Nutrition of Sheep Grazing Crested Wheatgrass Versus Crested Wheatgrass-Shrub Pastures during Winter

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Abstract

Grazing sheep on improved pastures during winter offers an economically attractive alternative to supplementation in sagebrush steppe ecosystems. We studied diet selection and nutrition of sheep grazing in crested wheatgrass *(Agropyron desertorum)* and crested wheatgrass-shrub *(Kochia prostrata, Atriplex canescens, Purshia tridentata, Artemisia tridentata, Chrysothamnus nauseosus, Ceratoides lanata)* pastures during early-January (period 1), mid-January (period 2), and late-January (period 3). Diet selection by esophageally fistulated sheep differed during each of the 3 periods because the amount of available forage changed with snow depth, trampling, and utilization. Sheep grazing crested wheatgrass (CW) pastures consumed diets that were about 55% mature grass and 45% green vegetative growth during periods 1 and 2, and 93% mature grass and 7% green vegetative growth during period 3. Sheep grazing crested wheatgrass-shrub (CWS) pastures consumed diets that were about one-half grass and one-half shrub during all periods. Organic matter intake (g • kg $BW^{.075}$), determined from total fecal output and in vitro digestibility estimates, were higher (P = 0.036) for sheep grazing CWS pastures than for sheep grazing CW pastures during periods 1 (38 vs. 28) and 3 (31 vs. 27), but were similar (P<0.10) during period 2 (28 vs. 26). Diets of sheep grazing CWS pastures contained more (P = 0.002) crude protein (%) than diets of sheep grazing CW pastures during periods 1 (9.0 vs. 5.8), 2 (7.3 vs. 6.6), and 3 (7.9 vs. 4.6). In vitro organic matter digestibilities (%) of diets of sheep in CW and CWS pastures were similar during period 1 (45 vs. 48), but higher (P = 0.001) for sheep grazing in CW pastures during periods 2 (46 vs. 29) and 3 (32 vs. 24). We stocked pastures heavily to accentuate differences between sheep diets in CW and CWS pastures during period 1-3; we believe results from period 1 best represent the potential nutritional benefits of shrubs on snowy winter ranges.

Harvesting hay during summer and feeding it during winter accounts for over half of the variable costs of ranching in the Intermountain West (Simonds 1980). The machinery, irrigation, fertilizer, seed, fuel, and labor associated with winter feeding of livestock represent a major expense for the livestock industry. Substantial savings would result if the amount of hay fed to livestock during winter could be reduced through enhanced management of winter ranges.

Salt desert shrub ecosystems, which constitute the traditional winter ranges in the Intermountain West, cannot support all animals that must be fed during winter. However, the sagebrush semidesert (West 1983a) and steppe (West 1983b) ecosystems of the region are much larger, and offer alternative wintering areas. About 4 million ha of these rangelands have been seeded with crested wheatgrass *(Agropyron desertorum* and *A. cristatum).* These species are renowned for their ease of establishment and tolerance of spring grazing, drought, and cold. Unfortunately, they tend to become fibrous at maturity, usually in early June. Thereafter, their palatability and nutritional quality decline rapidly (Murray et al. 1978). Knipfel (1977) concluded that mature crested wheatgrass was nutritionally inadequate for pregnant ewes.

Two properties of crested wheatgrass give it potential as a winter forage. Mature plants retain high levels of digestible carbohydrates offering a source of energy (Cook and Harris 1968, Cook 1972); and green vegetative growth produced, given adequate precipitation during fall, can persist throughout winter. However, it remains uncertain whether or not this vegetative growth contains sufficient protein for efficient digestion of fiber by ruminants (Moir and Harris 1962, Van Gylswyk 1970, Van Soest 1982).

Commercial protein concentrates are expensive and may be difficult to dispense on snowy winter ranges. Some species of shrubs maintain crude protein levels of 6–17% during winter (Cook and Harris 1977, Otsyina et al. 1982). Shrubs are not usually covered by snow, and could be a suitable source of protein and dry matter for livestock grazing crested wheatgrass ranges during winter.

The objective of our research was to examine the influence of shrub availability on diet selection, organic matter intake, and nutritional status of sheep grazing in crested wheatgrass pastures in winter.

