Forage Diversity and Dietary Selection by Wintering Mule Deer

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Abstract

During a 30-day grazing trial, six mule deer (*Odocoileus hemionus hemionus*) at pasture altered their food selection significantly as availability of forage changed. At the beginning of the trial when forbs and grasses were abundant, they comprised better than 50% of the diet; but by the end of the trial when these preferred forages were less abundant, grass and forb declined. Shrub use increased and forb and grass use decreased as snow depths increased. Results support the conjecture that big sagebrush (*Artemisia tridentata wyomingensis*) in excess of 30% in the diet is detrimental to mule deer nutritional health.

Empirical experience with domestic livestock (Cook and Harris 1968; Galt et al. 1969) and some research results suggest that availability of a variety of forages improves herbivore nutrition. Several published accounts offer field observations in support of this contention with respect to the welfare of deer (Leach 1956; Trout and Thiessen 1968; Wallmo and Regelin in press). As a result of feeding experiments, some researchers suggest that deer fare better when native forages are fed in combination or with cultivated hay, than when fed alone (Dietz and Yeager 1959; Gill 1972; Ullrey et al. 1971), but there is no other experimental evidence to support the hypothesis. The present paper presents information on forage availability and forage selection by deer in a small pasture on big sagebrush (*Artemisia tridentata wyomingensis*) winter range in north central Colorado

Methods

The pasture, 6 km southeast of Kremmling, Colo., was 2.18 ha in size (108 × 202 m). It was stocked with three male and three female mule deer, all yearlings (18-19 months old), for 30 days. They were introduced to the pasture on January 19, 1972, the 7th day of a 10-day period of transition from their pen ration (alfalfa pellets and hay offered *ad lib.*) plus native forage, to native forage alone. For 13 days prior to January 19, they had been exposed to the same forage species in two other pastures. During the first 4 days in the 2.18-ha pasture, they received decreasing amounts of concentrate (from 0.5 to 0.2 kg/deer/day). The stocking rate, 83 deer-days/ha, is in the range observed for wild deer on open range in the vicinity.

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Standing crop of herbage was estimated at the end of the preceding growing season (August 1971) with double-sampling procedures (Carpenter 1976). Four-hundred fifty quadrats, each 30 × 61 × 46 cm, width × length × height, were read with an electronic capacitance meter (Neal and Neal 1973; Carpenter et al. 1973). Ninety of the quadrats were clipped to provide a regression of herbage weights on meter readings in order to use the larger sample to estimate herbage biomass. Current annual growth was clipped from all portions of shrub crowns which occurred on the clip plots. Few shrubs exceeded the 46 cm height limitation of the meter and their contribution to overall forage yields was considered insignificant. These estimates indicated there were approximately 1,945 kg (oven-dry) of shrub current annual growth and 900 kg of grass and forb herbage in the pasture at the end of the previous summer. Big sagebrush made up over 95% of the annual shrub yield. Other shrub forage included in order of abundance, were stems of serviceberry (*Amelanchier alnifolia*) snowberry (*Symphoricarpos oreophilus*), and green rabbitbrush (*Chrysothamnus viscidiflorus*)—all deciduous shrubs. Grasses made up 85% of the herbaceous vegetation. The most abundant was bluebunch wheatgrass (*Agropyron spicatum*), with pine needlegrass (*Stipa pinetorum*) second in abundance. At least seven other species were common, including western wheatgrass (*Agropyron smithii*), mutton bluegrass (*Poa fendleriana*), bluegrama (*Bouteloua gracilis*), bottlebrush squirreltail (*Sitanion hysterix*), prairie Junegrass (*Koeleria cristata*), and needleandthread grass (*Stipa comata*). The most abundant forb was a recumbent, perennial phlox (*Phlox bryoides*) which typically maintains green leaves through winter. Three other species classified as forbs—fringed sage (*Artemisia frigida*), buckwheat (*Eriogonum umbellatum*), and mat penstemon (*Penstemon caespitosus*)—provided very small amounts of green foliage. Several other infrequent forbs were present only as dead stems of annual growth.

