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Mountain big sagebrush browse decreases dry matter intake, digestibility, and nutritive quality of sheep diets

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Abstract

A metabolism study evaluated the influence of increasing quantities (0–30% dry matter basis) of mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana* Rydb. Beetle) on dry matter intake and in vivo digestibility of wether diets. Diets consisted of hand-harvested, coarse-ground and frozen current year's growth of mountain big sagebrush leaves and twig tips mixed with chopped native grass hay. Dry matter intake decreased from 93 to 23 g dry matter day^{-1} kg metabolic weight^{-1} and in vivo dry matter digestibility from 59 to 0% with increasing levels of sagebrush in the diet. With increasing levels of sagebrush in the diet, water, lignin, and nitrogen contents increased in the diet, but decreased in the dung, while fiber components decreased in both the diet and dung. Total nitrogen intake decreased from 1.58±0.041 to 0.406±0.070 g day^{-1} kg metabolic weight^{-1}, and nitrogen retention decreased from 0.80 g day^{-1} kg metabolic weight^{-1} with no sagebrush to a slight loss of nitrogen with 30% sagebrush in the diet. Mountain big sagebrush was not readily consumed by wethers when fed together with grass; as low as 10% sagebrush in the diet seems to adversely influence intake and digestibility. Therefore, when other more favorable forages are not available, sheep and other ruminants with similar physiological responses to mountain big sagebrush may not meet their nutrient requirements through increased sagebrush consumption.

Key Words: livestock nutrition, forage quality, Wyoming

Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana* Rydb. Beetle) is a dominant big sagebrush subspecies in the central Rocky Mountains, forming extensive stands, usually in combination and competition with other shrubs and herbaceous species (Beetle 1960, Beetle and Young 1965). Mountain big sagebrush is reported to be a preferred sagebrush taxon by mule deer in southwestern Montana (Personius et al. 1987, Striby et al. 1987), in eastern Oregon (Sheehy and Winward 1981), and in eastern Utah (Welch et al. 1983), but not in Wyoming (Beetle 1960) or in northcentral Colorado (Dietz et al. 1962). Mountain big sagebrush generally is not preferred by either sheep or cattle (Beetle 1960, Cook et al. 1961, Ngugi et al. 1992), although during January in Utah sheep preferred planted mountain big sagebrush over other browse species in a crested wheatgrass [*Agropyron desertorum* (Fisch. ex Link) J.A. Schultes]-shrub pasture (Gade and Provenza 1986).

Laboratory analyses indicate mountain big sagebrush browse has relatively high nutrient content (Dietz et al. 1962, Striby et al. 1987, Welch and Wagstaff 1992). However, the nutritive value of most sagebrush species, including mountain big sagebrush, is still uncertain because of deleterious effects of substances in sagebrush on digestibility (Johnson et al. 1976).

Mountain big sagebrush is abundant on spring-fall and summer ranges (Beetle 1960), and many mountain big sagebrush plant communities are grazed by livestock as well as big game (Cook et al. 1961). Therefore, if mountain big sagebrush is to be managed in a multiple animal use program, basic information on its nutritive value and its influence on other dietary components for livestock is needed. The objective of this research was to determine the effects of increasing quantities of mountain big sagebrush on dry matter intake and in vivo digestibility of native grass hay fed to wethers.

Methods

A metabolism study was conducted in late fall in Laramie, Wyo., using 16 Rambouillet wether lambs (28–41 kg body weight) raised on sagebrush rangeland in central Wyoming. Four diets were fed in a completely randomized single factor experimental design. Diets consisted of mixtures of hand-harvested current year's growth of mountain big sagebrush leaves and native grass hay. Sagebrush leaves were harvested in September from the western edge of Medicine Bow Range, Carbon County, Wyo., and stored in sealed plastic bags in a freezer until fed.

To reduce feed selectivity, the grass hay was ground through a hammer mill and the browse through a Wiley mill fitted with a 20 mm screen. The Wiley mill was prechilled with dry ice; thus sagebrush remained frozen during grinding.

