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'Hobble Creek' big sagebrush vs. antelope bitterbrush as a winter forage

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Abstract

From a planting of antelope bitterbrush (*Purshia tridentata* Purshia DC) and 'Hobble Creek' mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana* Rydb. Beetle), pairs of plants were selected to test the following 2 hypotheses: (1) wintering mule deer (*Odocoileus hemionus hemionus*) prefer (as measured by percent use and/or grams of dry matter removed) 'Hobble Creek' big sagebrush over antelope bitterbrush, and (2) the winter nutrient content of 'Hobble Creek' forage exceeds that of antelope bitterbrush. Results of this study support the 2 hypotheses. 'Hobble Creek', a monoterpenoid-producing shrub, was preferred by wintering mule deer over a nonmonoterpenoid-producing shrub, antelope bitterbrush. Also, 'Hobble Creek' nutrient content was superior to that of antelope bitterbrush.

Key Words: ***Artemisia tridentata*, mule deer, nutrition, *Odocoileus hemionus hemionus*, palatability, preference, *Purshia tridentata***

Big sagebrush (*Artemisia tridentata* Nutt.) is an important winter forage for wintering mule deer *(Odocoileus hemionus hemionus)* in the Rocky Mountains (Smith 1950, Leach 1956, Kufeld et al. 1973). However, its use in range seeding projects is limited. The perception that big sagebrush is largely unsuitable and unused is due to low palatability to cattle and its ability to quickly mask evidence of use. These 2 characteristics have led to many negative statements in the literature, such as: "An excellent case in point is the experience with *Artemisia tridentata,* which in the winter has a crude protein content of over 11% (Welch and McArthur 1979) and on this basis should be an excellent winter feed source for wildlife and livestock. However, *A. tridentata* is of limited palatability to most animals. The low palatability appears to be related to high monoterpenoid content" (McKell 1989); or "big sagebrush is a forage of last choice" (Nagy et al. 1964, Nagy and Tengerdy 1968, Dietz and Nagy 1976, Nagy 1979). Yet these statements conflict with our observations that on several winter ranges mule deer browsed heavily on big sagebrush first, in spite of the availability of other species of shrubs. Can it be possible that mule deer preferred big sagebrush or some forms of big sagebrush over other species of shrubs?

To quantify our field observations and those of others (Leach 1956, Welch and Andrus 1977) and to answer the above question, we designed this study to compare wintering mule deer preference, monoterpenoid, and nutrient content of 'Hobble Creek' mountain big sagebrush (Welch et al. 1986) to antelope bitterbrush (*Purshia tridentata* Purshia DC).

Hypotheses tested were: (1) wintering mule deer prefer (as measured by percentage of use or grams of dry matter removed) 'Hobble Creek' big sagebrush over antelope bitterbrush, (2) monoterpenoid content of 'Hobble Creek' exceeds that of antelope bitterbrush, and (3) winter nutrient content of 'Hobble Creek' big sagebrush exceeds that of antelope bitterbrush.

Methods

On a mule deer winter range located about 5 km south of Provo, Utah, about 400 'Hobble Creek' containerized transplants were planted on a 2.1-m grid (Nelson 1984). Three years prior, bare root stock of antelope bitterbrush had been transplanted on the same site. Source of the antelope bitterbrush was unknown. The bitterbrush had been planted on a 1.5-m grid. Four years after planting the 'Hobble Creek' plants, both species of plants were about 0.3 m in height with equal numbers of surviving plants. Their limited growth was largely explained by heavy browsing during winter by mule deer (data on file Shrub Science Lab).

Fifteen plant pairs ('Hobble Creek'-antelope bitterbrush) were selected to measure preference. Fifteen 'Hobble Creek' plants were selected at random and paired with the nearest antelope bitterbrush plant. Mean distance between plant pairs was 1.2 ± 0.60 m. An additional 10 plant pairs were selected at random for determining monoterpenoid and nutrient content.

To determine preference, 10 shoots on each plant were chosen at random throughout the entire crown of all test plants. These shoots were numbered and tagged with plastic tape just below the terminal bud scale (bitterbrush) or growth leaf scars (sagebrush). Prior to browsing, distance between growth leaf scars and end of terminal leaves for the big sagebrush and terminal bud scale scars and terminal bud for antelope bitterbrush was measured to the nearest millimeter. During the browsing period, distance from the terminal bud scale or growth leaf scars to end of browsed shoot was measured. We assumed that with equal availability the more utilized forage is the preferred forage.

As an alternate method for determining preference, we determined the number of grams of dry matter (DM) removed from the 10 marked shoots per plant for each measuring date. This was accomplished by determining the grams of dry matter per centimeter of shoot. Dry weight per centimeter of shoot was determined by removing a shoot from each of the 20 (10 pairs) plants used in the monoterpenoid-nutrient study. Shoots were measured to the nearest 0.01 cm, oven dried at 100° C for 72 hours, and weighed. A mean DM weight per centimeter of shoot was calculated for the 2 plant groups. Grams of dry matter removed per 10 shoots per plant were calculated by multiplying length of shoot eaten, measured to 0.01 cm, by mean number of grams of DM per centimeter.

