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Food Habits of Moose from Augustów Forest

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Food habits of moose during autumn have been determined on the basis of analysis of 39 rumen content samples. Trees and shrubs comprise more than 87% of the diet. The most important species were pine (51.6%), trembling aspen, birch, limetree, gray willow, and alder buckthorn. The composition of winter food was identified on the basis of 68,516 bites recorded on shoots in the course of moose tracking. Shoots of trees and shrubs are the most important group of plants in the diet. They comprise more than 99% of diet during this season. Among trees pine is the most important species (92.6%), gray willow and alder buckthorn occupying the first position among shrubs. Daily food consumption in winter was calculated as a result of tracking. Cows consume on average 19.5 kg of fresh twigs, calves — 17.0 kg, and bulls — 16.0 kg.

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I. INTRODUCTION

An increase in moose numbers during recent years and the extension of their range in certain regions of the country brought about serious damage in pine regeneration (Morow, 1974). This problem starts to acquire economic importance in forest management. Moose expansion and occupation of ever new ecological niches by them inclines to the question what an impact on primary production is exerted by big ungulates in places of their existence.

The rapid increase in moose numbers in this country took forest and wildlife management unaware. No management quidelines were developed for the species, there were also no basic research on moose biology and ecology.

The literature abounds with papers on moose diets. And so, *e.g.* Peterson (1955) in his monograph presented results of studies on diet composition and food habits of moose in North America, Skuncke (1949), Hagen (1958, 1962), Koivisto (1963), Loisa & Pulliainen (1968), Andersson (1971) studied the diet of moose in Scandinavia. In USSR more detailed studies on moose diets were carried out in tundra and taiga (Knorre, 1959; 1959a) and a complete review of Soviet literature under this line is given by Heptner & Nasimovič (1967).

Peterson (1955), Danilov (1958), and Heptner & Nasimovič (1967) indicate that food of moose consists of plants of several hundreds of species, ne-

vertheless the basic food within individual portion of range is secured by plants of 25—30 species. Characteristic, that along with an increasing fertility of sites and richness of vegetation, increases also the diversity of moose food. Hence the importance of local studies on their diets.

In Poland until now there were no studies on moose diet and certain remarks are contained in only two papers (Anonymous, 1820; Korsak, 1934).

The purpose of the present work was to investigate the composition, quantity, and variation of the food taken during autumn and winter seasons. These seasons of year were selected, because moose feed then mainly on browse, causing most severe damage in forest management.

The food carrying capacity of individual habitats occupied by mose in the Augustów Forest was also tentatively appraised.

II. CHARACTERISTICS OF THE STUDY AREA

Studies were carried out in the Augustów Forest (north-eastern Poland, 53°40′—54°10′, — 22°40′23°32′) with the area of more than 14.8 thous. ha. Organic soils prevail there. They are classed to the section of hydromorphic soils with all classes included. Climatic conditions are characteristic by a low mean annual temperature (6.1°C), short vegetation season (192 days), long period of snow cover prevalence (104 days). Annual amplitude of temperature, which is to some degree a measure of continental character of climate amounts to 23°C.

On the background of above described natural conditions forest site types presented in table 1 were formed. Forest stands consist of: pine — 74%, alder — 10.1%, birch — 9.4%, spruce — 6.2%, and oak, ash, trembling aspen, and limetree — jointly 0.3%. As one can note pine is the dominant species in stands. It forms rather considerable percentage of stands even in untypical for this species sites (fresh and moist deciduous forest). Great per cent of area under alder and birch attracts one's attention.

III. STUDY PROCEDURE

Composition of diet, its variation and food selection, were studied with the aid of the analysis of rument content samples and tracking in snow after animals during feeding.

1. Analysis of Rumen Content Samples

Samples (39) have been taken from moose harvested in the course of hunting season (September 1 — November 30) during years 1971—1973. Four samples were taken in February and March of 1972. Samples consisting of subsamples taken manually from various portions of rument have been placed in a container with 1 litre volume and flooded with 10% aqueous solution of formalin. The remaining content of rumen has been measured with 1 l dish and recorded on a card together with date and place of kill, sex and age of moose, its weight before and after dressing, weight of internal organs (lungs, heart, liver, and kidneys), and weight of kidney and intestinal fat separated manually.