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Diets were hand-mixed daily (on dry matter basis) in the following proportions of grass hay:sagebrush: 100:0, 90:10, 80:20, and 70:30. The amount fed each day was adjusted on the basis of previous day's voluntary intake, to an amount that would result in about 10% refusal (orts).

The metabolism study consisted of a 24-day pre-treatment adjustment period, during which all wethers were fed grass hay twice per day. Ad libitum intake was determined for all wethers during the last 6 days of the pre-treatment period. Wethers were then fed the assigned diets, allowed a 9-day adjustment period followed by a 6-day total dung and urine collection period. Sheep fed alfalfa hay and big sagebrush may tolerate up to 20–25% sagebrush in the diet if given a 6-day adjustment period, but big sagebrush contains substances highly toxic to sheep if fed without the adjustment period (Johnson et al. 1976). On the sixth day of the adjustment period, all wethers were fitted with harnesses and dung collection bags.

During the collection period, total daily feed intake, orts, dung and urine output were measured and sampled. Samples were composited by animal. Dung samples were stored in plastic bags in a freezer. Urine samples were acidified after collection and stored in air-tight plastic bottles at 5° C. Following the collection period harnesses and dung collection bags were removed and all wethers received ground hay for a 6-day post-treatment period.

Feed, orts, and dung samples were oven-dried at 50° C and then ground through a 1-mm screen of a Wiley mill. Dry matter, organic matter, and total nitrogen were determined according to AOAC (1980). Acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) were determined by the procedures of Goering and Van Soest (1970). Urine samples were analyzed for nitrogen content using the Kjeldahl procedure (AOAC 1980).

To determine if animals were selecting against sagebrush, feed and orts samples were sent to the Composition Analysis Laboratory, Colorado State University, Fort Collins for botanical composition analysis (Sparks and Malechek 1968). Differences in the ratio of grass hay to sagebrush fragments in the diet and orts were attributed to sorting.

Average daily feed intake (g dry matter day^{-1} kg metabolic weight^{-1}) was calculated as the difference between quantity of feed offered and quantity of feed refused. Apparent in vivo dry matter and organic matter digestibility coefficients (%) were calculated as the difference between daily feed intake and daily total dung output, divided by feed intake, and multiplied by 100. All values are expressed on a dry matter basis. Nitrogen balance was calculated by subtracting the grams of nitrogen in the dung and urine from the grams of nitrogen consumed.

Differences in relative density of discerned fragments of sagebrush in diets and orts were tested with the ANOVA (analysis of variance) procedure of SAS (1990). Linear, quadratic, and cubic effects of sagebrush levels were evaluated with single degree of freedom comparisons appropriate for equally spaced treatments (orthogonal polynomials) according to procedures outlined by Snedecor and Cochran (1989). Relationships between and among nutritive characteristics of diets were determined using correlation and regression analysis; the MAXR regression procedure was used to evaluate more than one variable affecting dependent variables (SAS 1990). All differences discussed are significant at $P < 0.05$ unless otherwise stated.

Results and Discussion

Dietary Discrimination

Microhistological analyses of diet and orts samples showed a consistently higher density (3–8 percentage units) of sagebrush fragments in the orts than in the corresponding diets (Fig. 1). Thus, wethers selected against mountain big sagebrush. Assuming the mean percent relative density of discerned sagebrush fragments in each diet indicates the relative proportion by weight of sagebrush in each diet, and because of selection against sagebrush, the actual percentages of sagebrush ingested for the 10, 20, and 30% diets were computed as 11.6±0.06%, 19.2±0.79%, and 28.0±0.57%, respectively.

