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SELECTION OF BIG SAGEBRUSH BY SAGE GROUSE

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ABSTRACT.—Feeding sites of wintering sage grouse (*Centrocercus urophasianus*) were located, one each in stands of three subspecies of big sagebrush (*Artemisia tridentata*: ssp. *tridentata*, basin; ssp. *vaseyana*, mountain; and ssp. *wyomingensis*, Wyoming). Evidences of differential use of plants within subspecies were observed. Whole leaves from fed-on and nonfed-on big sagebrush plants were examined for intrasubspecies chemical comparisons of crude protein, phosphorus, in vitro digestibility, and monoterpenoids. No significant differences were detected except for in vitro digestibility of Wyoming fed-on and nonfed-on big sagebrush and monoterpenoid content of basin big sagebrush. Nutritive content of all three subspecies was high, which may in part help to explain wintering sage grouse weight gains.

Smith (1950) was the first to report differential preference of a wintering animal, mule deer (*Odocoileus hemionus hemionus*), for individual plants of big sagebrush (*Artemisia tridentata*). Since then, other workers have reported differential preference of mule deer not only for individual plants but for subspecies of big sagebrush and accessions within subspecies (Plummer et al. 1968, Scholl et al. 1977, Willms et al. 1979, Sheehy and Winward 1981, Welch and McArthur 1986, Personius et al. 1987). Other animal species also express differential preference for individual plants, subspecies, and accessions within subspecies of big sagebrush. These include domestic sheep (*Ovis aries*, Sheehy and Winward 1981, Welch et al. 1987), pygmy rabbit (*Brachylagus idahoensis*, White et al. 1982), and sage grouse (*Centrocercus urophasianus*, Remington and Braun 1985). The last species, sage grouse, is the subject of this investigation.

Wintering sage grouse have a near-obligate relationship with sagebrush, particularly big sagebrush (Braun et al. 1977, Autenrieth 1981, Roberson 1986). Leaves of sagebrush are the primary winter food for sage grouse (Patterson 1952, Wallestad et al. 1974). The Remington and Braun (1985) report is the first evidence that sage grouse may[3] express differential preference for subspecies of big sagebrush and for individual plants within subspecies. The purpose of our study was to locate wintering sage grouse fed-on and nonfed-on big sagebrush plants in stands of three subspecies of big sagebrush (*A. t.* ssp. *tridentata*, basin; *A. t.* ssp. *vaseyana*, mountain; *A. t.* ssp. *wyomingensis*, Wyoming) and to watch for evidence that might support the report of Remington and Braun (1985) that sage grouse show preferential use among subspecies and individuals within subspecies. Also, the nutritive value was determined for leaves from fed-on and nonfed-on plants.

STUDY SITE

The study area, on the Awapa Plateau near Loa, Utah, in western Wayne County, supports a population of sage grouse. Specific study sites were Jake's Knoll on sections 22 and 23 (R1E, T29S), Vance Reservoir on sections 10 and 11 (R1E, T29S), Elsie's Nipple on section 33 (R2E, T28S), and a Wyoming big sagebrush flat south of State Highway 24 about 12.9 km west of Loa, on sections 2 and 7 (R1E, T27S).

Elevations range from the Jake's Knoll site at about 2,650 m to the Elsie's Nipple site at about 2,500 m. Black sagebrush (*A. nova*) and mountain big sagebrush were the dominant shrubs at the Jake's Knoll and Vance Reservoir

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[3]We do not fully accept the interpretation of the data presented in the Remington and Braun (1985) report concerning the preferential use of Wyoming big sagebrush over mountain big sagebrush by wintering sage grouse. Data in their Table 1 suggest two to one that the use of Wyoming and mountain big sagebrush is a function of occurrence and not palatability differences between the two kinds of big sagebrush. We believe their random sample method is biased because portions of mountain big sagebrush grow at the bottom of draws where sage grouse seldom feed. Consequently, part of their perceived preferential use could be due to feeding habit and not to palatability differences.

sites. Mountain big sagebrush on these two sites was limited to the bottom of drainages, northern exposures, and swells where water tends to concentrate. Black sagebrush was distributed on the flats and on southern exposures. In the Elsie's Nipple site, basin big sagebrush and Utah juniper (*Juniperus osteosperma*) were the dominant shrubs. On the site south of State Highway 24, Wyoming big sagebrush was the dominant shrub.

