VARIATION IN BIGHORN SHEEP FOOD HABITS AS MEASURED BY FECAL ANALYSIS

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Abstract: Ten fecal samples from Rocky Mountain bighorn sheep on semiarid range in southern Colorado were collected at 2-week intervals for 18 months and analyzed microhistologically for food habits. These data are used to analyze sources of variation in food habits related to 2-week periods, seasons, sites and years. Food habits vary significantly between seasons, sites and years but are similar among 2-week periods within seasons. Results suggest that food habits data from a limited number of seasons, years or sites should be interpreted with caution.

Variation in food habits of ungulates has concerned wildlife biologists since they first recognized the importance of determining carrying capacity based on forage production and food habits. With bighorn sheep, Ovis canadensis, geographic and seasonal variation in food habits has traditionally been recognized; however, other sources of variation have received less attention.

Todd (1972), in a review of bighorn sheep food habits, noted that bighorn food habits vary significantly with availability of forage species and therefore among habitat sites and among subspecies of sheep.

Although these sources of variation have been recognized and documented, certain recent efforts in wildlife management and wildlife habitat analysis have tended to implicitly ignore such variation or to minimize its importance. Examples of recent efforts in which variation in bighorn food habits has been either implicitly or explicitly ignored can be cited:

(1) Environmental Statements. Many recent environmental impact statements (EIS's) and analyses, including but not limited to range management EIS's have dealt with bighorn food habits. Some of these have presented food habits based upon 1 study or even 1 season and implied that these represented food habits for an entire region.

(2) Models. Models, particularly models for allocating forage between competing herbivores, are being developed and make use of bighorn food habits data. Some of these models treat food habits as static, i.e. as if they do not change in response to availability of forage species.

(3) Handbooks. A number of guidelines and/or handbooks are being developed by federal agencies for management of and/or analysis of impacts on a wide variety of species, including bighorn sheep, in areas subject to mining, timber harvest, grazing, and other developments. Some handbooks provide superficial reviews of bighorn food habits and by providing a simplified summary, imply that substantial variation in food habits among regions, sties, seasons and years is not significant.

We recognize the necessity of working with incomplete data at times and even of basing management decisions on such data. However, we also recognize a need to identify and state weaknesses or limitations of data being used for such purposes. Recognition and quantification of the inherent variation in bighorn food habits should help in evaluating the strengths or weaknesses of data regardless of how such data are used.

The purpose of this paper is to analyze sources of variation in bighorn sheep food habits related to 2-week periods, seasons, sites and years.

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STUDY AREA

The Trickle Mountain area is located in south-central Colorado approximately 20 km west of Saguache. The study area, including all seasonal ranges of the Trickle Mountain bighorn sheep herd, is bounded on the north by the Continental Divide, on the south and west by Colorado Highway 114 and on the east by a line running south from Antora Peak. The area measures about 30 km by 15 km and consists of approximately 45% lands administered by the BLM and 45% U.S. Forest Service lands. The remaining 10% of land is privately owned, mostly along creeks at lower elevations.

Elevations range from 2,500 m along Saguache Creek to over 3,600 m along the Continental Divide. Vegetation varies from shortgrass types dominated by blue grama (Bouteloua gracilis) at the lower elevations to pinon-juniper, ponderosa pine, Douglas fir and subalpine meadow types. The physiography of the area is characterized by numerous rocky outcrops and talus cliffs, these areas being favored by bighorn sheep. Common understory species on these areas are blue grama, fescues (Festuca sp.), muhly's (Muhlenbergia sp.), bluegrasses (Poa sp.), rabbitbrush Chrysothamnus sp.), fringed sagebrush (Artemisia frigida), true mountainmahogany (Cercocarpus montanus), and pingue (Hymenoxys richardsonii).

METHODS

Microscopic analysis of cutinized plant epidermal fragments and lignified cell walls was used to determine bighorn diets. Fecal samples were collected from 10 bighorn defecations at 2-week intervals from January 1978 through June 1979. The botanical composition was estimated for each defecation using a microhistological technique (Ward 1970, Free et al. 1970). Fecal samples were ground over a 2 mm screen and plant fragments were washed and collected over a 0.1 mm screen. Plant residues

from the fecal samples were prepared on microscope slides and analyzed according to the procedure described by Sparks and Malechek (1968). One microscope slide was made from each defecation and the plant fragments occurring in 20 separate microscope fields viewed at 100X were quantified.

Results from analysis of each defecation were averaged to obtain a diet for each 2-week period. Diets were also summarized by season and year for analyzing sources of variation. In August, fecal samples were collected and analyzed from 3 distinct sites within the study area used by bighorn sheep in summer. These sites represented extreme contrasts in elevation, vegetation and topography. For comparing year-to-year variation within the same season, data collected during this study were compared with data collected in 1971 from the same area by Todd (1975).

