Mule Deer Preference and Monoterpenoids (Essential Oils)

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Abstract

Wild wintering mule deer browsed on a uniform shrub garden near Helper, Utah.[1] On this garden, 21 accessions from 5 *Artemisia* taxa were selected to test the relationship between deer preference for these accessions and the amount of monoterpenoids present in the accessions. Deer preferences were determined by measuring removal of current year's growth. Samples of current year's growth (leaves and stems with terminal buds) were collected at the time preference measurements were taken to determine monoterpenoid content. Deer use ranged from zero to 83% of the current year's growth. Total monoterpenoid content among accessions varied from 0.75 to 3.62% of dry matter. Coefficients of determination, preference versus monoterpenoid levels (total and individual) ranged from 0 to 18%. The monoterpenoid content of various accessions of *Artemisia* taxa was not significantly related to deer preference.

Because of the bacteriostatic and bactericidal properties of monoterpenoids (essential oils), a number of workers became concerned about possible adverse effects monoterpenoid-producing plants might have on ruminant digestion through suppressing rumen microorganisms. Nagy et al. (1964), Oh et al. (1967), Nagy and Tengerdy (1968), and Schwartz et al. (1980a) have reported in vitro evidence that monoterpenoids, when in high enough concentrations, do suppress activities of rumen microorganisms. From these reports the following hypotheses have emerged: (1) when big sagebrush exceeds 15–30% of the diet, ruminant digestion will be adversely affected[2] (Wallmo and Regelin 1981); (2) the "theoretical" decline of mule deer in the western United States may be due to high (over 15–30%) big sagebrush consumption (Dietz and Nagy 1976); and (3) mule deer selected monoterpenoid-containing forage plants with the least amount of monoterpenoids (Nagy and Tengerdy 1968, Schwartz et al. 1980b, Wallmo and Regelin 1981).

The third hypothesis, monoterpenoid content versus preference, is the subject of this study. During digestibility trials, Smith (1950) noted that penned deer showed definite aversion to individual big sagebrush plants. Mule deer preference for certain accessions and/or individual plants of big sagebrush has been observed in the field by a number of researchers (McArthur et al. 1979, Sheehy and Winward 1981, Welch et al. 1981). Welch et al. (1981) demonstrated differential preference of wintering mule deer for accessions of big sagebrush grown on a uniform garden. A few attempts have been made to relate monoterpenoid content to preference (Sheehy 1975, Scholl et al. 1977, Radwan and Crouch 1978, Schwartz et al. 1980b, Narjisse 1981, White et al. 1982b). Results of these studies fall into two categories: (1) monoterpenoids adversely influence preference (Schwartz et al. 1980b, Narjisse 1981-goats), and (2) monoterpenoids have little influence on preference (Scholl et al. 1977, Radwan and Crouch 1978, Narjisse 1981-sheep, White et al. 1982b). With this conflict in mind, we undertook this study to determine wintering mule deer preference for accessions of *Artemisia* taxa grown on a uniform garden as related to monoterpenoid content.

Materials and Methods

From a uniform shrub garden located near Helper, Utah, we selected 21 accessions of sagebrush to determine the relationship between wild mule deer preference for these accessions and monoterpenoid content. The following species and subspecies of sagebrush were represented in the study: *Artemisia tridentata* ssp. *tridentata* (basin big sagebrush), *A.t.* ssp. *vaseyana* (mountain big sagebrush), *A. nova* (black sagebrush), *A. arbuscula* (low sagebrush), and *A. cana* (silver sagebrush). In all, 21 accessions from various Utah and Nevada sites were chosen (Table 1). For each accession, 5 plants were randomly selected to determine mule deer preference and monoterpenoid content. We expressed preference of mule deer for the various accessions as a percent of current year's growth (vegetative stems and leaves) used.