MATERIALS AND METHODS

Feeding sites, one each for three subspecies of big sagebrush, were located with the aid of radio-collared sage grouse (Hulet et al. 1986). At each feeding site, fed-on and nonfed-on plants were tagged and mapped. A plant had to meet certain criteria to be selected as a nonfed-on plant and to remain as such for this study. The criteria were: (1) no signs of being fed on by sage grouse or any other animal, (2) presence of fresh sage grouse tracks or droppings around or through the plant, (3) within 1.5 m of a fed-on plant, and (4) remained a nonfed-on plant while sage grouse were feeding on the sites for at least two weeks. These four criteria increased the probability that the selected nonfed-on plants were really plants that the sage grouse were discriminating against. Careful and close—on hands and knees—inspection was required to identify nonfed-on plants.

In early February 1984, vegetative samples of current year's growth were removed from five fed-on and five nonfed-on plants on three sites supporting stands of one of three subspecies of big sagebrush. Samples were placed in individual plastic bags, packed in snow inside a cooler, and transported to a laboratory freezer. Frozen whole leaves were separated from stems with a pair of small surgical scissors and were then kept frozen by placing them inside a 1-L, stainless steel, wide-mouth vacuum bottle containing 500 ml of liquid nitrogen. Later all leaves were poured out of the vacuum bottle into a strainer. After the liquid nitrogen evaporated, the leaves were placed in a plastic bag, sealed, and stored in a freezer until needed for grinding. Grinding was done inside the mortar of a steel, motorized mortar and pestle that had been precooled twice with liquid nitrogen. Liquid nitrogen was then poured over the leaves and the leaves ground to a fine powder. The leaf material was placed in a plastic bottle with airtight cap after grinding and stored in a freezer until needed for chemical analysis.

Chemical determinations made on the samples were dry matter, monoterpenoids, in vitro digestibility, crude protein, and phosphorus. Dry matter was determined by oven drying at 100 C until constant weight was achieved, usually after 48 hours. Monoterpenoids were extracted and analyzed by the method outlined by Welch and McArthur (1981). This method is based on Soxhlet extraction with absolute ether and gas chromatographic analysis. Concentration of monoterpenoids was expressed on a dry-matter basis. Pearson's (1970) method was used to determine in vitro digestibility of ground leaves. Rumen inoculum was obtained from a slaughterhouse steer (Welch et al. 1983, Striby et al. 1987). Digestibility data were expressed as a percentage of dry matter digested. Crude protein was determined by the Kjeldahl method (Association of Official Analytical Chemists 1980); and the data were expressed as a percentage of dry matter. Phosphorus was determined by wet digestion-spectrophotometric method (Association of Official Analytical Chemists 1980); and the data were expressed as a percentage of dry matter. Unpaired t-tests ($P = .05$) were used to compare fed-on and nonfed-on plants within subspecies for the various chemical determinations.

RESULTS AND DISCUSSION

This study supports and extends the field observations of Remington and Braun (1985) concerning sage grouse preferential use of individual plants within subspecies of big sagebrush. Because the stands of subspecies in our study area were disjunct, we were unable to make any judgments concerning selection at the subspecies level.