Diets were compared using Kulcyznski's similarity index (Oosting 1956).

RESULTS

Temporal Variation in Bighorn Food Habits

Seasonal food habits of bighorn sheep on the study area in 1978 are shown in Table 1. Major species in the year-round diet were muhly's (Muhlenbergia filiculmis and M. montana), fescue (primarily Festuca arizonica), sagebrush (primarily Artemisia frigida), fourwing saltbush (Atriplex canescens), and true mountainmahogany.

Estimates of seasonal food habits were calcualted by averaging data from 6 or 7 2-week periods within each season. Food habits for each 2-week period were compared to seasonal food habits (Table 2). These comparisons allow evaluation of the significance of variation in bighorn food habits among 2-week periods within seasons. Similarity indices for 2-week periods vs. the seasonal diets ranged from 48-89%; the average similarity being highest in winter (80%) and lowest in spring and summer (60 and 59%, respectively). Thus, for habitats similar to the Trickle Mountain area, a determination of bighorn food habits during a 2-week period can be expected to detect about 60% of the animal's seasonal diet (at the genus level) during spring or summer. Higher rates of detection should be expected during fall and winter.

Table 1. Major forages in diets of bighorn sheep on the Trickle Mountain study area in 1978, as estimated by fecal analysis.

	Season				
	Winter	Spring	Summer	Fall	Year-round
Grasses and Grasslike Plants	22	52	39	36	38
Fescue (*Festuca* sp.)	5	11	4	6	7
Muhly (*Muhlenbergia* sp.)	7	16	10	9	10
Sedge (*Cyperaceae*)	2	8	10	3	5
Other Grasses	8	17	15	18	16
Browse	76	41	48	61	56
Saltbush (*Atriplex canescens*)	8	1	7	28	11
True mountainmahogany (*Cercoparpus montanus*)	tr	4	19	2	6
Sagebrush (*Artemisia* sp.)	55	22	4	20	25
Other Browse	13	14	18	11	14
Forbs	2	7	13	3	6

Table 2. Similarity indices[1] for estimated bighorn diets during 2-week period vs. estimated diets over full seasons, Trickle Mountain study area, 1978.

Season	No. of 2-week periods	Similarity Indices	
		Mean (%)	Range (%)
Winter	6	80	71-89
Spring	7	60	50-72
Summer	6	59	48-62
Fall	7	72	62-80

[1] Calculated using Kulcyznski's index of similarity for genera.

Comparing bighorn diets between seasons (Table 3), winter and summer diets were most dissimilar (only 38% overlap), whereas winter and fall diets were most similar (57%). Spring and fall diets were somewhat more representative of the year-round diet than were winter and summer diets.

Food habits of bighorns varied considerably between 1978 and 1979, in both the winter and spring seasons (Table 4). Overlap of estimated diets between years was only about 50% in each season. The 2 winters were quite different in total snowfall. In 1979, snowfall at Saguache, the nearest weather station, was the highest in 25 years. Further, the spring of 1979 was relatively wet and warm, resulting in abundant forb and grass production on the study area. By contrast, 1978 had an average-to-mild winter in terms of snowfall followed by a dry cold spring (Table 5).

Seasonal food habits data for 1978 and 1979 were compared to similar data collected from the Trickle Mountain area during 1971 by Todd (1975). Similarity indices (Table 6) are high for winter and spring, 1978 vs. 1971, being 90 and 75% respectively. However, other between-years comparisons produced lower indices and the index for winter, 1979 vs. 1971 was only 36 percent.

Geographic Variation in Bighorn Food Habits

Bighorn fecal samples were collected from 3 dissimilar sites within the 15 x 30 km study area (Table 7). These sites, representing habitat extremes, are utilized in summer by individuals from what is considered a single herd of bighorn sheep. Bighorn food habits for August, 1979 (Table 8) indicate similarity between the 2 sites at lower elevation (similarity index = 74%). However, the bighorn diet at Antora Peak was quite different from the diets estimated for the lower sites (indices of only 22 and 35%).

DISCUSSION

Hansen (1971) and Todd and Hansen (1973) have indicated the value of fecal analysis in estimating food habits of bighorn sheep. The technique, as used in this study, identifies dietary components at the generic level. However, of major genera in the diet, in most cases only one species of

Table 3. Similarity indices[1] for among-seasons comparisons of bighorn diets, Trickle Mountain study area, 1978.

