8)	40 (10)	46 (13)	14 (7)	35 (20)

[a] <1% of diet.

[b] Graminoids contributing <1% to the total winter diet including *Calamagrostis rubescens, Elymus cinereus, Oryzopsis hymenoides,* and *Poa* sp.

[c] Forbs contributing <1% to the total winter diet including *Achillea millefolium, Arenaria* sp., *Astragalus* sp., *Oxytropis* sp., *Balsamorhiza sagittata, Commandra umbellata,* Cruciferae, *Eriogonum* sp., *Lupinus* sp., and unidentifiable herbaceous composites (at least nine possible genera).

[d] Shrubs and trees contributing <1% to the total winter diet including *Amelanchier alnifolia, Arctostaphylos uva-ursi, Artemisia frigida, Atriplex* sp., *Chrysothamnus viscidiflorus, Pinus flexilis, Prunus* sp., *Ribes* sp., *Sarcobatus vermiculatus,* and *Symphoricarpos* sp.

Table 2. Canopy coverage estimates for plant taxa ≥1% of total seed plant canopy coverage and percentages of these taxa in winter bighorn diets on the Cinnabar winter range (CWR) and Everts winter range (EWR). Minor taxa (<1% of total seed plant canopy coverage) noted in footnotes were identified in vegetation plots. Minor taxa in bighorn fecal samples are given in Table 1.

Category	CWR		EWR	
	% of total seed plant canopy coverage	% of total winter diet	% of total seed plant canopy coverage	% of total winter diet
Graminoids				
Agropyron sp.	21	24	14	20
Bromus sp.	10	3	4	6
Carex sp.			1	5
Elymus cinereus			2	tr[a]
Festuca sp.	7	6	3	3
Koeleria cristata	6	9	18	9
Oryzopsis hymenoides	1	tr	1	tr
Poa sp.	5	tr	10	tr
Stipa sp.	2	2	6	10
Identifiable minor grasses[b]	tr	1		
Total (including unidentified grasses)	50	54	60	59
Forbs				
Astragalus sp./*Oxytropis* sp.	1	0	3	tr
Cirsium vulgare	1	0		
Cruciferae	2	tr	2	tr
Phlox sp.	4	2	6	2
Unidentifiable composites	2	tr	3	tr
Identifiable minor forbs[c]	2	1	3	1
Total (including unidentified forbs)	13	6	18	7
Shrubs and trees				
Artemisia frigida	1	tr	2	tr
Artemisia sp. (excluding *A. frigida*)	24	25	4	6
Eurotia lanata	1	8	9	20
Chrysothamnus nauseosus	3	3	2	4
C. viscidiflorus	4	tr	2	0
Gutierrezia sarothrae	1	0		
Ribes sp.	1	tr		
Sarcobatus vermiculatus			2	tr
Identifiable minor shrubs and trees[d]	1	3	tr	2
Total (including unidentified shrubs and trees)	37	41	21	35

[a] <1% of seed plant canopy coverage or overall winter diet.
[b] Includes *Carex* sp. and *Elymus cinereus* in the CWR.
[c] Includes *Allium textile, Antennaria* sp., *Cerastium arvense, Cirsium vulgare* (EWR only), *Collinsia* sp., *Eriogonum* sp., *Geum* sp., *Potentilla* sp., *Lewisia rediviva, Lomatium* sp., Scrophulariaceae, *Taraxacum officinale*, and *Tragapogon dubius*.
[d] Includes *Atriplex* sp., *Gutierrezia sarothrae* (EWR only), *Juniperus* sp., *Sarcobatus vermiculatus* (CWR only), *Symphoricarpos* sp., *Rhus trilobata*, and *Ribes* sp. (EWR only).

influence of differences in growth form on the relationship between available forage and canopy coverage (Daubenmire 1959).

RESULTS

Fecal samples indicated that bighorns in the study area fed primarily on graminoids and woody species throughout the winter (Table 1). Major forage items used by bighorns on the CWR and EWR included two woody taxa, sage (*Artemisia* spp. excluding *A. frigida*) and winterfat (*Eurotia lanata*), and five graminoid taxa, wheatgrasses, junegrass (*Koeleria cristata*), fescues, needlegrasses (*Stipa* spp.), and bromes (*Bromus* spp.). Only one forb category, *Phlox* spp., was consistently utilized.

Although diets in the wintering areas were similar (Spearman's rank-correlation, r_s, for the entire winter was 0.76 and the associated probability of no correlation was $P < 0.01$), some differences were apparent. EWR samples showed significant ($P < 0.05$) fluctuations in content by forage class with sharp increases in grasses and corresponding declines in browse during December and March ($P < 0.05$). Proportions of graminoids and browse in CWR samples remained relatively stable ($P > 0.05$) throughout the winter. Winterfat was the most important browse item in EWR samples, and sage (excluding *A. frigida*) was the dominant item in CWR samples. Needlegrasses, bromes (*Bromus* sp.), and sedges (*Carex* sp.) contributed more and fescues less to EWR samples than to CWR samples (Student's t tests, $P <$ 0.05).

