HEAVY UTILIZATION OF WOODY PLANTS BY MOOSE DURING SUMMER AT DENALI NATIONAL PARK, ALASKA

Victor Van Ballenberghe[1], Dale G. Miquelle[2], James G. MacCracken[2]

[1]Institute of Northern Forestry, 308 Tanana Drive, Fairbanks, Alaska 99775-5500; [2]Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83843

ABSTRACT: Diet composition of wild adult moose (*Alces alces*) in Denali National Park, Alaska, during summer was estimated by direct observation of habituated animals and by microhistological fecal analysis. Both methods indicated that willows (*Salix* spp.) comprised about 80-85% of the diet during June, July, and August. Fecal analysis could not differentiate willow species; direct observations indicated moose were eating 7 willow species. About 46% of the summer diet consisted of diamondleaf willow (*Salix planifolia pulchra*). This species ranked first in the diet each month. Other woody species including resin birch (*Betula glandulosa*), and green alder (*Alnus crispa*) contributed small fractions to the diet. Herbaceous species constituted about 2% of the diet.

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Moose in Alaska occupy a wide variety of habitats ranging from highly productive riparian sites to low-elevation black spruce (*Picea mariana*) forests where forage is scarce (LeResche *et al.* 1974). Diverse terrestrial and aquatic habitats in different regions of the state are exploited by moose for food and cover. Moose populations in Alaska occur not only at lower elevations but also near treeline in the Chugach, Wrangell, Alaska, and Brooks mountain ranges and their foothills.

Moose have catholic food habits (Peek 1974) and adapt well to the vegetation of many diverse habitats in boreal and subarctic regions (Telfer 1984). Few studies have defined summer diets in more than general terms despite the growing realization that summer is a key period in the annual cycle of energy accumulation and depletion for moose (Schwartz *et al.* 1988). In theory, during summer moose should select forbs and aquatics rather than woody plants because digestibility and rumen passage rates of the former are higher and they may contain higher concentrations of critically important minerals including sodium (Belovsky 1978). Field studies generally have confirmed this hypothesis (LeResche and Davis 1973, Peek *et al.* 1976, Miquelle 1979), but moose in mountainous areas where shrubs are dominant may lack access to both forbs and aquatics. If so, this may have important implications for energy and mineral metabolism of moose and may be reflected in their time, energy, and mineral budgets. The purpose of this study was to estimate summer diet composition of moose occupying mountainous habitats in central Alaska.

STUDY AREA AND METHODS

Denali National Park is located in central Alaska (60°40' N, 149°20'W) about 240 km south of Fairbanks. The study area was in the eastern portion of the park adjacent to the first 30 km of park road. Habitats are mountainous with elevations ranging from 540 to 1,825 m. Much of the study area occurs near treeline (760 m).

Vegetation types (Viereck and Dyrness 1980) include open forest stands of primarily white spruce (*Picea glauca*) with occasional willow (*Salix* sp.) and resin birch (*Betula glandulosa*). Willow and alder are dominant components of the vegetation along water courses. Dense stands of willows, resin birch, or mixtures of these species occur at and above timberline. Willow-dominated stands reach maximum densities on north-facing slopes where soil moisture is greater.

During June, July, and August in 1981 and 1982 we counted bites of foraging moose

and classified bites by plant species. Both radiocollared and uncollared moose were observed; data were collected during 49 observations of 11 adult females and 8 adult males. Sampling units consisted of observations made on one day of one animal engaged in one or more foraging bouts. Data were collected by teams of up to 3 observers who worked within 20 m of habituated study animals. Wallmo *et al.* (1973) found that this distance results in highly accurate identification of plant species. Two observers used binoculars and positioned themselves alongside feeding animals, parallel to and slightly behind the line of travel. A third team member recorded data.

During foraging bouts approximately 100 bites per species were assigned to 3 size classes in order to estimate bite size. After the bout, bites taken by moose were simulated by clipping 30 samples per species in the same size ratio as taken by the moose. Samples were bagged, oven-dried, and weighed. We estimated bite size for important plant species from these data by pooling observations and determining mean dry weight per bite. Diet composition was based on percentage dry weight of species consumed by observed moose. This was derived from the product of bite count and bite size data for each plant species.

Fresh fecal samples were collected during 1981 and 1982 from moose during foraging bouts and from other moose observed to determine rates of fecal deposition. Monthly sample sizes ranged from 52-58. Samples were frozen, then oven-dried and ground to pass a 1 mm screen. A subsample of each defecation was combined with others from the same month for each year. The composite sample was mixed and 10 microscope slides per month were prepared. Twenty microscope fields per slide (200 fields/month/year) were systematically located and plant fragments were identified by one of us(JGM) who did not participate in the bite count study and had no knowledge of that study's results. Frequency of occurrence of identified plants was converted to percent relative density following Sparks and Malecheck (1968).

Differences in percentage of important plant species in fecal samples between 1981 and 1982 and among months were tested with one-way analysis of variance (ANOVA) (Sokal and Rohlf 1969) followed by the Tukey HSD procedure.

RESULTS

About 54,000 bites of foraging moose were classified by species. Data for all animals, months, and years were pooled for a generalized presentation of summer diet composition (Table 1).

Observed moose consumed at least 16

Table 1. Percent of the diet contributed by various plant species eaten by moose during summer in Denali National Park, Alaska, 1981-82. Diet composition was determined from bite counts and estimated bite size for each plant species.