During early morning and late afternoon on each day of the 30-day grazing study, forage selection of one to three of the deer was observed. The number of bites (one apparent gathering of food) taken of each plant species was recorded as described by Wallmo et al. (1972). Observation periods lasted as long as the deer grazed intently. Seventy-eight such deer "meals" were observed, averaging 75 minutes in duration (range 16-126 min) and 928 bites per meal (72,351 total bites). Portions of at least 28 species were eaten (some ingested material was unidentifiable), including four shrubs, 11 or more grasses, 10 or more forbs, and three lower plants (two lichens, one moss). Eleven species contributed 1% or more to the total bites (Table 1).

The deer were weighed on January 19 and 26, February 2, 9, 13, and 17. The deer, ranging from 41 to 71 kg, weighed a total of 337 kg on January 19. At a mean forage intake rate of 17 g/kg/day of air-dry forage (Alldredge et al. 1974), they could have consumed approximately 172 kg of forage over the entire grazing period, or about 6% of the herbage present. In a similar pasture nearby, the intake rate of deer of the same age was estimated to average 15.6 g oven-dry forage/kg/

Table 1. Major components of recorded mule deer diets for a 30-day period. (Jan. 19–Feb. 17, 1972) in a 2.18-ha pasture on big sagebrush winter range.

Species	Symbol	Bites/day (±SE)	Percentage total bites
Agropyron spicatum	Agsp	1049±112	43.4[a]
Artemisia tridentata wyomingensis	Artr	311± 56	13.0
Phlox bryoides	Phbr	209± 45	8.7
Stipa pinetorum	Stpi	133± 22	5.5[a]
Agropyron smithii	Agsm	78± 16	3.2[a]
Poa fendleriana	Pofe	67± 21	2.8[a]
Amelanchier alnifolia	Amal	65± 18	2.7
Symphoricarpos oreophilus	Syor	47± 14	1.9
Chrysothamnus viscidiflorus	Chvi	47± 17	1.9
Bouteloua gracilis	Bogr	39± 12	1.6
Artemisia frigida	Arfr	26± 7	1.1

[a] Unidentified grasses, 10.2% of total, may have included some of these species.

day (Carpenter and Baker 1975).

Snow depths were measured along systematically located sampling points throughout the pasture. Measurements were made on six different dates over the 30-day trial. Snow depth was measured whenever an obvious change had occurred.

Results

Composition of the observed diets of the deer changed dramatically from the beginning to the end of the study (Fig. 1).

