Variation in Winter Levels of Crude Protein Among *Artemisia tridentata* Subspecies Grown in a Uniform Garden

BRUCE L. WELCH AND E. DURANT McARTHUR

Abstract

We discovered that the midwinter crude protein content of *Artemisia tridentata* is under genetic control. Our study demonstrated that some accessions of *A. tridentata*, grown under uniform conditions, contained significantly higher levels of crude protein than others. Subspecies *tridentata* contained significantly higher levels of crude protein than subspecies *vaseyana* and *wyomingensis*. However, the accessions that contained the highest levels of crude protein have been reported to be the least palatable to mule deer. A superior strain of *A. tridentata* can be developed by combining the high protein-yielding accessions with accessions that are higher in palatability. The new strain could supply more protein for mule deer on winter ranges.

Browse consumed by wintering mule deer on western ranges is low in crude protein, so low that these animals could develop protein deficiency. Such a deficiency weakens deer and could result in death (French et al. 1956; Dietz 1965; Ullrey et al. 1967, Halls 1970; Nagy and Wallmo 1971; Thompson et al. 1973; Smith et al. 1975). However, the crude protein levels in the diet of these animals can be increased by providing range plants that contain high crude protein levels. One candidate for providing higher levels of crude protein is *Artemisia tridentata*. Our reason for suggesting this plant is twofold: (1) *A. tridentata* crude protein is highly digestible (53.5%) and (2) it contains more crude protein than any other winter range plant (Smith 1950; Bissell et al. 1951; Cook et al. 1952; Smith 1957; Dietz et al. 1962; National Academy of Sciences 1964).

We noted a large amount of variation among the reports on winter levels of crude protein for *A. tridentata*—8.5% to 14.4% (Smith 1950; Bissell et al. 1951; Cook et al. 1952; Dietz et al. 1962; National Academy of Sciences 1964). The lack of uniformity among the studies made it impossible for us to determine the cause of the variation. If genetic factors are important, then breeding and selection schemes could be devised to maximize *A. tridentata* crude protein levels. To determine the effects of genetic factors on crude protein levels, we measured the midwinter crude protein content among 21 accessions of *A. tridentata* grown under uniform conditions. Significant variation would indicate that genetic factors are important in determining crude protein levels.

Materials and Methods

Seedlings from 21 wild populations of *A. tridentata* were transplanted during the spring of 1970 to a uniform garden[1] at the Snow Field Station, Ephraim, Utah (Table 1). All three subspecies of *A. tridentata* were represented: 10 accessions of *A. tridentata* spp. *vaseyana;* seven accessions of *A. tridentata* spp. *tridentata;* and four accessions of *A. tridentata* spp. *wyomingensis* (Table 1). Subspecies were identified by morphological criteria (Beetle and Young 1965; Winward and Tisdale 1977) and chemical criteria (Stevens and McArthur 1974). Within each accession, five plants were selected at random. We then sampled that portion of each plant that would be eaten by wintering mule deer—current year leaves and stems. We did our sampling in mid-January of 1976 and 1977. All samples were collected in a 4-hour period, placed in paper bags, frozen with dry ice, and stored in a laboratory freezer. Samples were dried at 100°C and powdered in a Thomas-Wiley Mill. Nitrogen content for all samples of a given winter were determined by the Kjeldahl method and the crude protein level calculated (Association of Official Agricultural Chemists 1965).

Table 1. Locations of 21 Populations of *Artemisia tridentata*.

Subspecies	Accessions	County and state
vaseyana	Alton	Kane, Utah
	Colton	Utah, Utah
	Sardine Canyon	Cache, Utah
	Benmore	Tooele, Utah
	Petty Bishop's Log	Sanpete, Utah
	Durkee Springs	Sevier, Utah
	Salina Canyon	Sevier, Utah
	Clear Creek Canyon	Sevier, Utah
	Pinto Canyon	Washington, Utah
	Indian Peaks	Beaver, Utah
tridentata	Clear Creek Canyon	Sevier, Utah
	Big Brush Creek	Uintah, Utah
	Loa	Wayne, Utah
	Dove Creek	Dolores, Colorado
	Evanston	Uinta, Wyoming
	Wingate Mesa	San Juan, Utah
	Dog Valley	Juab, Utah
wyomingensis	Evanston	Uinta, Wyoming
	Kaibab	Coconino, Arizona
	Trough Springs	Humboldt, Nevada
	Milford	Beaver, Utah

Data presented represent an averaging of determinations made for the two winters. This averaging was possible because variation due to winter was nonsignificant. Completely random analysis of variance was used to detect significance among subspecies, among accessions within subspecies *vaseyana*, among accessions within subspecies *tridentata*, and among accessions within subspecies *wyomingensis*. Duncan's multiple-range test ($\alpha = .01$) was used to test for significant differences among treatment means.

Authors are research plant physiologist and research geneticist, respectively, Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Ogden Utah 84401, located at the Intermountain Station's Shrub Sciences Laboratory, Provo, Utah.

Manuscript received October 5, 1978.

[1] The uniform garden is cooperatively maintained by Snow College, the Agricultural Experiment Station of Utah State University, the Utah State Division of Wildlife Resources (W-82-R), and the Intermountain Forest and Range Experiment Station.