Deer, 35 in number, were first sighted on the study site 3 December 1988. Our first measurements were taken that day. Plants were subsequently measured every 5th to 6th day. The last measurements were taken on 19 December 1988. Shortly after this date, heavy accumulation of snow limited movement of the deer and availability of plants. Prior to this, deer had unrestricted

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movement and freedom to choose among several shrub species, dried and green grasses, and dried forbs. Therefore, any browsing on test plants was by choice.

Current year's growth was removed from the 20 paired plants on 25 November 1988 to determine monoterpenoid and nutrient content. Shoots from individual plants were stored in plastic bags at 0° C. In vitro digestibility, crude protein, phosphorus, and monoterpenoids were measured. In vitro digestibility was determined by using the technique outlined by Pearson (1970). As suggested by Clary et al. (1988) 2 donor animals were used (Because of homogeneity of variance the 2 trials were pooled). Inocula were obtained from slaughtered steers. Welch et al. (1983a) and Striby et al. (1987) found that inocula sources did not have a significant effect on the in vitro digestibility of range forages. The CO_2 injected inocula was processed within 45 minutes after removal from the rumen (Milchunas and Baker 1982). Crude protein levels were determined by measuring the amount of Kjeldahl nitrogen (Association of Official Analytical Chemists 1980) and multiplying the results by 6.25. Phosphorus levels were determined by the phosphomolybdenum method (Association of Official Analytical Chemists 1980). Monoterpenoid analyses were performed by the method outlined by Welch and McArthur (1981). Nutrient values were expressed on a DM basis. Data were statistically analyzed by use of paired T tests. Significance level was 5%.

Results

Weight of dry matter per centimeter of shoot was significantly greater for 'Hobble Creek' than for antelope bitterbrush (0.07 g vs. 0.02 g/cm of shoot). Mean shoot lengths for the 2 plants species were 12.9 cm for 'Hobble Creek' and 12.8 cm for antelope bitterbrush. Mean shoot diameter near growth leaf scars was significantly larger for 'Hobble Creek' than for antelope bitterbrush (2.25 vs. 1.61 mm). The test plants of both species were of equal numbers, equal height, and equal shoot length and pairs were in close proximity (i.e., availability of both species to deer was equal).

Mean usage, expressed as percentage of current year's growth removed, was not significantly different at the first 2 measurement dates, but did differ for the final 2 (Table 1).

Table 1. Preference of wintering mule deer for 'Hobble Creek' mountain big sagebrush and antelope bitterbrush. Preference is expressed as percentage of current year growth removed per measurement data. Data are means and standard deviations for 15 interspecific pairs of plants.

Dates	Hobble Creek	Antelope bitterbrush
	(% used)	
3 Dec 1988	22.8 ± 26.0a[1]	20.6 ± 19.5a
8 Dec 1988	40.3 ± 22.9a	31.9 ± 22.9a
12 Dec 1988	66.4 ± 8.9a	46.6 ± 21.0b
19 Dec 1988	68.3 ± 8.8a	52.3 ± 22.7b

[1]Any 2 means sharing the same letter within a date are not significantly different at the 5% probability level (Paired t-test).

When usage was expressed as grams of DM removed from the 10 marked shoots per plant, 'Hobble Creek' was significantly more heavily utilized than antelope bitterbrush throughout the study period (Table 2). Mean weight of DM removed from the 10 shoots per plant per measuring period ranged from 2.00 to 6.13 grams for 'Hobble Creek' and from 0.53 to 1.33 for antelope bitterbrush (Table 2). This second data set for preference represents the adjustment made for difference in shoot weight between the 2 species.

Big sagebrush was significantly more digestible than antelope bitterbrush (52.6% vs. 30.0%, Table 3) and higher in crude protein content 10.5% vs. 6.0%. Mean phosphorus levels were greater for 'Hobble Creek' compared to antelope bitterbrush (Table 3). Mean total monoterpenoid level in the big sagebrush was 2.11% of DM compared with no detectable levels of monoterpenoids in antelope bitterbrush.

Table 2. Preference of wintering mule deer for 'Hobble Creek' mountain big sagebrush and antelope bitterbrush. Preference is expressed as grams of dry matter removed per 10 shoots per plant per measurement date. Data are means and standard deviations for 15 interspecific pairs of plants.

Dates	Hobble Creek	Antelope bitterbrush
	(g)	(g)
3 Dec 1988	2.00 ± 2.67a[1]	0.53 ± 0.57b
8 Dec 1988	3.60 ± 2.10a	0.84 ± 0.64b
12 Dec 1988	5.97 ± 1.17a	1.19 ± 0.59b
19 Dec 1988	6.13 ± 1.01a	1.33 ± 0.62b

[1]Any 2 means sharing the same letter within a date are not significantly different at the 5% probability level (Paired t-test).