Methodology used to measure forage used has been described elsewhere (Welch et al. 1981). Basically, it consists of prebrowsing and postbrowsing measurements. The prebrowsing measurements were made on November 20, 1980. By December 17, 1980, 4 of the 21 accessions had already received heavy deer usage. Any additional use on these 4 accessions would have resulted in current year's growth with terminal buds being unavailable for use in determining monoterpenoid content. On December 18, 1980, we took the postbrowsing measurements and vegetative samples needed for running the monoterpenoid determinations. As suggested by Nichols (1973) all samples were collected within a 90-minute period (10-11:30 a.m.). We removed the same type of tissue from plants as was removed by deer, namely, the terminal buds, and corresponding length of twigs with leaves (4 cm). For the 10 accessions that had not received any use, we sampled the first 4 cm of the twigs from terminal buds (leaves and stems). Samples collected from a given accession were pooled and frozen on-site with liquid nitrogen and transported in dry ice to laboratory freezers. Sample preparation, extraction, and monoterpenoid determinations have been described elsewhere (Welch and McArthur 1981).

Data were expressed as percent used (preference) and as percent of dry matter (monoterpenoid content). Correlation analysis, factor analysis, principal components, and multiple regressions were used to measure the relationship between preference and monoterpenoid content (total and individual).

Results

Deer consumed 0 to 83% of the current year's growth among 21 accessions of sagebrush (Table 2). The relationship between wintering mule deer preference for accessions of sagebrush and mono-

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[1]The shrub garden at the Gordon Creek Wildlife Management area near Helper, Utah, is cooperatively maintained by the Utah State Division of Wildlife Resources (W-82-R, Job 1) and the Intermountain Forest and Range Experiment Station.

[2]A number of studies have been reported that challenge the idea that big sagebrush monoterpenoids (essential oils) suppress microbial digestion (Smith 1950, 1952, 1957, Sheehy 1975, Welch and McArthur 1979, Tueller 1979, Connolly et al. 1980, Kufeld et al. 1981, Narjisse 1981, Welch and Pederson 1981, Cluff et al. 1982, Pederson and Welch 1982, White et al. 1982a).

terpenoid content is given in Table 2.

Correlation coefficients ranged from 0–43%. Correspondingly, coefficients of determination ranged from 0–18%. We found no significant relationship between preference and monoterpenoid content with factor analysis, principal components analysis, or multiple regression.

Discussion

Other attempts have been made to relate monoterpenoid content to animal preference. Sheehy (1975) reported that the relative concentration of 8 monoterpenoids could account for 90% of the variation in mule deer utilization among 7 sagebrush taxa. Scholl et al. (1977), however, using relative concentration of 8 monoterpenoids could only account for 20.7% of the variation in wild mule deer preference for 12 sagebrush taxa. Radwan and Crouch (1978) found that "families of Douglas-fir" varied significantly in yield and composition of monoterpenoids, but differences were not related to black-tailed deer preference. White et al. (1982b) using pygmy rabbits *(Brachylagus idahoensis)* as test animals reported no significant relationship between grams of big sagebrush eaten and monoterpenoid content (r^2 values ranged from 0–12%). In a test to determine the influence of the odor of monoterpenoids on food preference in sheep and goats, Narjisse (1981) found that, for the first 2 days of the trial, sheep ate more food from feed bins lacking monoterpenoids. Selection after the first 2 days was random. Goats did not discriminate against monoterpenoid odor. Next, Narjisse tested to determine if anosmic sheep and goats would discriminate against the taste of monoterpenoids. He mixed monoterpenoids with pelleted feed and gave his animals a choice between pellets with and without monoterpenoids. Goats discriminated against the taste of monoterpenoids, sheep did not.

The strongest evidence that monoterpenoids influence animal

Table 1. Acquisition location of 21 accessions of sagebrush grown on a uniform garden.

Species and subspecies	Accession	County and state
Artemisia tridentata ssp. *tridentata*		
	Indianola	Sanpete, Utah
	Oman	Carbon, Utah
	Ivie Creek	Sevier, Utah
	Unknown source	
Artemisia tridentata ssp. *vaseyana*		
	Hobble Creek	Utah, Utah
	East Austin	Lander, Nevada
	Colton	Utah, Utah
	Austin	Lander, Nevada
	Monticello	San Juan, Utah
	Spanish Valley	Grand, Utah
	Milford	Beaver, Utah
Artemisia nova		
	Manti	Sanpete, Utah
	Black Mountain	Sevier, Utah
	Spring Valley	White Pine, Nev.
	Pine Valley	Millard, Utah
	Mayfield	Sanpete, Utah
Artemisia arbuscula		
	Salina	Sevier, Utah
	Paradise	Humboldt, Nevada
	Austin	Lander, Nevada
	Indian Peaks	Beaver, Utah
Artemisia cana		
	Soldier's Summit	Wasatch, Utah