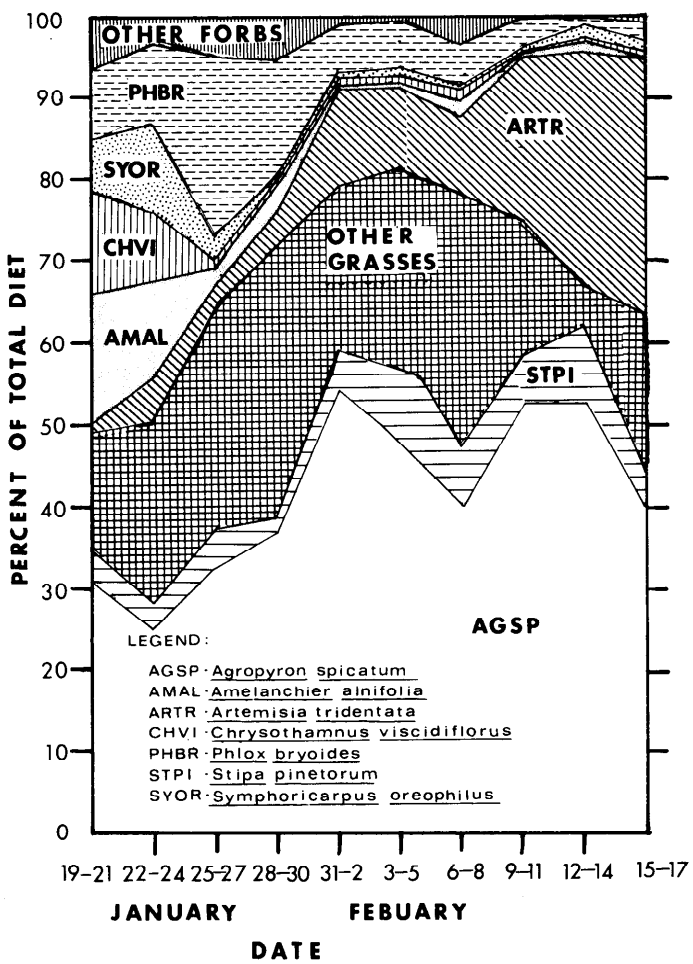

Fig. 1. *Composition of observed intake for six mule deer at pasture for 30-day period.*

A miscellany of species other than grasses and sagebrush made up half the diet initially, but they diminished to 5-6% of the diet near the end. The few serviceberry shrubs present were browsed avidly from the start until the available current annual growth was removed. The pattern of use of snowberry was similar. Though green rabbitbrush was quite common, most plants had been closely cropped by jackrabbits (*Lepus townsendi*). The deer removed the remaining stems rapidly and continued to browse on the basal stubs. Phlox was widespread in the pasture. As the use of serviceberry, snowberry, and rabbitbrush decreased, the use of phlox increased, then abruptly dropped as its supplies became exhausted.

Other species—28 in all—comprised about 5% of the observed intake in the first week and less than 0.5% in the last week. Though the consumption of species other than grasses decreased rapidly after the first week, the mean number of species in the meals did not change appreciably until 3 weeks had passed (Fig. 2). This suggested that deer were no longer encountering many of the original species while foraging.

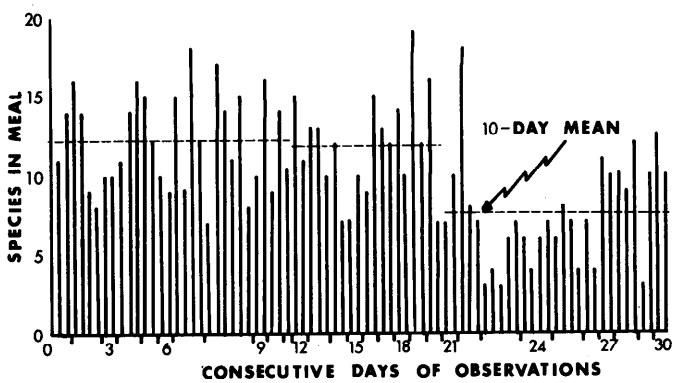

Fig. 2. *Number of plant species used in each mule deer meal for 30-day period. A meal is defined as forage consumed during one observation period.*

Consumption of grasses increased dramatically in the first 2 weeks, while serviceberry, snowberry, and rabbitbrush consumption decreased. Though sagebrush was abundant, it remained a minor element in the diet for 2 weeks, then its use increased abruptly (Fig. 1). However, the increase in sagebrush consumption was directed to certain apparently preferred plants (Carpenter 1976). Most of the individual sagebrush plants were