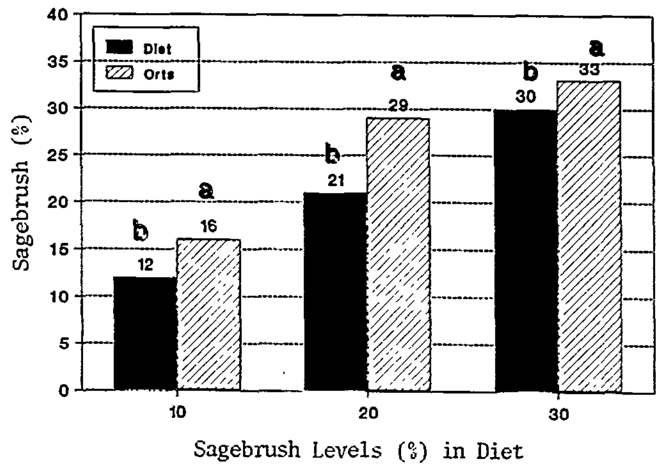

Fig. 1. Mean (N=4) relative density (%) of discerned fragments of sagebrush in diets and orts. Treatment means with a different letter are significantly different at P <0.05.

Dry Matter Intake

All wethers had similar dry matter intakes (i.e., 83 to 93 g day^{-1} kg metabolic weight^{-1}) before being placed on different diets (Fig. 2). However, intakes decreased within 24 hour following the introduction of sagebrush in the diet. Wethers on the 30% sagebrush diet decreased intake from 88 to 23 g day^{-1} kg metabolic weight^{-1}. There was a negative linear relationship between increasing level of sagebrush in the diet and level of intake (Table 1). For each 1% increase in sagebrush in the diet, there was a 2.35 g day^{-1} kg metabolic weight^{-1} decrease in dry matter intake. Sagebrush levels in the diet accounted for 90% of the variation in dry matter intake.

Table 1. Dry matter intake (DMI, mean ± SE, g dry matter day^{-1} kg metabolic weight^{-1}, N=4) and in vivo digestible dry matter (DDM, mean ± SE, %, N=4) relative to sagebrush level.

	Sagebrush Level					P - Value	
Item	0	10	20	30	SEM	L	Q
	(%)						
DMI	93.3±1.9	71.0±7.0	47.8±5.9	22.8± 3.8	9.36	0.01	0.79
DDM	58.8±1.4	47.1±1.5	25.5±6.7	-2.7±10.0	12.15	0.01	0.19

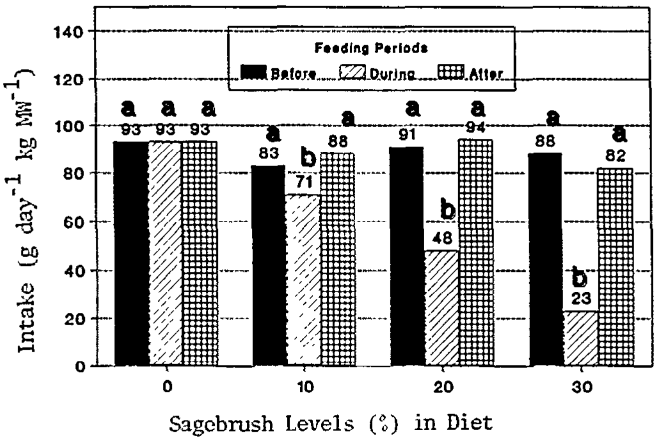

Fig. 2. Mean dry matter intake (g dry matter day^{-1} kg metabolic weight-1) before (6-day pre-treatment average, N = 16), during 6-day treatment, N = 4), and after 6-day post-treatment average, N = 16) the metabolism trial. Treatment means within the same level of sagebrush with a different letter are significantly at *P*<0.05.

Following the removal of sagebrush from the diet, feed intake returned to pre-treatment levels within 24 hours for 15 of the 16 wethers. One of the wethers previously on 30% sagebrush gradually, but consistently increased feed intake to pre-treatment level.

On average, wethers on the 10% sagebrush diet consumed 7.6 g of sagebrush dry matter kg of metabolic weight^{-1} day^{-1} and those on the 20 and 30% sagebrush diets consumed 8.4 and 6.4 g, respectively. Ngugi (1990) reported the sagebrush used in this research contained 2.0% terpenoids (dry matter basis); thus the average daily intake of terpenoids would have been 150, 170, and 130 mg kg metabolic weight^{-1} for wethers on diets of 10, 20, and 30% sagebrush, respectively. Wethers in our study apparently tolerated no more than 170 mg of terpenoids kg metabolic weight^{-1} day^{-1}.