Table 2. The relation between mule deer preference for accessions of 5 taxons of *Artemisia* grown in a uniform garden and the monoterpenoid content of the accessions. The relation between preference and monoterpenoid content is expressed as correlation coefficients *(r)* and as coefficients of determination *(r^2)*. Mule deer preference expressed as a percent of current year growth eaten. Monoterpenoid content expressed as a percent of dry matter. Note, that not all monoterpenoids found in the accessions are listed (remaining data on file at the Shrub Sciences Laboratory, 735 North 500 East; Provo, Utah 84601).

Accessions of *Artemisia* taxa	Total monoterpenoids	α-Thujone	β-Thujone	Camphor	% Used
Indianola-t*	1.08	0.09	0.27	0.03	00
Unknown-t	3.62	0.00	0.27	0.00	00
Oman-t	1.41	1.21	0.04	0.12	00
Ivie Creek-t	1.27	0.00	0.00	0.07	00
Hobble Creek-v	2.21	0.00	0.16	1.04	83
East Austin-v	2.48	1.27	0.05	0.00	57
Colton-v	1.82	0.00	0.32	0.39	83
Austin-v	2.18	0.01	0.17	0.37	40
Monticello-v	0.89	0.00	0.00	0.20	57
Spanish Valley-v	1.67	0.00	0.00	0.23	67
Milford-v	2.45	0.00	0.00	1.25	69
Salina-a	0.97	0.00	0.76	0.06	15
Paradise-a	1.09	0.00	0.00	0.00	21
Austin-a	1.36	0.00	0.00	0.30	00
Indian Peaks-a	1.14	0.00	0.00	0.19	56
Soldier-c	2.72	0.00	0.00	0.00	00
Manti-n	1.05	0.00	0.00	0.39	00
Black Mountain-n	1.17	0.00	0.00	0.45	00
Spring Valley-n	0.75	0.00	0.00	0.45	00
Pine Valley-n	1.22	0.00	0.00	0.43	48
Mayfield-n	2.27	0.00	0.05	0.63	00
r	0.14	0.00	0.01	0.43	—
r^2	0.02	0.00	0.00	0.18	—

*t=*Artemisia tridentata* ssp. *tridentata*
v=*Artemisia tridentata* ssp. *vaseyana*
a=*Artemisia arbuscula*
c=*Artemisia cana*
n=*Artemisia nova*

preference comes from Schwartz et al. (1980b), who used tame mule deer as test animals in cafeteria feeding trials. The trials were designed to determine preference for 3 species of juniper and for pelleted feed treated with different levels of monoterpenoids. Their results showed that tame mule deer preferred feed that had the lowest levels of oxygenated monoterpenoids. Barbar et al. (1969) reported that sagegrouse selected sagebrush containing the lowest concentrations of monoterpenoids.

Thus, 3 studies (Barbar et al. 1969, Schwartz et al. 1980b, Narjisse 1981-goats) have supported the contention that monoterpenoid levels influence test animal preference and 5 studies (Scholl et al. 1977, Radwan and Crouch 1978, Narjisse 1981-sheep, White et al. 1982, this study) did not. It may be in the case of cafeteria trials by Schwartz et al. (1980b) and Narjisse (1981-goats), where all other factors were held constant, that monoterpenoids significantly influenced preference and that under field conditions in our study, monoterpenoid influences were masked by other factors.

One of these other factors could be animal experience. Zimmerman (1980) reporting on cattle on shrub ranges in Nevada noted that it is important that calves stay with their mothers to learn how to survive on shrub ranges. Without this experience, it would be doubtful that calves could survive on shrub diets. Narjisse (1981) in range tests reported that experienced range sheep consumed significantly higher levels of big sagebrush than inexperienced sheep. Carpenter et al. (1979) found that tame mule deer also increased big sagebrush consumption over time. Unknown animal factors may play as important a role in preference as plant factors do.

In summary, our study shows that monoterpenoid content of the various accessions of *Artemisia* taxa was not significantly related to deer preference.

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