In laboratory samples have been placed on soil sieves with 2 mm diameter mesh and rinsed under tap water. The fraction, which passed sieves, was classed

as unidentifiable remainder (Dzięciołowski, 1970). The portion of sample, which was retained by sieves, has been segregated and identified in a wet state under binocular with 5×magnification. Following to identification to species or a group of plants, the material has been dried at the temperature of 70°C during 48 hours, its volume being measured and weight determined with the accuracy to 0.01 g.

In numerous cases the identification of plant parts down to species was impossible. Then the material has been classed to one of following groups: 1) trees and shrubs, 2) dwarf shrubs, 3) grasses, sedges, and rushes, 4) bryophytes, 5) pteridophytes, 6) herbaceous plants.

Results were presented in percentages of dry weight and volume.

The high proportion of heather and bark of pine and trembling aspen to be found in certain rumen samples made it possible to calculate the mean weight

Table 1

Comparison of forest area according to forest site types.

Forest site type	ha	%
Fresh coniferous forest	6,798.70	45.79
Moist coniferous forest	766.04	5.16
Bog conifereous forest	581.34	3.92
Fresh mixed coniferous forest	1,580.29	10.64
Moist mixed coniferous forest	1,007.56	6.79
Mixed deciduous forest	707.12	4.79
Fresh deciduous forest	81.87	0.55
Moist deciduous forest	117.03	0.79
Ash alderwood	1,092.66	7.37
Alderwood	2114.93	14.24
Total	1,4847.54	100.00

of these food classes. And so, 50 cm² of peeled pine bark weighs 2,400 g (standard deviation $\delta \pm 0.410$ g), 50 cm² of peeled aspen bark — 2,962 g ($\delta = \pm 0.058$ g), and 10 twigs of heather — 0.182 g ($\delta = \pm 0.027$).

2. Examination of Feeding Places with the Aid of Tracking in Snow

The most reliable and abundant data may be secured while using this technique. It permits also to evaluate preferences and diurnal consumption of food.

The procedure is following. A fresh track of moose or moose group has been undertaken and followed. In spots of feeding plant species on which moose fed and quantities of consumed plant parts have been recorded in observation cards. Each bite was accepted as one observation. The material collected included 68,516 bites. During the winter of 1971/1972 also the diameter of each bite was measured. Date and atmospheric conditions were also recorded in observation cards. The length of track in each habitat, number of bedding places, and number of pellet groups were also plotted on a sketch and a map of plant associations.

On the basis of 1000 measurements of diameter at browse point the mean diameter at browsing was determined for shoots of: pine, trembling aspen, birch, gray willow, alder buckthorn, whortleberry, and juniper (100 shoots). Samples of 1000 shoots with definite diameter were taken and the mean weight, volume, and

Table 2

Moose diet during autumn as determined on the basis of 39 rumen content samples.

Plant group, Species or genus	Plant part consumed	Weight g	%	Volume ml	%
	TREES AND SHRUBS				
Pinus silvestris L.	needles	895.710		4150.4	
	shoots	69.970		255.6	
	bark	13.510		52.7	
		992.700	**49.4**	**4458.7**	**49.2**
Salix cinerea L.	leaves	126.660		635.8	
	shoots	66.920		236.0	
		193.580	**9.6**	**871.8**	**9.6**
Populus tremula L.	leaves	71.540		358.0	
	shoots	39.850		118.8	
	bark	52.460		209.8	
		163.850	**8.1**	**686.6**	**7.8**
Frangula alnus Mill.	leaves	117.210		675.4	
	shoots	35.960		118.6	
	seed	0.820		5.8	
		153.990	**7.7**	**799.8**	**8.8**
Betula pubescens Ehrh.	leaves	78.370		287.2	
	shoots	47.890		192.2	
		126.260	**6.3**	**479.4**	**5.3**
Tilia cordata Mill.	leaves	75.240		460.2	
	shoots	13.590		45.0	
		88.830	**4.4**	**505.2**	**5.6**
Quercus robur L.	leaves	13.800		66.0	
	shoots	1.040		4.6	
		14.840	**0.7**	**70.6**	**0.7**
Evonymus europaea L.	leaves	3.380		11.4	
	shoots	6.260		22.4	
		9.640	**0.5**	**33.8**	**0.4**
Corylus avellana L.	leaves	6.140		26.9	
	shoots	2.830		11.2	
		8.970	**0.4**	**38.1**	**0.4**
Alnus glutinosa (L). *Gaertn*	leaves	2.100		8.2	
	shoots	4.180		15.0	
		6.280	**0.3**	**23.2**	**0.3**
Betula verrucosa Ehrh.	leaves	1.210	0.1	5.6	—
Juniperus communis L.	needles	0.630		3.8	
	shoots	0.430		1.8	
		1.060	**0.1**	**5.6**	
Salix caprea L.	leaves	0.830	0.1	3.8	0.2
Fraxinus excelsior L.	leaves	0.340	—	1.2	
Picea excelsa (Lam.) Lk.	needles	0.020		—	
	shoots	0.180		0.6	
		0.200	**—**	**0.6**	
Abies alba Mill.	needles	trace		—	
Indetermined		20.790	1.0	69.6	0.7
Subtotal		1783.370	88.7	8053.6	88.8

