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Early winter food habits of Manitoba moose as determined by three rumen analysis methods[1]

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Early winter food habits of moose (*Alces alces*) from Hecla Island and Manitoba game hunting area 26 in southeastern Manitoba were studied in 1978 and 1979. Twenty-five plant taxa were identified in 86 rumen samples. In decreasing order of importance, moose fed mainly on red-osier dogwood (*Cornus stolonifera*), balsam fir (*Abies balsamea*), willow (*Salix* spp.), mountain maple (*Acer spicatum*), trembling aspen (*Populus tremuloides*), bog birch (*Betula glandulifera*), and balsam poplar (*Populus balsamifera*). These taxa constituted about 98% of the diet by weight. Most rumens contained several of these taxa, with some containing traces of the uncommon ones. The diet of moose from the two study areas was similar, but Hecla Island moose showed a shift in diet from 1978 to 1979. The diet was not influenced by sex or age of the moose.

Three methods of food habit determination were used: presence/absence, abundance score, and dry weight. All three methods yielded very similar results. Although some rumen samples had a volume of only 0.13 L, sampling volume was not significantly correlated with the number of taxa identified per sample. Gains curves showing the cumulative total number of taxa versus successive samples collected indicated that the number of samples analyzed was adequate.

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Les habitudes alimentaires de l'orignal (*Alces alces*) de l'île Hecla Island et du territoire de chasse Manitoba Game Hunting Area 26 dans le sud-est du Manitoba ont fait l'objet d'une étude en 1978 et 1979. Vingt-cinq taxons de plantes ont été reconnus dans 86 échantillons de rumen. L'orignal se nourrit surtout, par ordre décroissant d'importance, de cornouiller stolonifère (*Cornus stolonifera*), de sapin baumier (*Abies balsamea*), de saules (*Salix* spp.), d'érable à épis (*Acer spicatum*), de peuplier faux-tremble (*Populus tremuloides*), de bouleau glanduleux (*Betula glandulifera*) et de peuplier baumier (*Populus balsamifera*). Des taxons constituent environ 98% de la masse alimentaire. La plupart des rumens examinés contenaient plusieurs de ces taxons et certains contenaient des traces de taxons plus rares. La diète de l'orignal s'est avérée semblable aux deux endroits, mais il s'est produit un changement dans la diète des orignaux d'Hecla Island de 1978 à 1979. La diète n'est fonction ni de l'âge, ni du sexe des orignaux.

Trois méthodes ont permis de mettre en relief les habitudes alimentaires des orignaux: présence/absence, abondance et poids sec. Les trois méthodes donnent des résultats très semblables. Certains rumens ne contenaient qu'un très petit volume alimentaire (0,13 L), mais il n'y a pas de corrélation significative entre le volume et le nombre de taxons identifiés par échantillon. Les courbes illustrant le nombre total cumulé de taxons en fonction des échantillons successifs indiquent que le nombre d'échantillons analysés est suffisants.

[Traduit par le journal]

Introduction

Food habits of moose (*Alces alces*) in western Canada are poorly known (Peek 1974) and virtually no data have been published from Manitoba. The objectives of this study were to determine the early winter diet of moose in two separate study areas in southeastern Manitoba and to compare methods of determination and adequacy of samples.

Study areas and methods

Two study areas were chosen: Hecla Island, in Lake Winnipeg, and Manitoba game hunting area 26 (GHA 26) on the east shore of Lake Winnipeg between the Winnipeg and the Wanipigon Rivers.

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Hecla Island belongs to the Manitoba Lowlands (Rowe 1972). The forest, on the flat and poorly drained land, is a mosaic of balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), trembling aspen (*Populus temuloides*), balsam poplar (*Populus balsamifera*), birch (*Betula* spp. including bog birch *B. glandulifera*), and mountain maple (*Acer spicatum*) interspersed with more open areas with willows (*Salix* spp.) and red-osier dogwood (*Cornus stolonifera*). During the past few years, Hecla Island has supported a large moose population with densities in 1978 reaching 2.3 moose/km^2 of suitable habitat and with some areas having up to 5.2 moose/km^2 (Crichton 1980). Moose densities in 1979 were slightly lower owing to poor reproduction and harvesting in 1978.