Methods

Study Site

The study site is located 12 km south of Nephi in central Utah at 39.38° north latitude and 111.51° west longitude. The site is on an alluvial fan between 2 mountain ranges at 1,615 m elevation. Slopes are 0–4%. Soils are deep silt loam derived from shale, limestone, and sandstone. Average annual precipitation is 32 cm, 35–40% of which is snow. Weather fronts bring strong wind, particularly from the southwest, and the site is exposed to extreme chill factors and drifting snow during such episodes. The average temperature for December is –1.5° C and for January is 1.6° C.

The physical design of the experimental pastures consisted of 2 replications of 3.6 ha each. Each replication was split into a crested wheatgrass (CW) pasture (1.8 ha) and a crested wheatgrass-shrub (CWS) pasture (1.8 ha). The following species of shrubs were planted in discrete 0.2-ha blocks (17 rows • $block^{-1}$) within the CWS pastures (approximate number of shrubs in parentheses): forage kochia *Kochia prostrata* (714), fourwing saltbush *Atriplex canescens* (289), bitterbrush *Purshia tridentata* (357), sagebrush *Artemisia tridentata* subsp. *vaseyana* (357), rabbitbrush *Chrysothamnus nauseosus* var. *albicaulis* (357), winterfat *Ceratoides lanata* (714), and a mixture of all shrub species (714). In addition, the CWS pastures contained a 0.2-ha block of fourwing saltbush, bitterbrush, and CW, and a 0.2-ha block of CW.

Nutritional Parameters

Fifty-two nonpregnant ewes, primarily Columbia-Targhee crosses accustomed to foraging on rangelands, were used to provide data on weight response and to manipulate vegetation. We placed half of these sheep in CW and half in CWS pastures, similar to pastures described above, 17 days prior to the initiation of the experiment to allow animals to adapt to grazing conditions. Thirteen sheep were placed in each experimental pasture on 30 December 1982 and were removed on 29 January 1983.

In addition, 2 esophageally fistulated wethers were placed in each pasture. The diet of each animal was sampled on at least 2 days during each of 3 sample periods in early-January (1-5), mid-

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This paper is published with the approval of the director, Utah Agr. Exp. Sta., Utah State Univ., Logan as journal paper No. 3018.
Manuscript accepted 29 May 1986.

January (15–20), and late-January (25–28). The collections began about 0800 hr and sheep were allowed to forage for about 45 min. Samples were placed in plastic bags, packed in snow, and immediately stored in a cooler. After each sample period, samples from each animal were composited and frozen.

Four ewes in each pasture were fitted with collection bags to estimate fecal output. Forage intake was determined using the equation:

$$\text{Organic matter intake} = \frac{\text{total fecal organic matter output}}{(100\text{-in vitro organic matter digestibility})\ (0.01)}$$

Values for fecal output and in vitro organic matter digestibility were averaged for animals within treatments for each of the 3 sample periods. The first 2 collection periods lasted 5 days, and the final collection period lasted 3 days.

We weighed animals and attached fecal collection bags the day before sampling. The rear of the bag was made of mesh screen to allow urine to pass through when a ewe squatted to urinate. We collected feces in the morning of each sample day and in the evening of the last day. Each sample was weighed, thoroughly mixed, and subsampled. Subsamples were frozen and later dried at 105° C and ashed at 600° C to determine dry and organic matter contents.

All animals were weighed before they were transported to the study site and at the beginning of each sample period. As the study progressed, snow depth and forage utilization levels increased, and some sheep were removed from the experimental pastures. As a result, 47 sheep were weighed in period 1, 46 in period 2, and 22 in period 3.

Laboratory Analyses

Samples from esophageally fistulated sheep were freeze-dried and then ground using a Wiley mill with a 20-mesh screen. Crude protein (% of dry matter) was determined on duplicate subsamples using the Kjeldahl technique (Harris 1970). In vitro organic matter digestibility was determined on triplicate subsamples using the Moore modification of the Tilley and Terry technique (Tilley and Terry 1963, Harris 1970). We obtained inoculum from a rumen-fistulated sheep fed alfalfa hay. Fiber and permanganate lignin (% of dry matter) were determined using techniques described by Goering and Van Soest (1970).

Half of each fistula sample was analyzed botanically using the microscope point technique (Harker et al. 1964). This technique allows estimation of dietary components within broad categories (e.g., minor <20%, moderate 21–50%, major >50%; Marshall and Squires 1979), therefore we urge caution in comparing results among shrub species. At least 100 observations were made of each sample, but more observations were made of large or diverse samples. Each observation of grass from CW and CWS pastures was recorded as mature or green vegetative growth. For CWS samples, shrub fragments were identified to species when possible. Results are presented as a percentage of recognizable plant species and parts.