The selection against sagebrush in the diet offered, the immediate drop in feed intake following introduction of sagebrush in the diet, the immediate rise in feed intake upon removal of sagebrush from the diet, and the refusal of wethers to consume over 170 mg kg metabolic weight^{-1} day^{-1} of terpenoids from sagebrush suggests a food aversion similar to those described by Burritt and Provenza (1989), du Toit et al. (1991), and Thorhallsdottir et al. (1987).

Diets containing mountain big sagebrush were not readily consumed by wethers. Therefore, if other more desirable forages are not available, wethers may not meet their daily dry matter requirements by increasing sagebrush consumption. Consequently, their condition will decline.

The average calculated net energy for maintenance intakes for the 4 treatment groups were about 1,400, 1,000, 700 and 400 Kcal day^{-1} with 0, 10, 20, and 30% sagebrush in the diet, respectively. The net energy requirement for maintenance was estimated as 660 Kcal/day^{-1} (NRC 1985). Based on these data, wethers on the 30% sagebrush diet were receiving about 60% of their maintenance energy requirements.

Similar studies involving determination of intake and/or digestibility of sagebrush or diets containing sagebrush at subspecies level are not available in the literature. Although Smith et al. (1966) reported the influence of varying levels of big sagebrush (*Artemisia tridentata* Nutt.) on diet intake and digestibility, the non-sagebrush composition of the diets used varied with different levels of sagebrush in the diet and thus confounded the influence of level of big sagebrush on intake and digestibility. Also, the diet composition was apparently reported on an as-fed basis and thus levels of big sagebrush (dry matter basis) in diets would be much lower than the reported 13, 22, 35, and 45% sagebrush.

Sheehy and Winward (1981) evaluated the relative preferences of free-roaming mule deer and sheep for 7 sagebrush taxa in Oregon. They observed sheep consumed, but did not prefer, mountain big sagebrush compared to the other 6 sagebrush taxa. Striby et al. (1983) using big sagebrush leaves from Montana with about 25% of their volatile oils removed by solvent extraction, reported 77 g and 78 g kg metabolic weight^{-1} as daily intakes of offered alfalfa hay or a mixture of 37% big sagebrush and 63% alfalfa hay, respectively.

In Vivo Digestible Dry Matter

In vivo digestible dry matter (DDM) decreased from 59% for grass hay and no sagebrush to 0.0% for the diet containing 30% sagebrush (Table 1). In vivo organic matter digestibility coefficients were very similar to those for in vivo dry matter. In vivo digestible dry matter was highly correlated (r = 0.93) with dry matter intake. Sagebrush levels in the diet accounted for 80% of the variation in in vivo digestible dry matter. For each 1% increase in sagebrush in the diet, there was a 2.1% decrease in in vivo digestible day matter.

Decreases in in vivo digestibility of the diet with increasing levels of sagebrush in the diet indicate sagebrush interfered with the digestive processes. These results are contrary to those of Smith et al. (1966) who reported big sagebrush had no effect on digestibility. The difference may be due to differences between the sagebrush subspecies used in the 2 studies. Moreover, as previously mentioned, the level of sagebrush in the diet on a dry matter basis and the lack of the same feeds at all levels of dietary sagebrush confounded the effects in the previously mentioned study.

Welch and Wagstaff (1992) concluded that too much emphasis has been made concerning the negative influence of monoterpenoids on microbial digestion. However, volatile compounds in big sagebrush inhibited digestion of grass cell walls (Hobbs et al. 1986) and extraction of non-volatile terpenoids from sagebrush increased in vitro organic matter digestibility by 12.3% (Striby et al. 1987). Big sagebrush also contains highly lignified, indigestible cell walls, surrounding a large and relatively digestible fraction of cell solubles (Kufeld et al. 1981).