On four occasions we observed the feeding behavior of sage grouse for 2 hours. We saw a general wandering by the birds among the sagebrush plants, as if they were inspecting the plants. Then, for no apparent reason, one bird would start eating the leaves of a plant. Often (60% or more of the time) a feeding bird would be joined by others. In these groups there appeared to be no particular

TABLE 1. Nutritive comparison between leaf tissue of fed-on and nonfed-on plants of big sagebrush for wintering sage grouse. Each subspecies of big sagebrush is represented by five fed-on and five nonfed-on plants. Data expressed as a percentage of dry matter. Data statistically analyzed by unpaired t-test comparison between fed-on and nonfed-on plants within subspecies.

Subspecies	Crude protein %	Phosphorus %	In vitro digestibility %
A. t. ssp. *vaseyana*			
fed-on	9.5	0.18	56.4
nonfed-on	9.2	0.18	55.8
A. t. ssp. *tridentata*			
fed-on	14.9	0.21	60.0
nonfed-on	15.4	0.22	57.8
A. t. ssp. *wyomingensis*			
fed-on	12.3	0.20	58.4[a]
nonfed-on	12.6	0.19	54.1

[a]T-test detected significant difference between the two means for in vitro digestibility for *A. t.* ssp. *wyomingensis* at the 5% probability level.

TABLE 2. Comparisons between the monoterpenoid levels of wintering sage grouse fed-on and nonfed-on plants of mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*, leaf tissue). Data expressed on a dry-matter basis. Unpaired t-tests used to compare treatment means.

		Percentage of monoterpenoid								
Plant type	Plant no.	α-pinene	Camphene	1,8 Cineol	8.50[a]	β-thujone	Camphor	13.06[a]	Terpineol	Total
Nonfed-on	1	0.00	0.00	0.07	0.00	1.48	0.05	0.04	0.56	2.20
	2	0.00	0.00	0.00	0.00	2.74	0.00	0.08	0.67	3.49
	3	0.00	0.06	0.00	0.00	2.57	0.36	0.00	0.62	3.61
	4	0.03	0.20	0.68	0.01	1.52	0.98	0.00	0.47	3.89
	5	0.00	0.00	0.11	0.00	2.84	0.00	0.04	0.65	3.64
Means		0.01	0.05	0.17	0.00	2.23	0.28	0.03	0.59	3.37
Fed-on										
	1	0.00	0.00	0.00	0.33	2.33	0.00	0.07	0.71	3.44
	2	0.00	0.00	0.00	0.00	2.76	0.00	0.08	0.78	3.62
	3	0.00	0.00	0.28	0.23	1.91	0.09	0.03	0.45	2.99
	4	0.00	0.00	0.19	0.00	3.05	0.00	0.00	0.13	3.37
	5	0.00	0.00	0.11	0.00	3.70	0.00	0.00	0.52	4.33
Means		0.00	0.00	0.12	0.11	2.75	0.02	0.04	0.52	3.55
t-test		NS[b]	NS	NS	NS	NS	NS	NS	NS	NS

[a]Unknown monoterpenoid, number represents retention time.
[b]NS means not significantly different at the 5% probability level.

relationship of birds to one another (hen-chick relationship). Birds seemed to mingle freely together. Once feeding on a plant started, it lasted from 5 to 15 min. Then the birds would start their wandering again. We did observe feeding on the same plants over 3 to 5 weeks; and, equally important, there was no feeding on plants selected as nonfed-on plants. These field observations strongly indicate preferential use of individual plants within subspecies. Consequently, we felt that the nonfed-on plants selected for this study had a high probability of being plants the birds were discriminating against.

Table 1 lists the nutritive comparisons between fed-on and nonfed-on plants of three subspecies of big sagebrush. The only significant ($P = .05$) comparison as detected by t-tests was for in vitro digestibility in Wyoming big sagebrush. Here, fed-on plants were more highly digestible. Remington and Braun (1985) reported that browsed Wyoming big sagebrush contained higher levels of crude protein than unbrowsed plants. They also observed that the most preferred subspecies, Wyoming big sagebrush, contained higher levels of crude protein than mountain big sagebrush (15.4 to 17.8% vs. 10.2 to 13.4%). They concluded that crude protein levels were important in sage grouse selection of big sagebrush plants. Our results do not support their observation. However, it is quite

TABLE 3. Comparisons between the monoterpenoid levels of wintering sage grouse fed-on and nonfed-on plants of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*, leaf tissue). Data expressed on a dry-matter basis. Unpaired t-tests used to compare treatment means.