Results

The mean midwinter crude protein content for 105 *A. tridentata* plants was 12.4% with a standard deviation of 1.9%. Others have reported the midwinter crude protein level as being 11.0% (Smith 1950), 11.8% (Bissell et al. 1951), and 10.1% (Dietz et al. 1962). Winter protein content for sagebrush was above the winter levels reported for other shrubs such as chokecherry (9.1%), cliffrose (8.4%), bitterbrush (8.3%), mountainmahogany (7.7%), juniper (6.2%), and Gambel oak (5.4%) (Smith 1957).

An analysis of variance detected significant differences attributed to subspecies (Table 2). Duncan's multiple-range test ($\alpha = 0.01$) detected significant differences in crude protein content between subspecies *tridentata* (14.5%) and subspecies *vaseyana* (11.1%) and *wyomingensis* (11.8%) (Table 2). These values were comparable to the results of a similar study conducted in Oregon, which showed that subspecies *tridentata* contained 13.9% crude protein, *vaseyana* 10.4%, and *wyomingensis* 12.5% (Sheehy 1975).

Table 2. Analysis of variance and test of significant differences among the midwinter mean crude protein content of three subspecies of *Artemisia tridentata*—2-year summary—percentages on dry weight basis.

Source	d.f.	s.s.	m.s.	*F*
Subspecies (3)	2	241.2	120.6	75.4*
Error	102	172	1.6	

Duncan's Multiple-Range Test**

	Subspecies		
	vaseyana	*wyomingensis*	*tridentata*
Percent of crude protein	11.1	11.8	14.5

* $\alpha = 0.01$.
** Any two means not underscored by the same line are significantly different at the 99% level.

Within subspecies *vaseyana*, we found significant differences attributed to accession (Table 3). Accessions from Salina Canyon (11.7%), Clear Creek Canyon (11.7%), and Colton (12.0%) were significantly higher in crude protein content than the Benmore (10.0%) or Durkee Springs (10.0%) accessions. However, the Salina Canyon, Clear Creek Canyon, and Colton accessions were not significantly higher in crude protein content than the Sardine Canyon (10.5%), Pinto Canyon (11.0%), Indian Peaks (11.2%), Petty Bishop's Log (11.2%), and Alton (11.3%) accessions.

Fob subspecies *tridentata*, some accessions were significantly higher in crude protein than others (Table 4). The Dove Creek accession contained a significantly higher crude protein level (16.0%) than did accessions from Wingate Mesa (12.8%), Big Brush Creek (13.1%), Loa (14.5%), and Dog Valley (14.5%). Dove Creek was not significantly higher in crude protein than accessions from Evanston (15.2%) and Clear Creek Canyon (15.3%).

Table 4. Analysis of variance and test of significant differences among the midwinter mean crude protein content of 7 accessions of *Artemisia tridentata* spp. *tridentata*—2-year summary—percentages on dry weight basis.

Source	d.f.	s.s.	m.s.	*F*
Accessions (7)	6	41.8	7.0	10.0*
Error	28	20.5	.7	

Duncan's Multiple-Range Test**

Accessions						
Wingate Mesa	Big Brush Creek	Loa	Dog Valley	Evanston	Clear Creek Canyon	Dove Creek
12.8	13.1	14.5	14.5	15.2	15.3	16.0

* $\alpha = 0.01$.
** Any two means not underscored by the same line are significantly different at the 99% level.

An accession of subspecies *wyomingensis* (Table 5) from Evanston contained higher crude protein levels (12.9%) than accessions from Trough Springs (11.0%) and Milford (11.2%).

Discussion

Our results showed that the subspecies and accessions of *A. tridentata* have significantly different genetic capacities for crude protein production (Tables 2, 3, 4, 5). Subspecies *tridentata* is the least preferred by mule deer of the three subspecies of *A. tridentata* (Stevens and McArthur 1974; Sheehy 1975; McArthur et al. 1979). Data presented in this study show that subspecies *tridentata* contained significantly higher levels of crude protein than the more preferred subspecies *vaseyana* and *wyomingensis*. We are not suggesting a causative relationship between crude protein levels and preference. We will attempt to combine the protein-yielding abilities of accessions like those of Dove Creek with those that

Table 3. Analysis of variance and test of significant differences among the midwinter mean crude protein content of 10 accessions of *Artemisia tridentata* spp. *vaseyana*—2-year summary—percentages on dry weight basis.

Source	d.f.	s.s.	m.s.	*F*
Accessions (10)	9	21.5	2.4	3.43**
Error	40	26.3	.7	

Duncan's Multiple-Range Test**

Accessions									
Benmore	Durkee Spring	Sardine Canyon	Pinto Canyon	Indian Peaks	Petty Bishop's Log	Alton	Salina Canyon	Clear Creek Canyon	Colton
10.0	10.0	10.5	11.0	11.2	11.2	11.3	11.7	11.7	12.0

* $\alpha = 0.01$.
** Any two means not underscored by the same line are significantly different at the 99% level.

Table 5. Analysis of variance and test of significant differences among the midwinter mean crude protein content of 4 accessions of *Artemisia tridentata* spp. *wyomingensis*—2-year summary—percentages on dry weight basis.

Source	d.f.	s.s.	m.s.	*F*
Accessions (4)	3	11.0	3.67	8.34*
Error	16	7.1	.44	

Duncan's Multiple-Range Test **

Accessions			
Trough Springs	Milford	Kaibab	Evanston
11.0	11.2	11.9	12.9

* $\alpha = 0.01$.
** Any two means not underscored by the same line are significantly different at the 99% level.

are most palatable (McArthur and Plummer 1978; McArthur et al. 1979).

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