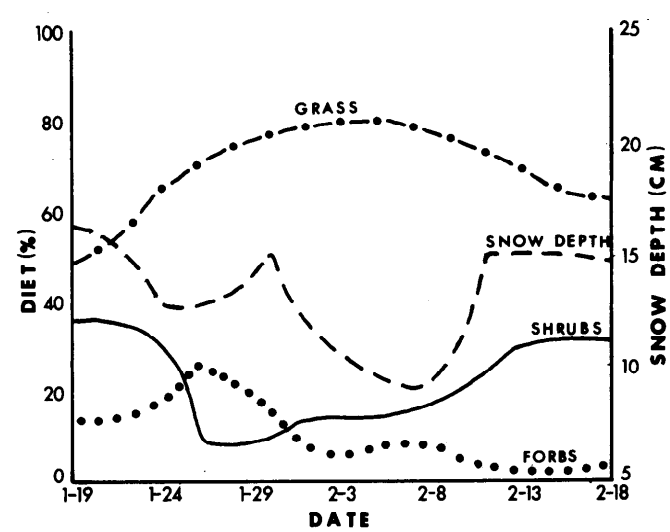

Fig. 3. *Relationship of snow depth to diet composition of mule deer at pasture.*

unused or browsed only slightly.

There was also a relationship between forage selectivity and snow depth dynamics. Snow depths in the pasture were greatest at the beginning and end of the trial, and were least during the periods of January 24–27 and February 5–7. Grass consumption and forb consumption increased as snow depths decreased, while shrub consumption parallelled changes in snow depth (Fig. 3). However, the magnitude of the responses to snow depth tended to diminish as forage diversity declined over time.

Snow depths in the pasture varied throughout the 30-day period, and undoubtedly interacted with grazing to influence forage availability. Average snow depth in the pasture was approximately 22 cm at the beginning of the trial and declined to a low of 9 cm by February 7. New snowfalls occurred on February 9 and 10 so that snow depths at the end of the trial averaged 16 cm.

During the 30-day period, the six deer experienced a mean weight loss of 6.2%. However, after the third week three deer gained weight, and two maintained weight. The sixth deer (Deer No. 9) lost weight drastically in the 4th week (Fig. 4).

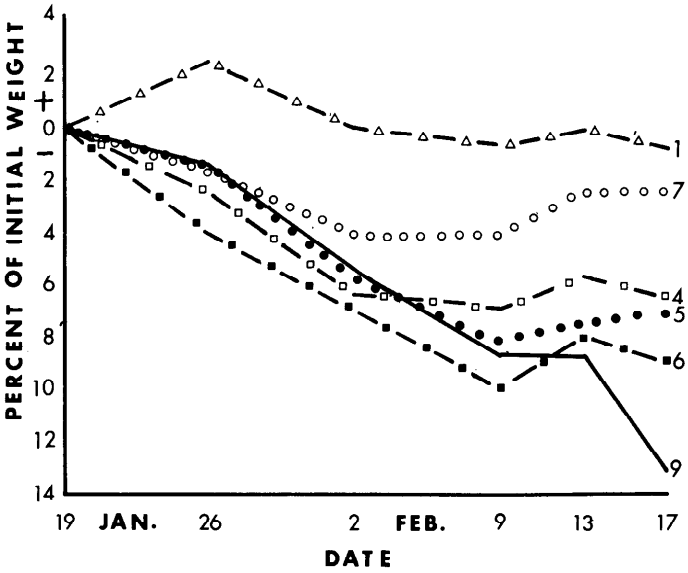

Fig. 4. *Weight changes for the six mule deer at pasture during 30-day period.*

Discussion

Interpretation of our observations of deer diet selection and forage availability is difficult because the data were observational and not experimental. Instead we suggest a number of hypothetical explanations to stimulate additional experimental research.

First, the data suggest that sagebrush in general is low palatability and is taken in quantity only when alternative forage is exhausted as postulated by Leach (1956) and Longhurst et al. (1968). Plants with high content of essential oils, such as big sagebrush, may be unpalatable because the oils are toxic to rumen microflora (Nagy et al. 1964; Longhurst et al. 1968; Nagy and Tengerdy 1967). Nagy et al. (1964) suggest that big sagebrush in excess of 15–30% of the diet impairs digestion. Longhurst et al. (1968) reported that the oxygenated monoterpene fraction of the essential oil complex is particularly toxic to rumen microbes, and they reported an inverse relationship between palatability of aromatic plant species and tissue concentrations of oxygenated monoterpenes. Jobman (1972) reported similar results when mule deer were offered cafeteria choices of three species of juniper. Species lowest in oxygenated monoterpenes were most palatable and vice versa.