Table 3. Comparison of winter nutrient content between 'Hobble Creek' mountain big sagebrush and antelope bitterbrush. Data given for 10 interspecific pairs of plants. Data are means and standard deviations expressed as a percentage of dry matter.

Nutrients	Hobble Creek	Antelope bitterbrush
	(% dry matter)	
In vitro digestion	52.6 ± 2.6a[1]	30.1 ± 2.8b
Crude protein	10.5 ± 0.9a	6.0 ± 0.5b
Phosphorus	0.18 ± 0.1a	0.1 ± 0.01b

[1]Any 2 means within a nutrient sharing the same letter are not significantly different at the 5% probability level (Paired t-test).

Discussion

Results, expressed on a percentage of use and on a weight removed basis, indicated mule deer preferred 'Hobble Creek' big sagebrush over antelope bitterbrush. These observations are supported by 3 reports in the literature. First, Leach (1956) noted a marked shift in the diet of California mule deer from antelope bitterbrush in the fall to big sagebrush in the winter. He stated (Leach 1956:279) that "the low utilization of antelope bitterbrush in the winter could not always be attributed to the unavailability of antelope bitterbrush forage." In other words, deer chose to eat big sagebrush in the winter. Secondly, Welch and Andrus (1977), studying rose hip use by wintering mule deer in Utah, reported that at first only "vasey big sagebrush" and Woods rose (*Rosa woodsii* Lindl.) showed signs of being heavily browsed by deer. Antelope bitterbrush and black chokecherry (*Prunus virginiana* L.) in the study site were not heavily browsed for another month. Thirdly, Gade and Provenza (1986) reported that percentages of mountain big sagebrush were higher in the winter diet of domestic sheep than antelope bitterbrush and 5 other species of shrubs and green crested wheatgrass (*Agropyron desertorum* Link Schult.).

Our results concur with previous studies (Welch et al. 1981) and challenge the theory that big sagebrush is consumed by mule deer in the late winter or "very early spring" as a starvation food.

The high digestibility of 'Hobble Creek' (52.6%) indicated it exceeds the maintenance requirements for energy (Ammann et al. 1973). Similarly, the crude protein content of 10.5 exceeds the crude protein requirements of mule deer (Welch 1989). Maintenance requirement for phosphorus is about 0.25% of dry matter (Welch 1989). 'Hobble Creek' and all other winter forages do not meet this requirement except for some grasses that green up in the fall (Welch 1989). Unfortunately, deep snow can cover up the grass making it unavailable. The higher phosphorus content in big sagebrush could reduce the severity of the phosphorus deficiencies in mule deer.

Data presented by Carpenter et al. (1979) support the idea that big sagebrush can help meet the maintenance requirement of wintering mule deer. They were studying the dietary selection of 6 mule deer on an enclosed Wyoming big sagebrush winter range (*A.t.* ssp. *wyomingensis* Beetle and Young). As a subspecies, Wyoming big sagebrush is not as preferred by wintering mule deer as mountain big sagebrush (Welch et al. 1986). However, Carpenter et al. (1979) found that the majority of the animals were either gaining weight or maintaining weight at the peak of Wyoming big sagebrush consumption. They did suggest that, due to the presence of monoterpenoids in the Wyoming big sagebrush, big sagebrush in excess of 30% in the diet is detrimental to mule deer nutritional health.

It has been suggested that monoterpenoids of big sagebrush have a negative influence not only on microbial digestion but also on shrub preference or palatability (Wallmo and Regelin 1981, MeKell 1989). Welch and Pederson (1981) discovered during an in vitro digestion trial that monoterpenoids were driven out of the digestive solution by volatilization. From this observation, they hypothesized that monoterpenoid levels in the digestive system could be reduced to a nontoxic level. Later studies conducted on 5 different species of animals supported the Welch and Pederson (1981) hypothesis (Cluff et al. 1982, White et al. 1982, Foley et al. 1987, Welch et al. 1989).

Results of the monoterpenoid determinations from this study do not support the contention that these compounds have a negative influence on preference, nor do they concur with the statement of McKell (1989) quoted in the introduction of this paper. Welch et al. (1983b) reported no significant relationship between monoterpenoid content and wintering mule deer preference for accessions of big sagebrush containing various amounts of monoterpenoids. We believe that too much emphasis has been and continues to be made concerning the negative influence of monoterpenoids on microbial digestion and preference.

Summary

Our 2 hypotheses were supported. 'Hobble Creek' mountain big sagebrush, a monoterpenoid producing shrub, was preferred by wintering mule deer over a nonmonoterpenoid shrub-antelope bitterbrush. Also, 'Hobble Creek' nutrient content was superior to that of antelope bitterbrush. The authors can supply small lots of 'Hobble Creek' seed to those who wish to conduct similar studies.

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