Relatively high in vitro dry matter digestibility figures have been reported for mountain big sagebrush by Striby et al. (1987) (45.4–52.7%; IVOMD; inoculum), Welch and Pederson (1981) (48.7–55.8%), and Welch and Wagstaff (1992) (52.6 ± 2.6%). However, the relationship between in vivo digestibility and in vitro digestibility for big sagebrush needs additional study. Of the 13 forages subjected to both in vivo and in vitro digestibility trials for mule deer by Urness et al. (1977), big sagebrush was the only forage for which in vitro digestibility (62%) exceeded in vivo digestibility (54%).

Antimicrobial action of volatile oils is well documented (Maruzzella and Lichtenstein 1956, Nagy et al. 1964, Oh et al.

Table 2. The average chemical composition (mean±SE, %, N=16) of the grass hay and sagebrush consumed by the wethers. Means per chemical followed by a different letter are significantly different at $P<0.05$.

Chemical[1]	Feed Material	
	Grass	Sagebrush
	%	
NDF	67.7±0.5a	31.0±0.3b
ADF	40.5±0.4a	22.0±0.4b
Cellulose	30.5±0.3a	14.0±0.4b
Ash	8.6±0.2a	5.3±0.3b
ADL	7.9±0.1b	9.0±0.5a
Nitrogen	1.7±0.02b	2.0±0.3a

[1] NDF - neutral detergent fiber; ADF - acid detergent fiber; ADL - acid detergent lignin;

1968, Wallmo et al. 1977). Maruzzella and Lichtenstein (1956) reported that 91% of plant volatile oils tested exhibited an inhibitory effect on gram positive and gram negative bacteria. Using in vitro techniques, Nagy et al. (1964) found monoterpenoids from big sagebrush suppressed the growth of rumen microorganisms from mule deer. Thus, one explanation for the depression in in vivo digestible day matter is the influence of volatile oils on rumen microorganisms. A depression of rumen microbial activity would result in a decrease in dry matter digestibility. Whether there are other factors influencing diet digestibility is not known at this time.

Forage Components, Diet, and Dung Chemical Composition

The average chemical composition (%) of the grass hay and sagebrush, consumed by the wethers is shown in Table 2. Grass hay was higher in fiber and ash; sagebrush was higher in lignin and nitrogen.

The values for the diet differed slightly from the values for forage components in the material offered because of animal selection against sagebrush. The greatest variation (i.e., selection) among wethers for different components in intake was for ADL (CV = 15%) and the least variation was for ADF (CV = 6%). Diet and dung chemical composition relative to sagebrush level is shown in Table 3.

A comparison of orthogonal polynomials showed the relationships between sagebrush levels and most of the chemical components in the diet and in the dung were best described by linear relationships rather than by quadratic or cubic relationships; the exceptions are noted. Water content (%) in the diet increased rapidly with increasing levels (%) of sagebrush; however, water content in the dung decreased rapidly with increasing levels of sagebrush in the diet. Although water intake was not measured, wethers on diets of 20% and 30% sagebrush were observed to drink less water than those on 0% or 10% sagebrush. Urine output (ml urine kg metabolic weight^{-1}) was not highly correlated with sagebrush level ($r = -0.44$), but tended to decrease with increasing levels of sagebrush in the diet. The low dung water content, low water intake, and low urine volume of wethers on diets with higher amounts of sagebrush were similar to the results of Powell and Arnold (1986) studying metabolism of wethers on diets of variable forage quality.

A quadratic relationship between neutral detergent fiber (NDF) contents (%) and sagebrush levels (%) in the diet indicated a relatively sharp decline in NDF contents in the diet of wethers on all grass hay to those on a diet of 10% sagebrush and relatively less difference in NDF contents in the diets of wethers on 10, 20, and 30% sagebrush levels. The relationship between sagebrush levels (%) in the diet and NDF contents (%) in the dung was linear.

The relationship between acid detergent fiber (ADF) contents and sagebrush levels in the diet ($r = -0.37$) was similar to that between NDF contents and sagebrush levels in the diet, but significant at only the 16% level. However, ADF contents (%) in the dung were highly correlated with sagebrush levels in the diet. With increasing levels of sagebrush in the diet, cellulose levels (%) decreased linearly in the diet and in the dung. Increasing levels of sagebrush in the diet increased lignin contents (ADL, %) in the diet and decreased ash contents (%) in the diet. Relationships between sagebrush levels in the diet and either lignin contents in the dung ($r = -0.18$) or ash contents in the dung ($r = -0.21$) were negative, but relatively weak.