GHA 26 is mainly Northern Coniferous Forest, underlaid by the southwestern part of the Canadian Shield, but a narrow strip along Lake Winnipeg is part of the Manitoba Lowlands (Rowe 1972). The region contains numerous rock outcrops, uplands with thin soil, and poorly drained lowlands. The vegetation is similar to that on Hecla Island but the average moose density is only about 0.1 moose/km^2 (V. F. J. Crichton, unpublished data).

All moose rumens were collected in the first 2 weeks of December during the 1978 and 1979 hunting seasons. Three rumen samples were obtained from a region immediately south of GHA 26. Rumen samples were placed in plastic bags and frozen in the field.

We used three methods to determine diet: presence/absence, abundance score, and dry weight. The presence/absence method is based on occurrence of taxa in individual rumens, followed by calculation of percentage occurrence of each taxon in all the rumens. The abundance score and the dry weight methods are based on subjective abundance scores and dry weights of taxa within rumens, respectively. They involve calculation of percentages of taxa in each rumen followed by determination of mean percentages for all rumens. In the case of the dry weight method, we ignored unidentified plant material and variability in water content of taxa. All of the important browse species of moose on Hecla Island and in GHA 26 have a similar water content (Zach and Mayoh 1982).

First, each sample was spread in a white enamel tray and the abundance of each taxon was scored using the following scale: 5, dominant; 4, abundant; 3, common; 2, occasional; and 1, rare. Then a 1-L subsample or the total sample, if less was available, was washed through a 6.35-mm sieve and spread evenly in a gridded white enamel tray of 890 cm^2 marked off into 138 equal squares. Plant material from 36 randomly selected squares was then used for dry weight determination, which involved 24 h of drying at 80°C. On the average 12.6 ± 1.2% (n = 86) of the plant material by weight could not be identified.

To investigate bias owing to loss of small particles during straining (Bergerud and Russell 1964), we ranked subjective abundance scores (SAS) and percentage dry weight (PDW) of the various taxa within each rumen. Tied ranks were assigned if necessary. We then computed a rank deviation (RD), RD = SAS–PDW, for each taxon in each rumen. Thus, RD < 0 indicates that a taxon is underestimated during subjective assessment; RD = 0 suggests agreement of the two measures of abundance; and RD > 0 indicates that a taxon is overestimated during subjective assessment and (or) lost during straining.

The sex of all animals was recorded. Ages of Hecla Island moose, were determined by using the dental cementum technique (Sergeant and Pimlott 1959). The ages of moose from GHA 26 were not determined.

Unless otherwise noted, all the values quoted are means and associated standard errors.

Results

As shown in Table 1, there was some bias in the analysis. Ignoring uncommon taxa, balsam fir, trembling aspen, mountain maple, red-osier dogwood, and willow were underestimated by abundance scores, whereas balsam poplar and bog birch were overestimated and (or) lost during straining. Thus, dry weight values for the latter taxa must be interpreted carefully. The lists of taxa for each measure of abundance and all the identifiable taxa were identical for each rumen, indicating that none of the taxa was missed while assigning abundance scores nor were any lost by straining.

The mean sample volume collected was 0.90 ± 0.02 L (n = 86); the smallest sample was only 0.13 L. The probability of sampling all the taxa in a rumen may be inversely related to sample volume. To test this hypothesis we correlated volume and number of taxa detected. Based on the pooled data, no significant relationship was indicated (r_s = 0.10, $P >$ 0.05, Spearman's rank correlation coefficient). Thus, the inclusion of samples of less than 1 L did not introduce any bias and the test suggests that moose rumen contents are homogeneously mixed. For this study, a sample volume of 1 L was excessive.