Vegetation Utilization

Shrub utilization was estimated by measuring the percentage removal of current year's twig production (Smith and Urness 1962) on 17 sample plants of each species within each pasture. The 1982 production of crested wheatgrass was estimated prior to the experiment by clipping and drying 5 samples from 1-m² areas within each pasture. Pastures were sampled (10 plots • pasture^{-1}) when snow melted in the spring of 1983 to estimate how much green vegetative growth and mature grass had been utilized, and the percentage of crested wheatgrass lost to trampling and snow compaction. The pastures were not grazed between the end of our experiment and snowmelt.

Weather Records

Records were required to understand how winter weather affected diet selection and intake. Because weather instruments were not available on the study site, we used records from the official reporting station at Levan, Utah. Levan is 12 km south of the study site on the same elevational contour and has similar aspect and prevailing winds.

Data Analysis

The experimental design was a factorial with 2 replications. Pasture type (CW vs. CWS) was the main effect, and the experiment was repeated in early-, mid-, and late-January. Animals were subsamples in this design. We consider probability levels ≤0.10 significant.

Results

Nutritional Parameters

A significant interaction (P=0.036) occurred for organic matter intake (Table 1). During the first period, sheep in the CWS pastures consumed more than did sheep in the CW pastures. During period 2 intakes were similar, but sheep in the CWS pastures again consumed more in period 3. Body weights did not differ for sheep used to estimate fecal output in CW vs. CWS pastures during sample periods 1 (63 vs. 63 kg), 2 (62 vs. 64 kg), or 3 (62 vs. 61 kg).

Table 1. Nutritional aspects of diets of esophageally fistulated sheep grazing in crested wheatgrass (CW) or crested wheatgrass-shrub (CWS) pastures during early-January (Period 1), mid-January (Period 2), and late-January (Period 3) of 1983.

	Period 1 (Jan. 1–5)		Period 2 (Jan. 15–20)		Period 3 (Jan. 25–28)		All Periods	
Assay	CW	CWS	CW	CWS	CW	CWS	CW	CWS
Organic matter intake (g.kg BW$^{-0.75}$)	28^a	38^b	26^a	28^a	27^a	31^b	27^a	32^a
crude protein (%)	5.8^a	9.0^b	6.6^a	7.3^b	4.6^a	7.9^b	5.6^a	8.1^b
in vitro organic matter digestibility (%)	45^a	48^a	46^a	29^b	32^a	24^b	41^a	33^b
neutral detergent fiber (%)	70^a	57^b	70^a	64^b	73^a	64^b	71^a	61^b
lignin (%)	13.1^a	12.3^a	9.5^a	17.5^b	11.9^a	17.4^b	11.5^a	15.7^b

^{a,b}Means within a period are significantly different (LSD 0.10 for organic matter intake; LSD 0.05 for crude protein, in vitro organic matter digestibility, neutral detergent fiber, and lignin).

Crude protein (CP) in diets of sheep in CWS pastures exceeded that of sheep in the CW pastures (P=0.002; Table 1). However, the magnitude of the effect depended on sample date (P=0.002).

We observed a similar time by treatment interaction (P=0.001; Table 1) for in vitro organic matter digestibility (IVOMD). IVOMD did not differ between pastures in period 1, but digestibilities of the CWS diets dropped sharply in period 2. The digestibilities of both diets declined in the final collection period, but remained lower for CWS than for CW diets.

CW diets were higher (P=0.017) than CWS diets in neutral detergent fiber (Table 1). CWS diets contained more lignin (P=0.012). A significant interaction (P=0.015) existed between time and treatment for lignin (Table 1). Lignin concentrations of both diets were similar during period 1, but were higher in CWS pastures during periods 2 and 3.

No significant differences in weight changes occurred between sheep in CW and CWS pastures. Small but significant (P=0.001) differences did occur at different sample dates. The average animal lost 3% of body weight during the adjustment period, gained 2% of it back between periods 1 and 2, and then lost 4% between periods 2 and 3.