	Winter	Spring	Summer	Fall	Year-round
Winter	100	50	38	57	65
Spring		100	52	54	74
Summer			100	49	65
Fall				100	74

[1]Calculated using Kulcyznski's index of similarity for genera.

Table 4. Comparison of winter and spring bighorn food habits between 1978 and 1979, Trickle Mountain study area.

	Percent Composition of Diet			
	Winter		Spring	
	1978	1979	1978	1979
Grass and Grasslike Plants	22	52	52	53
Fescues (*Festuca* sp.)	5	1	11	5
Muhlys (*Muhlenbergia* sp.)	7	14	16	8
Grama (*Bouteloua* sp.)	3	18	2	7
Sedges (*Cyperaceae*)	2	3	6	17
Other Grass	5	16	17	16
Browse	76	45	40	32
Yucca (*Yucca glauca*)	5	8	1	2
Fourwing Saltbush (*Atriplex canescens*)	8	9	1	3
Winterfat (*Ceratoides lanata*)	4	9	2	8
Sagebrush (*Artemisia* sp.)	55	14	22	7
Other Browse	4	5	14	12
Forbs	2	3	8	15
Kulcyznski's index of Similarity	50%		51%	

Table 5. Comparison of winter and spring weather data for Saguache, Colorado between 1978 and 1979.

	1978	1979
Temperature		
Average Temperature (°F) (January - March)	27.6	18.2
Departure From Normal	+1.0	-8.3
Average Temperature (°F) (April - June)	47.5	50.8
Departure From Normal	-3.2	+0.1
Snowfall		
Total Snowfall (in.)	7.4	35.3
Maximum Snow on Ground (in.)	5	23
Precipitation		
Total Precipitation (in.) (January - June)	2.89	3.55
Departure From Normal	-0.19	+0.47

Table 6. Comparison of seasonal bighorn diets between 1978 and 1979 vs. 1971, Trickle Mountain study area.

Source			
This Study		Todd (1975)	Kulcyznski's Similarity Index
Winter 1978	vs.	Winter 1971	90
Spring 1978	vs.	Spring 1971	75
Summer 1978	vs.	Summer 1971	68
Fall 1978	vs.	Fall 1971	59
Winter 1979	vs.	Winter 1971	36
Spring 1979	vs.	Spring 1971	64

Table 7. Comparison of three areas used by Trickle Mountain bighorn sheep during summer.

	Middle Creek	Buffalo Rocks	Antora Peak
Elevation	2,400 m (8,000 ft.)	3,000 m (10,000 ft.)	3,600 (12,000 ft.)
Season of Use (bighorn)	All Seasons	Spring, Summer, Fall	Summer
Vegetation Type	Shortgrass	Ponderosa Pine/Bunchgrass	Alpine Grassland
Animal Use			
Class of Sheep	Ewes and Lambs (summer) All Classes (other seasons)	Ewes and Lambs	Rams (early summer) All Classes (late summer)
Other Ungulates Making Significant Use of Range	Cattle (summer), Deer and Elk (winter) Antelope (year-round)	Cattle (summer), Elk (spring and fall)	None

Table 8. Comparison of bighorn food habits on three areas within the Trickle Mountain study area, August, 1978.

	Percent in Diet		
	Middle Creek	Buffalo Rocks	Antora Peak
Grass and Grasslike Plants	17	22	34
Wheatgrass (*Agropyron* sp.)	0	4	15
Fescue (*Festuca* sp.)	2	3	4
Muhly (*Muhlenbergia* sp.)	8	7	0
Sedge (*Cyperaceae*)	2	3	12
Other Grass	5	5	3
Browse	77	68	29
True mountainmahogany (*Cercocarpus montanus*)	55	41	1
Willow (*Salix* sp.)	7	12	4
Fourwing Saltbush (*Atriplex canescens*)	5	0	0
Sagebrush (*Artemisia* sp.)	0	7	4
Sumac (*Rhus* sp.)	0	0	5
Other Browse	10	8	15
Forbs	6	10	37
Penstemon (*Penstemon* sp.)	0	0	6
Cinquefoil (*Potentilla* sp.)	0	0	13
Other Forbs	6	10	18

Kulcyznski's Similarity Indices

Middle Creek vs. Buffalo Rocks	74%
Middle Creek vs. Antora Peak	22%
Buffalo Rocks vs. Antora Peak	35%

the genus was sufficiently abundant on the range to account for a significant portion of the diet.

Of all comparisons made, it is significant that the greatest dissimilarity (only 22% overlap) in diets was found between sites within the study area during one season. This suggests that caution should be used in interpreting food-habits data from a limited number of sites, even within a study area defined by movements of a single herd of animals.