Neutral detergent fiber in the diet was the best chemical predictor of both dry matter intake and in vivo digestible day matter; it accounted for 70% of the variation in dry matter intake values and 66% of the variation in in vivo digestible day matter values (Table 4). For each 1% increase in NDF contents in the diet, there

Table 3. Diet and dung chemical composition (mean ± SE, %, N=4) relative to sagebrush level.

Chemical[1]		Sagebrush in Diet				SEM	P-Value	
		0	10	20	30		L	Q
		%						
Water	Diet	11.2±2.4	26.7±1.3	37.5±4.3	46.8±2.4	5.46	0.01	0.27
	Dung	61.1±1.9	57.1±1.7	53.1±2.1	50.1±2.2	3.66	0.01	0.80
NDF	Diet	67.5±0.5	60.5±0.8	58.7±1.3	55.9±1.3	2.31	0.01	0.07
	Dung	59.9±1.8	57.0±0.8	55.8±0.3	54.9±0.2	1.91	0.01	0.33
ADF	Diet	40.2±0.4	37.4±0.7	38.2±0.4	37.6±1.9	2.11	0.16	0.30
	Dung	43.6±0.3	42.7±0.5	42.2±0.3	40.8±0.3	0.66	0.01	0.54
Cell.	Diet	30.1±0.3	28.1±0.6	27.1±0.3	26.7±1.2	1.36	0.01	0.24
	Dung	26.8±0.6	26.5±0.6	26.8±1.0	25.0±0.9	1.54	0.18	0.33
ADL	Diet	7.8±0.8	7.3±0.4	9.2±0.5	9.2±0.9	1.16	0.04	0.63
	Dung	11.6±0.9	11.1±0.4	10.5±1.0	11.6±0.6	1.28	0.51	0.41
Ash	Diet	8.7±0.3	8.1±0.2	8.4±0.2	7.5±0.2	0.46	0.01	0.49
	Dung	10.9±0.8	9.5±1.0	9.7±0.3	10.1±0.2	1.30	0.43	0.19

[1] DM - Dry matter; ADF - acid detergent fiber; NDF - neutral detergent fiber;
ADL - acid detergent lignin; Cell. - cellulose;

Table 4. Regression equations used to predict dry matter intake (g) per metabolic weight and in vivo digestibility (%). All regression coefficients are significant at $P<0.05$. (N = 16).

Y_i[1]	b_0	b_1	X_1	b_2	X_2	b_3	X_3	R^2	F
DMI	-245	+5.0	NDF					0.70	32.4
	-127	+4.1	NDF	- 7.7	ADL			0.80	26.1
	-156	+2.8	NDF	- 9.1	ADL	+15.0	ASH	0.85	22.9
	+94	- 2.3	SAGE					0.90	125.9
DDM	-241	+4.5	NDF					0.66	26.9
	- 86	+3.3	NDF	-10.1	ADL			0.86	40.9
	-109	+2.3	NDF	-11.2	ADL	+11.8	ASH	0.90	35.9
	+ 63	- 2.1	SAGE					0.80	57.4

[1] DMI = Dry matter intake (g day^{-1} kg metabolic weight^{-1}); DDM = In vivo digestible dry matter (%); NDF = Neutral detergent fiber in diet (%); ADL = Acid detergent lignin in diet (%); ASH = Ash in diet(%); SAGE = Sagebrush levels (%) in diet;

was a corresponding 5.0 g dry matter day^{-1} kg metabolic weight^{-1} increase in dry matter intake and 4.5% increase in in vivo digestible day matter.

In general NDF reflects the positive effect of grass, and ADL reflects the negative effect of sagebrush in the diet. Additional research should be conducted to determine whether NDF and ADL are equally good predictors of dry matter intake and digestible day matter for other herbage—browse diets.