Data from the botanical analysis are summarized in Table 2. During the first 2 sample periods, sheep in the CW pastures consumed diets that were about 50% green vegetative growth and 50%

Table 2. **Botanical composition of diets of sheep grazing crested wheatgrass (CW) or crested wheatgrass-shrub (CWS) pastures during winter.**

Plant species	Period 1 (Jan. 1-5)		Period 2 (Jan. 15-20)		Period 3 (Jan. 25-28)	
	CW	CWS	CW	CWS	CW	CWS
Grass						
Agropyron desertorum (mature)	57	36	54	58	93	48
Agropyron desertorum (green)	43	18	46	4	7	1
Total	100	54	100	62	100	49
Shrubs						
Artemisia tridentata ssp. *vaseyana*	—	28	—	19	—	24
Purshia tridentata	—	9	—	12	—	11
Atriplex canescens	—	6	—	5	—	0
Kochia prostrata	—	3	—	1	—	1
Chrysothamnus nauseosus var. *albicaulis*	—	0	—	1	—	15
Ceratoides lanata	—	0	—	0	—	0
Total	—	46	—	38	—	51

mature grass. During the third sample period, their diets averaged 93% mature grass and 7% green vegetative growth. Sheep in the CWS pastures consumed diets containing equal parts of shrub and grass throughout the experiment. Winterfat did not appear in the diet samples because it was present in low abundance and quickly utilized. Fourwing saltbush was utilized to a greater degree than the diet samples suggest because it was browsed in the afternoons.

Vegetation Utilization

Estimates of utilization of current year's shrub growth were as follows: winterfat, 100%; fourwing saltbush, 79%; bitterbrush, 52%; forage kochia, 34%; sagebrush, 29%; and rabbitbrush, 17%. Sheep stripped leaves from forage kochia and sagebrush, therefore their utilization estimates are conservative. Of the estimated 1,400 kg • ha^{-1} of grass in the CW pastures at the beginning of the experiment, about 92% was mature stems and leaves and 8% was green vegetative growth. During the experiment, sheep consumed about 39% of the mature crested wheatgrass and essentially all of the green growth. Most of the remaining mature grass (60%) was compacted by snow and trampled by sheep.

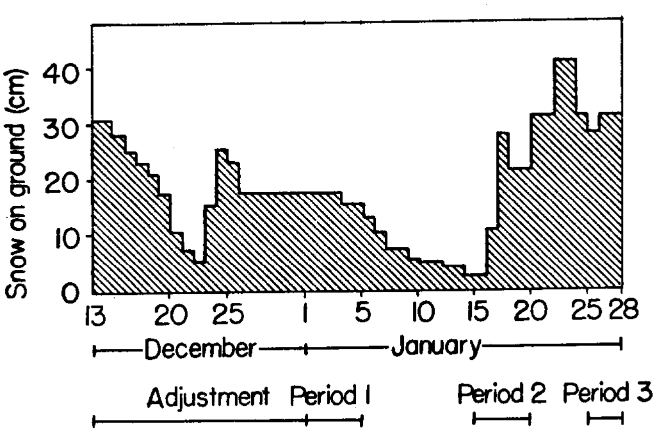

Fig. 1. *Snow depth at Levan, Utah, during December of 1982 and January of 1983. Levan is located 12 km south of the study site.*

Weather Records

Snow cover records for Levan, Utah, are presented in Figure 1. Four snow storms brought a total of 8.1 cm of precipitation, an equivalent of 65–100 cm of snow, or about 33% more than average. Snow was on the site throughout the experiment. The average December temperature was −3.5° C, 2.1° colder than normal. The average January temperature was 0.8° C, which is 2.4° warmer than normal. Temperatures ranged from −19.4 to 11.0° C.

Discussion

We stocked pastures heavily to accentuate differences between sheep diets in CW and CWS pastures. Cumulative stocking rates for the pastures were 0.2 AUM • ha^{-1} through period 1, 0.7 AUM • ha^{-1} through period 2, and 0.8 AUM • ha^{-1} through period 3. Our data suggest that lighter (e.g., 0.2–0.5 AUM • ha^{-1}) stocking rates are better because organic matter intake, nutrient content, and digestibility were higher, particularly for sheep in CWS pastures. Results from period 1, therefore, best represent the potential nutritional benefits of shrubs on snowy winter ranges.

Organic matter intake integrates a number of parameters that affect livestock performance, including nutritional characteristics of the diet and forage availability. Intake is apparently inversely related with cell wall content (Neutral Detergent Fiber, NDF) when diets contain more than 6–8% CP, but is directly related with CP at lower concentrations of CP (Van Soest 1982). Intake was well correlated with both NDF (r = 0.91) and CP (r = 0.99) for sheep in the CWS pastures, but poorly correlated with NDF (r = −0.24) and CP (r = −0.27) for sheep in the CW pastures. These results suggest that forage availability (Anrold 1970) also affected intake. We attribute the lower levels of intake by sheep in CW as compared to CWS pastures primarily to lack of forage availability caused by snow, and secondarily to physical and chemical characteristics of the forage. Rittenhouse et al. (1970) found that cattle consume considerably less forage when snow covers the ground (29g • kg BW$^{-0.75}$) than when it is absent (65g • kg BW$^{-0.75}$). In addition, metabolism and appetite of sheep may be lower during winter than at other times of year (Gordon 1964, Loudon 1985), which could also contribute to the relatively low levels of intake (Cordova et al. 1978) by sheep in both CW and CWS pastures.