Table 2, concluded.

		DWARF SHRUBS			
Calluna vulgaris (L.) Salisb.		115.440	5.7	484.8	5.3
Vaccinium vitis-idaea L.	leaves	59.630		252.8	
	shoots	6.770		26.2	
		66.400	**3.4**	**279.0**	**3.2**
Vaccinium myrtillus L.	leaves	1.140		6.8	
	shoots	12.080		55.0	
		13.220	**0.6**	**61.8**	**0.6**
Subtotal		195.060	9.7	825.6	9.1
		DICOTYLEDONOUS FORBS			
Mycelis muralis (L.) Dum.		3.770	0.2	16.6	
Ranuncus repens L.		0.970		5.8	
Agrimonia eupatoria L.		0.780		3.6	
Veronica sp.		0.040	0.1	0.2	0.3
Ajuga sp.		0.040		0.2	
Subtotal		5.600	0.3	26.4	0.3
		GRASSES, RUSHES			
Molinia coeruela (L.) Moench.		2.710	0.1	16.4	0.1
Indetermined grasses		19.780	1.0	123.2	1.4
Indetermined rushes		0.110	—	0.5	—
Subtotal		22.600	1.1	140.1	1.5
		PTERIDOPHYTES			
Pteridium aquilinum (L.) Kuhn		2.420		15.4	
Dryopteris spinulosa (Mill.) O. Kunze		0.220		1.2	
Subtotal		2.660	0.1	16.6	0.2
		MUSHROOMS			
Armilaria melea Vahl.		1.170		3.6	
Xerocomus subtomentosus (Lex. Fr.) Quel.		0.260		0.6	
Subtotal		1.430	0.1	4.2	0.1
		MOSSES, LICHENS			
Cladonia sp.		0.110		0.4	
Dicranum sp.		trace		—	
Sphagnum sp.		trace		—	
Subtotal		0.110		0.4	
Total		2010.830	100.0	9066.9	

length of shoot (bite) were calculated for definite species. Samples have been taken in various types of habitats, in vicinity of places of the previous feeding of moose.

3. Statistical Development of Results Concerning Food Relations

Three animal groups: bulls (32 individuals — 11 rumen samples, 21 trackings), cows (48 individuals — 20 rumen samples, 28 trackings), and calves of both sexes (47 individuals — 12 rumen samples, 35 trackings), two seasons of year (autumn, winter), and 26 species of plants consumed comprising more than 1% of diet in a sample, were included in analysis. Components of an analysis of variance for 3 directional classification in a non-orthogonal pattern were identified. Calculations were done on electronic digital computer Odra 1204. Table 4 gives results of testing of hypotheses about the effect of individual factors and their interaction.

IV. COMPOSITION OF MOOSE DIET DURING AUTUMN AND WINTER

1. Moose Diet during Autumn

Since there was found no statistically significant interaction between seasons of year *(S)* and diets of individual animal groups *(P)* nor statistically significant differentiation in diet composition among the three animal groups studied (Table 4), the data were treated jointly for both series. Composition of diet during this season was determined on the basis of analyses of 39 samples of rumen content (Table 2).

Trees and shrubs constitute the most important groups of plants in the autumnal diet of moose. This type of food comprises more than 88% of the whole diet in respect to weight and volume. From among trees the most important are: pine, trembling aspen, birch, and limetree, while in shrub group: alder buckthorn and willow.