Variation among sites accounts for some of the indicated seasonal variation in food habits. On Trickle Mountain, sheep are confined during the peak of winter to a range representing only about 1/5 of the study area. In contrast, during summer sheep use a great diversity of vegetation types. This, at least in part, accounts for the finding that within-season variation in food habits was highest in summer and lowest in winter, and for the finding that, of all seasons, winter and summer food habits overlap least with the year-round diet (Table 3).

The dissimilarity in food habits for these years are as different as food habits compared between seasons. If food habits can vary so from year to year, it would seem that past measurements of food habits would provide little predictive value. However, it must be emphasized that 1979 was a very unusual year, as even a casual perusal of weather records indicates. Our field observations during that winter indicated that bighorn sheep, as well as pronghorn antelope (Antilocapra americana), mule deer (Odocoileus hemionus), and elk (Cervus elaphus) on the study area, were restricted to less than 1/2 their normal winter ranges. Similarly, the spring of 1979 was much wetter and warmer compared to 1978. Forbs were more abundant and growth of grasses on lower elevations of the study area was greater. In contrast to the difference between 1978 and 1979, the similarities between diets estimated by Todd (1975) and those measured in this study during 1978 are reassuring and suggest that during normal years at least, seasonal food habits are similar from year to year.

A full understanding of the foraging dynamics of a wild or domestic ungulate population will require biologists to consider among-years variation in food habits. In particular, food habits during stressful

periods, such as occasional severe winters or droughts, should be evaluated. Management decisions, such as allocation of forage among species or commitments to increase or decrease populations, that are based upon food habits information collected only during "normal" years could lead to unwanted or unexpected results during unusual years.

Although it is beyond the scope of this paper to analyze in detail the abundant data on food habits of bighorns at Trickle Mountain, we feel that both the food habits and the variability among seasons, sites and years are explicable in terms of several factors. These are the known distribution patterns and forage preferences of bighorn sheep, the phenology, nutritional values and availabilities of forage plants, and climatic events occurring on the study area. On the other hand, much of the observed variation in bighorn food habits would be perplexing to a person not familiar with the area and the climatic and phenological events occurring when data were collected. Thus in designing and interpreting food habit studies of bighorn sheep or other animals, it is important that biologists be familiar with the animal species and its habits, the major forage species and their values, and characteristics of their study area. Design or interpretation of a food-habits study in the absence of such knowledge could lead to erroneous conclusions. Wikeem and Pitt (1979), working with bighorn sheep in enclosures, have illustrated the pitfall of using only diet data to derive such measures as preference rankings in the absence of subjective knowledge of the study area and of the behavior of animals on the range.

CONCLUSIONS

1. Bighorn food habits for a given site are relatively similar within seasons.

2. Food habits vary significantly between seasons and may vary significantly between years.

3. Food habits for the same season and year may vary significantly between sites on the same range.

4. Caution should be used in interpreting bighorn food habits data from a limited number of seasons, sites or years.

5. Knowledge of weather extremes, of habitat sites utilized by animals, of availability of major forage species, and of phenology of principal plant species on a study area is necessary to properly design and/or analyze food habit studies.

LITERATURE CITED

FREE, J. C., R. M. HANSEN, AND P. L. SIMS. 1970. Estimating dry weights of food plants in feces of herbivores. J. Range Manage. 23:300-302.

HANSEN, R. M. 1971. Estimating plant composition of wild sheep diets. pp. 108-115 In: E. Decker (Ed.) Proc. 1st N. Am. Wild Sheep Conf. April 14-15, 1971. Colo. State Univ., Ft. Collins, 188 p.

OOSTING, H. J. 1956. The study of plant communities. W. H. Freeman and Co., San Francisco. 440 p.

SPARKS, D. R. AND J. C. MALECHEK. 1968. Estimating percentage dry weights in diets using a microscopic technique. J. Range Manage. 21:264-265.

TODD, J. W. 1972. A literature review on bighorn sheep food habits. Colo. Div. Wildl., Spec. Rept. No. 27, 21 p.

_____. 1975. Foods of Rocky Mountain bighorn sheep in southern Colorado. J. Wildl. Manage. 39:108-111.

_____ AND R. M. HANSEN. 1973. Plant fragments in the feces of bighorns as indicators of food habits. J. Wildl. Manage. 37:363-366.

WARD, A. L. 1970. Stomach content and fecal analysis: methods of forage identification. pp. 146-158 In: Range and Wildlife Habitat Evaluation - A Research Symposium. U.S.D.A. Forest Service, Misc. Publ. No. 1147, 220 p.

WILKEEM, B. M. AND M. D. PITT. 1979. Interpreting diet preference of California bighorn sheep on native rangeland in south-central British Columbia. Rangelands 1:200-202.