However, it might be that deer only require some adjustment to the taste of big sagebrush before they increase consumption. Big sagebrush might be unpalatable until microbial populations adapt to it, whereupon it becomes more acceptable (Freeland and Janzen 1974). In such case, the higher protein content and digestibility of big sagebrush (Wallmo et al. 1977) could measurably enhance the nutritional quality of the diet.

Our results support the conjecture that big sagebrush in excess of 30% in the diet is inimical to mule deer nutritional health. The only deer in our sample to exceed 30% big sagebrush in the diet was deer No. 9, and No. 9 lost the most weight over the 30-day period (Fig. 4). Possibly 30 days is too short an interval to judge nutritional performance of deer on big sagebrush winter ranges. Nichol (1938) reported cyclic consumption of *Juniperus deppeana* by penned mule deer. He speculated that juniper and other conifers were not acceptable as a steady diet in significant quantities, but were salutary when taken occasionally. All conifers contain essential oils that inhibit rumen functions to some degree (Oh et al. 1970). There is a suggestion, though perhaps weak, of cyclic use of sagebrush in our study, similar to that reported for *Juniperus deppeana* (Nichol 1938) with a cycle length similar to Nichol's (Fig. 5). In our study the more heavily browsed sagebrush plants contained significantly less essential oils than the sagebrush population as a whole (Carpenter 1976). Thus, our deer may have minimized the inimical effects of sagebrush through dietary selection.

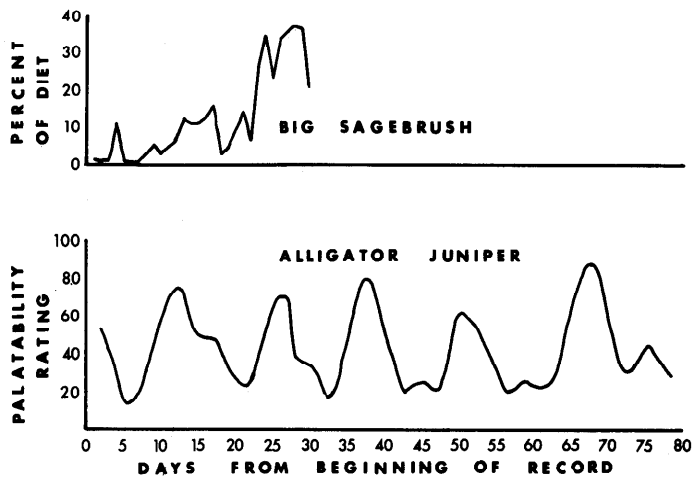

Fig. 5. *Upper: Percent sagebrush in daily sum of deer diets, this study. Lower: Cyclic palatability of pen-fed alligator juniper, from Nichol (1938).*

If ingestion of large quantities of sagebrush does inhibit digestive function of deer, one would expect winter losses to be most severe during winters of deep snow when sagebrush is the predominant available forage plant (Longhurst et al. 1968). In Middle Park, when these conditions prevailed, large die-offs of deer have occurred (Wallmo and Gill 1971).

Whether or not minor forages are a potentially important nutritional element is not clarified by this study. Browse species were high in lignin content and low in digestibility relative to grasses, though they contained more crude protein. It does seem significant, though, that availability of these minor forages decreased so rapidly. This result casts some doubt on the suitability of small pastures for studying the nutritional adequacy of native forages, a conclusion drawn earlier by McMahan (1964).

The data also suggest that when snow accumulations limit extent of winter ranges the complexity of relationships between dietary diversity, duration of site occupancy, and snow depth are increased. Generally, as the time of occupancy increases, forage diversity decreases and changes in snow depth modulate the degree and rate of this relationship.

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