		Percentage of monoterpenoids											
Plant type	Plant no.	1.07[a]	Camphene	4.84[a]	1,8 Cineol	8.50[a]	β-thujone	10.87[a]	Camphor	12.09[a]	12.45[a]	13.06[a]	Total
Nonfed-on													
	1	0.03	0.00	0.00	0.00	2.70	0.00	0.04	0.00	0.19	0.13	0.00	3.09
	2	0.03	0.00	0.00	0.00	1.96	0.03	0.26	0.30	0.05	0.00	0.00	2.63
	3	0.04	0.00	0.00	0.00	2.49	0.10	0.31	0.22	0.15	0.07	0.00	3.38
	4	0.06	0.00	0.44	0.08	0.12	0.28	0.00	0.48	0.00	0.00	0.12	1.58
	5	0.03	0.14	0.06	0.39	0.00	0.14	0.07	1.06	0.00	0.00	0.01	1.90
Means		0.04	0.03	0.10	0.09	1.45	0.11	0.14	0.41	0.08	0.04	0.03	2.52
Fed-on													
	1	0.05	0.00	0.00	0.00	2.67	0.07	0.27	0.19	0.08	0.00	0.04	3.37
	2	0.04	0.00	0.00	0.08	1.79	0.15	0.28	0.15	0.04	0.04	0.03	2.60
	3	0.03	0.00	0.00	0.00	2.03	0.06	0.34	0.00	0.07	0.00	0.00	2.53
	4	0.10	0.00	0.00	0.18	0.00	0.32	0.00	1.04	0.00	0.00	0.16	1.80
	5	0.03	0.00	0.00	0.00	1.37	0.00	0.41	0.00	0.00	0.00	0.00	1.81
Means		0.05	0.00	0.00	0.05	1.57	0.12	0.26	0.28	0.04	0.01	0.05	2.42
t-test		NS[b]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a]Unknown monoterpenoid, number represents retention time.
[b]NS means not significantly different at the 5% probability level.

TABLE 4. Comparisons between the monoterpenoid levels of wintering sage grouse fed-on and nonfed-on plants of basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*, leaf tissue). Data expressed on a dry-matter basis. Unpaired t-tests used to compare treatment means.

		Percentage of monoterpenoids												
Plant type	Plant no.	1.07[a]	1.89[a]	α-pinene	Camphene	4.84[a]	1,8 Cineol	8.50[a]	β-thujone	10.87[a]	Camphor	12.09[a]	12.45[a]	Total
Nonfed-on														
	1	0.04	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.36	1.04	1.94
	2	0.04	0.54	0.00	0.00	0.00	0.00	0.00	0.10	0.08	0.00	0.44	0.90	2.10
	3	0.04	0.40	0.00	0.00	0.00	0.00	0.00	0.06	0.12	0.00	0.44	1.02	2.08
	4	0.04	0.46	0.00	0.00	0.00	0.00	0.00	0.14	0.12	0.00	0.58	1.40	2.74
	5	0.04	0.50	0.00	0.00	0.00	0.00	0.00	0.06	0.02	0.00	0.32	0.84	1.78
Means		0.04	0.47	0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.00	0.43	1.04	2.13
Fed-on														
	1	0.12	0.00	0.14	0.08	0.90	0.00	0.00	0.38	0.00	1.58	0.00	0.00	3.20
	2	0.08	0.00	0.00	0.40	0.56	0.42	0.00	0.24	0.00	1.47	0.00	0.00	3.17
	3	0.08	0.00	0.02	0.00	0.46	0.20	0.50	0.36	0.32	0.44	0.00	0.10	2.48
	4	0.12	0.00	0.00	0.30	0.84	0.22	0.00	0.36	0.00	0.96	0.00	0.06	2.86
	5	0.08	0.00	0.00	0.28	0.20	1.20	0.00	0.16	0.06	1.16	0.00	0.00	3.14
Means		0.10	0.00	0.03	0.21	0.59	0.41	0.10	0.30	0.08	1.12	0.00	0.03	2.97
t-test		S[b]	S	NS	S	S	S	NS	S	NS	S	S	S	S