From Hecla Island we collected 32 and 34 rumens in 1978 and 1979, respectively, and from GHA 26, 17 rumens were obtained in 1978. Since these sample sizes are small, they may not include all the taxa used by moose. We examined the adequacy of the number of samples by plotting the cumulative number of identified taxa against successive samples collected. Gains curves level off rapidly showing that 15 to 20 samples are adequate for this study (Fig. 1).

To compare methods of diet determination, we correlated percentage values for the presence/absence, abundance score, and dry weight methods. Results of the three methods are strongly related for individual and combined data sets (Table 2). Reversals are mainly associated with unimportant taxa. Thus, the large amount of work involved in the dry weight method was unnecessary. Also, the results show that taxa found in a few rumens are usually eaten in small amounts, whereas the converse is true for taxa found in most rumens.

TABLE 1. Mean rank deviation scores (RD) based on ranking of subjective abundance scores (SAS) and percentage of dry weight (PDW) of the seven main taxa from a total of 86 moose rumens from southeastern Manitoba

Taxon	n^a	RD	SE
Balsam fir	77	−0.10	0.11
Balsam poplar	27	0.13	0.22
Trembling aspen	47	−0.10	0.12
Mountain maple	40	−0.15	0.11
Red-osier dogwood	71	−0.28	0.09
Bog birch	36	0.54	0.22
Willow	54	−0.16	0.13

NOTE: Besides the seven main food taxa, the following minor taxa were also identified: ash (*Fraxinus pennsylvanica*), jack pine (*Pinus banksiana*), alder (*Alnus rugosa*), bog rosemary (*Kalmia polifolia*), chokecherry (*Prunus virginiana*), hazelnut (*Corylus cornuta*), highbush cranberry (*Viburnum trilobum*), Labrador tea (*Ledum groenlandicum*), raspberry (*Rubus idaeus*), rose (*Rosa acicularis*), Saskatoon (*Amelanchier alnifolia*), wolfberry (*Symphoricarpos occidentalis*), Canada thistle (*Cirsium arvense*), yellow sweet clover (*Melilotus officinalis*), cattail (*Typha latifolia*), grasses (*Gramineae*), sedges (*Scirpus* spp.), and fungi. For details on these taxa see Zach and Mayoh 1982.

[a]Number of rumens in which taxa occur.

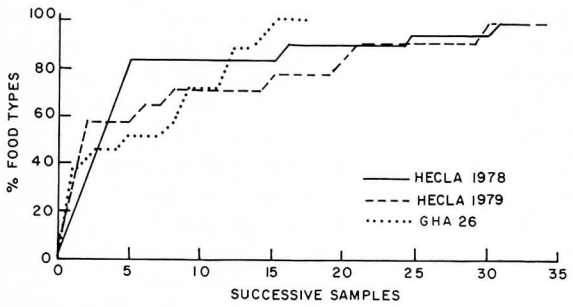

FIG. 1. Gains curves showing cumulative percentage of total number of taxa versus successive moose rumen samples collected.

We investigated diet differences relative to study area, year of study, and age and sex of moose by tests of independence using frequency of occurrence of the seven main taxa in the rumens. Other methods of determination give similar results. In terms of dry weight and ignoring unidentified plant matter, the seven taxa account for 98.1% of the moose's diet (Table 3).

The diet of moose from Hecla Island in 1978 and 1979 and from GHA 26 differed significantly ($X^2 = 26.83$, $P < 0.005$), and a posteriori comparisons showed that this was due to differences between Hecla Island moose in 1978 and 1979 ($X^2 = 16.02$, $P < 0.025$). In 1979, mountain maple and trembling aspen were more important than in 1978, but bog birch was less important in 1979 (Table 4). In terms of dry weight, the importance of balsam fir increased from 1978 to 1979, whereas willow showed the reversed trend (Table 4). In no case did the diet of Hecla Island moose differ significantly from that of moose in GHA 26.