The values for intake obtained by the technique we used are not absolute, but indicate relative differences (Cordova et al. 1978) that have significance for forages and environmental conditions similar to those in this experiment. Thus, results for the 3 sample periods illustrate the collective effects of snow depth and increasing levels of utilization on forage availability and intake. During period 1, grass availability was low while shrub availability and nutritional quality were high, and sheep in CWS pastures consumed 36% more forage per day than sheep in CW pastures. However, between periods 1 and 2 snow depth was low, grass availability was high, and sheep in CWS pastures consumed more grass and less shrub than in periods 1 and 3. As a result, intakes were comparable for sheep in CW and CWS pastures. During period 3, grass availability was again low, shrubs were still available but less nutritious, and sheep in CWS pastures consumed 15% more forage per day than sheep in CW pastures.

Throughout the experiment, diets of sheep in CWS pastures averaged 8.1% crude protein, above the 6–8% level generally recommended for ruminants (Van Soest 1982). In contrast, diets of sheep in CW pastures averaged 5.6% crude protein. During dry years or times of heavy snow accumulation, when green vegetative growth is scarce, supplemental protein obtained from shrubs might increase intake of mature crested wheatgrass. Otsyina et al. (1982) reported that mature crested wheatgrass contains 1.2–2.7% CP.

Relationships between crude and digestible protein (Holter and Reid 1959, Van Niekerk et al. 1967) may be misleading in comparing diet quality because shrubs often contain high levels of metabolites, such as tannins, that may lower protein availabilities (McLeod 1974, Rosenthal and Janzen 1979, Milton and Dintzis 1981, Mould and Robbins 1981). Nevertheless, many shrubs in the Intermountain West apparently contain enough digestible protein to meet the needs of ewes during gestation (Cook 1972, Cook and Harris 1977, Otsyina et al. 1982). Of the shrubs in our study, only bitterbrush contained appeciable levels of tannins (Provenza, unpubl. data).

The digestible organic matter contents of diets of sheep in CWS pastures were comparable to those for sheep in CW pastures at moderate stocking rates during sample period 1, but lower at higher rates during periods 2 and 3. The lignin contents of CWS diets were also comparable to those of the CW diets at moderate stocking rates, but were higher at increased levels of stocking. High lignin levels, caused by sheep consuming woodier portions of shrubs as utilization increased, probably caused the digestibilities of CWS diets to decline (Van Soest 1982).

Increased intake is generally positively correlated with body weight. The weights of sheep in this trial changed little, however, and the lack of correlation between intake and body weight for sheep grazing in CW vs. CWS pastures may indicate that the differences between diets for sheep in CW or CWS pastures were not of consequence. Alternatively, the grazing trial may have been too brief to detect changes in body weight between sheep in CW or CWS pastures (see Petersen and Lucas 1960).

Conclusions

Our preliminary findings suggest: (1) Shrubs were available when snow accumulated, which allowed sheep on CWS pastures to maintain higher levels of intake than sheep on CW pastures. (2) Shrubs allowed sheep to maintain adequate levels of crude protein, whereas sheep grazing on CW pastures were marginally deficient. Although crude protein concentrations remained high for sheep diets in CWS pastures, in vitro organic matter digestibilities declined markedly for sheep diets in CWS compared to CW pastures as utilization levels increased during sample periods 2 and 3. (3) We were unable to demonstrate different changes in body weight for sheep grazing in CW vs. CWS pastures perhaps because the nutritional differences were not of consequence, or perhaps because the trial was not of sufficient duration. (4) Compared to crested wheatgrass, relatively few shrubs were lost to trampling and snow compaction. Sheep could not graze about 60% of the mature crested wheatgrass because of snow compaction and trampling. However, trampling losses would likely be less at lower stocking rates. (5) We stocked pastures heavily to accentuate differences between sheep diets in CW and CWS pastures during periods 1-3; we believe results from period 1 best represent the potential nutritional benefits of shrubs on snowy winter ranges.

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