Comparison of ranked canopy coverages for all identifiable plant taxa indicated that vegetation composition on the two winter ranges was similar ($r_s = 0.65$, $P < 0.01$). Of 23 identifiable plant taxa that composed $\geq 1\%$ of the seed plant canopy coverage ($\geq 0.3\%$ overall canopy coverage) on either winter range, 17 (74%) were found in plots on both winter ranges (Table 2). Seed plant canopy coverage was equal (32%) on both sites. No differences were detected in graminoid, forb, or tree-shrub canopy coverages between the sites (Mann-Whitney U tests, $P > 0.05$), but abundant lightly browsed sages created a visual impression of greater shrub coverage on the CWR. Major differences between winter ranges included the dominance of sages on the CWR vs. dominance of winterfat on the EWR and the greater exposed soil surface on the EWR (34% vs. 6% on the CWR, $P < 0.05$).

Plants identified in fecal samples which were either not recorded in sample plots or represented <1% of total seed plant canopy coverage (12 in the CWR and 9 in the EWR) made up 5% and 3% of winter diets in the CWR and EWR, respectively. The six highest ranking plant categories made up 67% and 62% of the winter diet in the CWR and EWR, respectively. Spearman's rank-correlations between canopy coverage of plants composing $\geq 1\%$ of the seed plant canopy coverage and percent occurrence of these plant taxa in bighorn diets were 0.79 (monthly range 0.61–0.87, $P < 0.01$) in the CWR and 0.61 (monthly range 0.46–0.64, $P <$ 0.01–0.02) in the EWR.

DISCUSSION

The feeding patterns of bighorns on the EWR and CWR under winter conditions as mild as are likely to occur in the upper Yellowstone Valley were similar. Both populations exhibited high rank correlations between ranked diet items and ranked plant taxa in vegetation plots suggesting that many plant items were taken in proportion to their relative availability. Both populations fed most heavily on abundant items. Uncommon plants made minor contributions to diets at both sites.

Dietary differences between population units were evidently linked to site differences. The major fluctuations in the percentage of graminoids in EWR diets were possibly artifacts of higher soil heat absorption on the EWR due to its greater exposed soil surface (Oosting 1956). Higher heat absorption could have stimulated the short burst of new growth on grasses observed during the unseasonably mild month of December 1980 and should have facilitated earlier spring regrowth on the EWR than on the CWR. Bighorns on the EWR evidently responded to the increased availability of new growth by increasing graminoid consumption during December and March.

The only other study of bighorn food habits in the upper Yellowstone Valley (Oldemeyer et al. 1971) indicated a similar feeding pattern in the EWR unit during the similarly mild winter of 1965–66. Although mild winters are poor periods to test for the importance of intra- or interspecific competition on northern winter ranges, a mild winter should allow maximum selectivity in diets. Mountain sheep in the EWR and CWR were apparently not selective feeders in terms of botanical composition of diets. This is contradictory to some of the results obtained by Hobbs et al. (1983) using tame bighorns in Colorado in a more intensive study, but corresponds with results obtained in a food habits study of bighorns in north-central Montana during the moderate 1979–80 winter using techniques similar to those employed in this study (Kasworm et al. 1984). Differences between the forage class composition of diets in the Montana and Colorado studies could reflect differences in availability of plant species, but the differences in conclusions concerning the basic manner in which bighorns use available foods (i.e., selection for uncommon plants in Colorado vs. concentration on common plants in Montana) may be artifacts of inherent biases in the approaches used (see Holechek et al. 1982) or may reflect basic differences between feeding strategies exhibited by wild and supplementally fed tame animals.

Hainsworth (1981) contended that animals base their feeding strategies on energy or nutrients available from past meals. A tame animal maintained on high quality forage between feeding trials and subjected to relatively short acclimation periods prior to trials would, therefore, tend to be more selective than a wild animal that is conditioned throughout late autumn and winter to expect high quality forage items to be scarce and widely spaced. Bartmann et al. (1982) noted differences in winter feeding behavior between mule deer that were maintained for long periods of time on native forage (feeding bouts characterized by slow movement and continual feeding) and those maintained on high quality supplemental food prior to feeding trials on native forage (feeding bouts characterized by more rapid movement and sporadic feeding) that support this supposition. If experience plays a major role in determining feeding strategies, Hobbs et al. (1983) may have described a feeding strategy bighorns would follow if they had a high expectation of meeting maintenance requirements, whereas we identified a feeding strategy they would follow to minimize energy and/or nutrient deficits in a forage situation in which the expectation of meeting maintenance requirements was low.

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