TABLE 2. Spearman's rank correlation coefficients (r_s) of percentage contribution of taxa to moose diet based on three methods of determination

Data set	Number of taxa	Methods compared[a] 1 and 2	1 and 3	2 and 3
Hecla Island 1978	19	0.98[b]	0.92	0.95
Hecla Island 1979	14	1.00	0.98	0.98
GHA 26	17	0.97	0.92	0.95
Combined	25	1.00	0.95	0.96

[a]Methods of determination: 1, presence/absence; 2, abundance score; 3, dry weight.
[b]$P < 0.001$ in all cases.

TABLE 3. Percentage contribution to moose diet of the seven main taxa based on three methods of determination and 86 rumens from southeastern Manitoba

Taxon	Presence/absence, %	Abundance score %	SE	Dry weight %	SE
Balsam fir	19.6	21.3	1.6	21.6	2.2
Balsam poplar	6.9	5.6	1.0	5.0	1.3
Trembling aspen	12.0	12.2	1.4	12.0	2.0
Mountain maple	10.2	9.7	1.4	12.1	2.2
Red-osier dogwood	18.1	20.0	1.6	25.8	2.6
Bog birch	9.2	9.8	1.5	6.2	1.3
Willow	13.8	14.8	1.6	15.4	2.2
Other[a]	10.2	6.6		1.9	0.4

[a]See Table 1.

For both male and female moose, differences in diet among study areas and years were not significant, thus allowing pooling of data. Using these pooled data, no significant difference was detected in the diet of males and females ($X^2 = 1.44$, $P > 0.05$).

To investigate age differences we classified 1978 and 1979 Hecla Island moose separately into two groups of about equal size, one composed of animals older than 4.5 years and the other of all the younger animals. Homogeneity of age-classes of the 2 years allowed pooling. There was no indication that the age of the animals affected their diet ($X^2 = 2.53$, $P > 0.05$). The entire analysis was repeated comparing calves with older animals. Apparently, calves have a diet similar to that of adults ($X^2 = 2.46$, $P > 0.05$).

In decreasing order of importance, moose fed mainly on red-osier dogwood, balsam fir, willow, mountain maple, trembling aspen, bog birch, and balsam poplar (Table 3). From the 25 taxa identified (Table 1), the

TABLE 4. Percentage contribution to moose diet based on dry weight method of determination and frequency of occurrence (F) of the seven main taxa from rumens from Hecla Island 1978 (n = 32), Hecla Island 1979 (n = 34), and GHA 26 (n = 17)

	Hecla Island 1978			Hecla Island 1979			GHA 26		
	%	SE	F	%	SE	F	%	SE	F
Balsam fir	16.9	4.0	28	26.1	3.1	33	24.7	3.7	16
Balsam poplar	6.9	2.8	11	4.8	1.6	13	2.7	2.2	2
Trembling aspen	7.5	2.9	9	8.8	2.2	22	29.8	5.8	16
Mountain maple	6.6	2.5	10	21.9	4.4	23	2.7	1.7	4
Red-osier dogwood	25.3	4.6	25	26.5	3.7	27	17.5	4.5	16
Bog birch	11.0	2.9	19	3.0	1.4	7	4.9	1.8	7
Willow	22.6	4.7	21	8.2	2.4	18	16.0	4.2	12
Other[a]	3.2	0.8	18	0.7	0.3	10	1.7	0.5	9

[a]See Table 1.

three most important ones accounted for 62.8% of the plant material by weight (Table 3). Thus, moose fed mainly on shrubs and young trees. Forbs, grasses, and sedges were of minor importance and largely unavailable because of snow cover. Typically, most rumens contained two or more of the seven most important taxa with some containing traces of the uncommon ones. Some taxa occurred with great consistency; e.g., balsam fir and red-osier dogwood were found in 89.5 and 82.6% of all the rumens examined (Table 1).

Discussion

Early winter food habits of moose from Hecla Island and GHA 26 are best summarized by the data presented in Table 4. If differences between 1978 and 1979 Hecla Island moose are ignored, Table 3 gives an overall summary. Several studies have identified baslam fir, balsam poplar, trembling aspen, mountain maple, red-osier dogwood, bog birch, and willow as important browse species of moose in central and eastern North America (Peek 1974; Crête and Bédard 1975; Joyal 1976; McNicol and Gilbert 1980; Crête and Jordan 1981).