Species	% of diet
Salix planifolia pulchra	45.7
S. lanata	12.6
S. glauca	7.5
Betula glandulosa	6.9
Alnus crispa	6.5
S. alaxensis	6.2
S. novae-angliae	5.2
S. bebbiana	2.3[1]
S. arbusculoides	2.0
Epilobium spp.	1.4
Petasites spp.	0.6
Populus tremuloides	0.6[1]
Equisetum spp.	0.2[1]
Betula papyrifera	0.09[1]
Graminoids	0.09[1]
Populus balsamifera	0.01[1]
Unknown	2.0[1]

[1] Bite size was not determined for these species. Mean bite size (0.98) of other species was assigned to them.

different species including 12 woody plants and 3 forbs. Direct observation of moose indicated that about 96% of the diet consisted of leaves, twigs, and bark of woody species. Moose ate 7 willow species; these comprised 81.5% of the diet (Table 1). Diamondleaf willow contributed 45.7% to the diet and ranked first each month. Other important shrubs included resin birch (6.9%) and green alder (6.5%).

Data from fecal analyses indicated no differences between years for important forage species groups (p=0.548). Similarly, no differences were detected among months within species (p>0.05). As with the data from direct observations of foraging moose, fecal analysis data for both years and all months were pooled (Table 2).

Fecal analysis indicated that moose consumed woody and nonwoody species in about the same proportion as indicated by direct observations (Table 2). Fecal analysis could not differentiate willow species but the total contribution of willow to the diet was similar for the 2 techniques (86.1 vs. 81.5%, Table 2). Fecal analysis identified 2 species not detected by bite counts but failed to identify 2 species including one important forb (*Epilobium* spp., Table 2). Monthly comparisons of diets determined by bite counts indicated that diet richness peaked in July when forbs were available and the diet contained 15 species.

Table 2. Percent of the summer diet contributed by various plant species for moose in Denali National Park, Alaska as determined by fecal analysis and observed bites combined with estimated bite sizes. For each technique, data were pooled for all months, June through August, and both years, 1981 and 1982.

Species	Fecal analysis	Direct observation
Salix spp.	86.1	81.5
Betula glandulosa	9.2	6.9
Alnus crispa	1.1	6.5
Populus spp.	0.6	0.6
Petasites spp.	0.10	0.6
Epilobium spp.	--	1.4
Equisetum spp.	0.06	0.2
Graminoids	0.2	0.09
Rosa acicularis	0.02	--
Vaccinium spp.	0.04	--
Betula papyrifera	--	0.09
Unidentified	2.8	2.0

DISCUSSION

These data indicate heavy reliance on leaves and stems of woody plant species by moose in Denali National Park during summer. About 96% of the summer diet consisted of woody species. Two species of forbs, *Epilobium* spp. and *Petasites* spp. constituted only 2% of the diet.

Seven willow species were the most important woody plants in the diet. They contributed about 81.5% of the total bites corrected for bite size. Diamondleaf willow alone contributed about 46% to the diet.

Moose in our study consumed virtually no aquatic plants; their summer food habits contrasted with moose in many other areas of North America where aquatic plants are readily available and eaten (Peek 1974, Peek *et al.* 1976, Miquelle 1979). Similarly, forbs were a minor component of the diet unlike moose on the Kenai Peninsula, Alaska (25% forbs, LeResche and Davis 1973), moose in Newfoundland (35% forbs, Butler 1986), or those in Montana (70.6% forbs, Knowlton 1960). We suggest that these differences relate to the relative abundance of shrubs, forbs, and aquatics at Denali. Habitats used by moose there are mountainous, high-elevation, shrub-dominated sites where forbs are not abundant and aquatic habitats are virtually absent except for a few, scattered ponds.

Results of recent winter studies combined with our data provide a year-long picture of foraging patterns of moose at Denali National Park. Risenhoover (1987) reported that 94.3% of the winter diet was willows;

diamondleaf willow (18.9%) and feltleaf willow (44.4%) were the 2 most important species. Green alder (2.4%), resin birch (2.1%), and balsam poplar (*Populus balsamifera*) (1.2%) were the non-willow woody species moose consumed. These results confirm those reported by Murie (1944, 1963) who indicated that willows were the mainstay of moose throughout the year at Denali. Moose in certain other areas of Alaska rely much more on paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*) or other woody species when palatable willows are rare (Regelin 1987).

This study indicated that similar results are possible when determining summer food habits of moose by observation of foraging moose versus fecal analysis. We attribute this to a relatively simple diet and the good technical skills of a biologist experienced in fecal analysis, important requirements for accuracy identified by Gill *et al.* (1983). Fecal analysis, however, could not differentiate willow species, a major shortcoming that would have masked the importance of diamondleaf willow and failed to reveal certain willow species totally avoided by moose (e.g. Barrett willow, *Salix barrattiana*). Fecal analysis also failed to detect *Epilobium* spp., one of two important forbs, perhaps because it was highly digestible.

Possible errors associated with direct observation were difficult to assess. Observers were experienced with the bite count method (Miquelle 1979), practiced identifying species at appropriate distances, and 2 observers were present to agree on species identification. The presence of habituated moose greatly facilitated our ability to accurately identify food items, an advantage not available to investigators working with wild moose in most other areas. Consumption of forbs may be underestimated because bites taken at low heights in dense vegetation are difficult to observe. However, species identification was possible for 98% of observed bites.

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