[a]Unknown monoterpenoid; number represents retention time.
[b]NS means not significantly different at the 5% probability level
S means are significantly different at the 5% probability level.

obvious from Table 1 that the birds in our study did not have much of an intrasubspecies choice. Based on results of t-tests, fed-on and nonfed-on plants did not differ in crude protein levels. There were probable differences among subspecies, but, because the subspecies were disjunct, the birds did not have an opportunity at each feeding site to choose one over the other. The pattern of nutrient levels among the subspecies follows that of previous reports: basin big sagebrush was the most nutritious, followed by Wyoming and mountain big sagebrush (Welch 1983). Big sagebrush leaves are as nutritious as any winter forage found on Great Basin ranges (Behan and Welch 1986, Bunderson et al. 1986, Davis and Welch 1986). This may help explain in part why Beck and Braun (1978) reported weight gains in wintering sage grouse.

Tables 2, 3, and 4 list the comparisons between the monoterpenoid levels of the fed-on and nonfed-on plants. T-tests detected no significant differences ($P = .05$) between fed-on and nonfed-on plants for mountain and Wyoming big sagebrush for individual or total monoterpenoids. Significant differences may exist between the two subspecies (means of 3.55 and 3.37% vs. 2.42 and 2.52%). Welch and McArthur (1981) reported differences in monoterpenoid content of leaves and stems for these two subspecies. Remington and Braun (1985) noted differences in monoterpene content between Wyoming and mountain big sagebrush but not among browsed, unbrowsed, and random plants of the same subspecies.

The basin big sagebrush comparison is quite a different story. Table 4 shows that we are dealing with two distinct populations of basin big sagebrush. A criterion for a plant to be selected as a nonfed-on plant was to be within 1.5 m of a fed-on plant, meaning that the two populations were thoroughly mixed. All five nonfed-on plants contained two unknown monoterpenoids (1.89 and 12.09) not found in the fed-on plants. All five fed-on plants contained one unknown monoterpenoid (4.84) and camphor not found in the nonfed-on plants. Four fed-on plants contained camphene and 1,8 cineol. None of the five nonfed-on plants contained these two monoterpenoids. These differences are direct evidence that the study area supports two populations of basin big sagebrush. 'Hobble Creek,' a highly preferred big sagebrush by wintering mule deer (Welch and McArthur 1986) and by wintering domestic sheep (Welch et al. 1987), also contains high camphor levels, as do the fed-on plants listed in Table 4.

One might be tempted to claim that the birds and perhaps deer and sheep are selecting plants high in camphor. But a check of the camphor content in mountain and Wyoming big sagebrush listed in Tables 2 and 3 tempers such temptation. The differences in monoterpenoid content between fed-on and nonfed-on plants for basin big sagebrush are interesting, but behavioral data are lacking regarding preferences among subspecies.

We will be using the results of this study and that of Remington and Braun (1985) to justify a more definitive study. The heart of such a study will be the use of a uniform garden, placing birds in the garden to test their preference for subspecies, accessions, and individual plants of big sagebrush. This technique is similar to studies used for determining wintering mule deer and domestic sheep preferences for big sagebrush (Welch and McArthur 1986, Welch et al. 1981).

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