Cursory examination of the vegetation in our study areas indicated selective feeding. Red-osier dogwood, balsam fir, and willow were heavily browsed, whereas other common species such as balsam poplar, alder, and hazelnut remained virtually untouched. Our results suggest that moose prefer red-osier dogwood, which showed signs of extreme use on Hecla Island. Snyder and Janke (1976) made similar observations on Isle Royal, although moose there preferred American yew (*Taxus canadensis*). Yew is very rare on our study areas. The heavy reliance of moose on balsam fir in our study probably indicates reduced availability of more preferred taxa owing to browsing. If necessary, moose will switch readily to less preferred foods (Bergerud and Manuel 1968; Crête and Bédard 1975; Joyal 1976).

Food habits of moose can vary greatly in time and space (Peek 1974; Crête and Jordan 1981). The differences in diet of Hecla Island moose in 1978 and 1979 (Table 4) may relate to partial recovery of the vegetation following the first hunting season in 1978 during which the moose herd was reduced by about 20%. However, the spatial distribution of moose kills made by hunters differed drastically between the 2 years (V. F. J. Crichton, unpublished data). Since the vegetation on Hecla Island is very patchy in distribution, this is a much more likely explanation for the observed differences.

Our comparisons of the three methods of determination of diet strongly suggest that washing, straining, and dry weight determination are unnecessary, since methods based on raw rumen contents gave very similar results (Table 3). However, values based on dry weight are likely the best indicators of diet, since they involve the most quantitative data. Actually, the three methods measure different things. The presence/absence method involves the number of moose which have eaten the various taxa, irrespective of amount consumed, while the abundance score and dry weight methods are mainly concerned with amount consumed. In our study the three measures converge, as indicated by strong correlations (Table 2). Depending on the exact feeding pattern of moose, the exclusive use of the presence/absence method could lead to erroneous results.

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BERGERUD, A. T., and F. MANUEL. 1968. Moose damage to balsam fir/white birch forests of central Newfoundland. J. Wildl. Manage. **32**: 729–746.

BERGERUD, A. T., and L. RUSSELL. 1964. Evaluation of rumen food analysis for Newfoundland caribou. J. Wildl. Manage. **28**: 809–814.

CRÊTE, M., and J. BÉDARD. 1975. Daily browse consumption by moose in the Gaspé Peninsula, Quebec. J. Wildl. Manage. **39**: 368–373.

CRÊTE, M., and P. A. JORDAN. 1981. Régime alimentaire des Orignaux du sud-ouest Québécois pour les Mois d'Avril à Octobre. Can. Field-Nat. **95**: 50–56.

CRICHTON, V. F. J. 1980. Manitoba's second experimental moose hunt on Hecla Island. Manitoba Department of Natural Resources, Winnipeg.

JOYAL, R. 1976. Winter foods of moose in La Verendrye Park, Québec: An evaluation of two browse survey methods. Can. J. Zool. **54**: 1765–1770.

MCNICOL, J. G., and F. F. GILBERT. 1980. Late winter use of upland covers by moose. J. Wildl. Manage. **44**: 363–371.

PEEK, J. M. 1974. A review of moose food habits studies in North America. Nat. Can. (Ottawa), **101**: 195–215.

ROWE, J. S. 1972. Forest regions of Canada. Can. For. Serv. Publ. No. 1300.

SERGEANT, D. E., and D. H. PIMLOTT. 1959. Age determination of moose from sectioned incisor teeth. J. Wildl. Manage. **23**: 315–321.

SNYDER, J. D., and R. A. JANKE. 1976. Impact of moose browsing on boreal-type forests of Isle Royale National Park. Am. Midl. Nat. **95**: 79–92.

ZACH, R., and K. R. MAYOH. 1982. The food and food habits of Manitoba moose in early winter. Atomic Energy of Canada Limited Report, AECL-6832.