Nitrogen (N) Balance

Dietary nitrogen contents increased from 1.67±0.01 to1.82±0.06% with increasing levels of sagebrush in the diet (Table 5). Diets with the higher proportions of sagebrush had slightly higher nitrogen contents because sagebrush had a higher nitrogen content than the grass hay. Dung nitrogen varied little among diets, but urinary nitrogen concentrations (%) declined sharply with increasing sagebrush levels. In addition, nitrogen digestibility (%) declined sharply from 64.1±1.7% for grass hay only to 10.1%±12.3 for the diet with 30% sagebrush. Ruminants consuming shrub diets high in soluble phenolics/tannins frequently have reduced nitrogen digestibility, elevated dung nitrogen concentrations, and reduced nitrogen retention (Mould and Robbins 1981, Nastis and Malechek 1981, Wofford et al. 1985).

Total daily nitrogen intake (g N day^{-1} kg metabolic weight^{-1}) steadily decreased as levels of sagebrush in the diet increased. Dung nitrogen losses (g N day^{-1} kg metabolic weight^{-1}) also decreased with increasing levels of sagebrush in the diet.These were mainly a function of reduced dry matter intake by the wethers.

Urinary nitrogen losses (g day^{-1} kg metabolic weight^{-1}) among individual wethers on the 20% and 30% sagebrush diets were highly variable, but nitrogen losses declined with increasing levels of sagebrush. Wethers on the higher levels of sagebrush had low urine output (ml day^{-1} kg metabolic weight^{-1}) as well as low urinary nitrogen concentrations.

The amount (g N day^{-1} kg metabolic weight^{-1}) of nitrogen retained by wethers decreased with increasing sagebrush levels in the diet. It ranged from 0.80 g nitrogen day^{-1} kg metabolic weight^{-1} on the grass hay diet to a slight loss of nitrogen at the highest level of sagebrush. Although much of the ingested protein may have been metabolized to generate energy, the major limitation was the 5-fold decrease in total nitrogen intake with increasing concentrations of sagebrush in the diet. In a similar study with Angora goats in which 6 different shrub species, including big sagebrush, each comprised 30% of different shrub-prairie hay-straw diets, the sagebrush diet produced the lowest intake of OM (0.9% of body weight) and nitrogen (5.0 g day^{-1}) and the lowest nitrogen retention (–2.7 g day^{-1}) (Nunez-Hernandez et al. 1989).

Management Implications

Results of this metabolism study indicate mountain big sagebrush will and should comprise only a small part of the diet of wethers on mountain big sagebrush ranges. Therefore, in a shrub management program designed to benefit both sheep and big game habitat, benefits to sheep from maintaining or increasing mountain big sagebrush can not be justified.

Table 5. Mean (N=4) and standard error for dietary, dung and urinary nitrogen contents, nitrogen digestibility (%), and total nitrogen intake, dung and urinary nitrogen loss, and nitrogen balance (g day^{-1} kg metabolic weight^{-1}).

	Sagebrush (%) in Diet					P-Value	
	0	10	20	30	SEM	L	Q
Dietary N (%)	1.67±0.01	1.65±0.01	1.77±0.03	1.82±0.06	0.17	0.28	0.71
Dung N (%)	1.48±0.04	1.55±0.04	1.51±0.01	1.53±0.02	0.06	0.35	0.44
Urine N (%)	0.28±0.03	0.25±0.06	0.17±0.02	0.11±0.03	0.07	0.01	0.61
Digest. N (%)	64.1±1.7	50.2±2.0	36.8±4.5	10.1±12.3	12.9	0.01	0.34
Total N intake	1.58±0.041	1.17±0.123	0.84±0.086	0.406±0.070	0.16	0.01	0.89
Dung N	0.57±0.016	0.58±0.058	0.52±0.022	0.341±0.015	0.08	0.01	0.01
Urine N	0.22±0.036	0.24±0.094	0.13±0.028	0.065±0.020	0.10	0.03	0.41
N balance	0.80±0.081	0.35±0.103	0.19±0.040	-0.00033±0.049	0.16	0.01	0.10

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