Dwarf-shrubs constitute the next group in moose diet and comprise more than 10% of the weight of food taken. The most important are: heather and cowberry.

Grasses provide 1% of the diet in respect to weight. Difficulties in identification of this plant group confined it to only two items. One should assume that more species occur in the diet.

Herbaceous plants, pteridophytes, fungi, mosses, and lichens constitute only 0.5% of moose diet during autumn.

Altogether, moose diet on the study area during autumn consists of 32 identified plant species, out of which nine, namely: pine, gray willow, trembling aspen, birch, alder buckthorn, limetree, heather, and cowberry provide more than 94% of the bulk of food taken by moose.

2. Moose Diet during Winter

Composition of diet was determined on the basis of tracking of 88 moose (Table 3). In the course of tracking 68 316 bites were recorded. For the sake of the comparison of results bites were converted into grams of dry matter (see procedure). One bite of pine weighed 3.727 ± 0.070 g, that of birch — 0.682 ± 0.030 g, trembling aspen — 0.546 ± 0.042 g, alder buckthorn — 0.431 ± 0.035 g, gray willow — 0.361 ± 0.027 g, juniper — 0.217 ± 0.020 g, while 10 twigs of whortleberry weighed 0.362 ± 0.042 g.

Shoots of trees and shrubs constitute the most important group of plants in moose diet during winter (they comprise more than 99% in respect to weight). The most important tree species are: pine, birch, and aspen — comprising 97%. Gray willow and alder buckthorn (2.5%) take the first place among shrubs. Dwarf shrubs provide only 0.2% of moose diet during winter.

Moose diet during winter (determined on the basis of tracking and analyses of 4 rumen samples) consists of 16 species, among which pine provides 92.1% in respect to weight.

Table 3

Composition of moose diet during winter as determined on the basis of tracking.

Species	No. bites	Wt. (g dry matter)	%
Trees and shrubs			
Pinus silvestris L.	38,656	144,070.9	93.1
Betula pubescens Ehrh.	6,415	4,373.0	2.8
Salix cinerea L.	7,235	2,611.8	1.7
Populus tremula L.	3,544	1,935.0	1.3
Frangula alnus Mill.	2,868	1,236.1	0.8
Sorbus aucuparia L.	86	58.6	
Juniperus communis L.	198	42.9	
Tilia cordata Mill.	13	8.8	
Evonymus europaea L.	7	5.7	
Padus avium Mill.	22	6.9	
Rubus idaeus L.	3	2.0	
Carpinus betulus L.	2	1.3	
		126.2	0.1
Subtotal	59,049	154,355.0	99.8
Dwarf shrubs			
Vaccinium myrtillus L.	9,279	335.9	
Calluna vulgaris Salisb.	188	3.4	
Subtotal	9,467	335.3	0.2
Total	68,516	154,694.3	100.0

3. Variation in Diet Composition in Relation to Season

In September trees and shrubs constitute more than 80% of whole diet in respect to weight. The list consists of: gray willow — 21.9%, limetree — 20.9%, alder buckthorn — 16.6, trembling aspen — 11.0, birch — 10.2, oak — 4.5, and hazel — 2.1%. One should mention that leaves of above mentioned species occupy 90% of the weight (Fig. 1).

Grasses are consumed by bulls exclusively. Rumen content varies from 7 (bulls) to 25 litres (cows). Quantity of food consumed during this month depends upon sexual activity of animals. Most active bulls take very small quantities of food during a rut and their stomachs contain only grasses, ferns, and soil.

In mid-October moose start to intensity browsing of pine. In certain samples this species occupied more than 80% of rumen by weight and volume. Generally, pine constitutes 57.2% of diet during this month. Number of plant species consumed decreases. A high proportion of dwarf shrubs in diet is to be noted. Heather comprises 9.5, while whortleberry

— 8.6% of diet. Leaves constitute only circa 5% by weight of deciduous species present in samples.

In November pine occupied already 74.3% of moose diet and the species occurred in all rumen samples. In some samples, shoots and foliage of pine occupied the entire volume of rumen, in certain cases attaining 50 litres. The proportion of trembling aspen is increased (12.6%). Detached bark of trembling aspen and pine occurs in rumens. The proportion of dwarf shrubs is decreased in diet (heather 6.4 and whortleberry 0.7%).

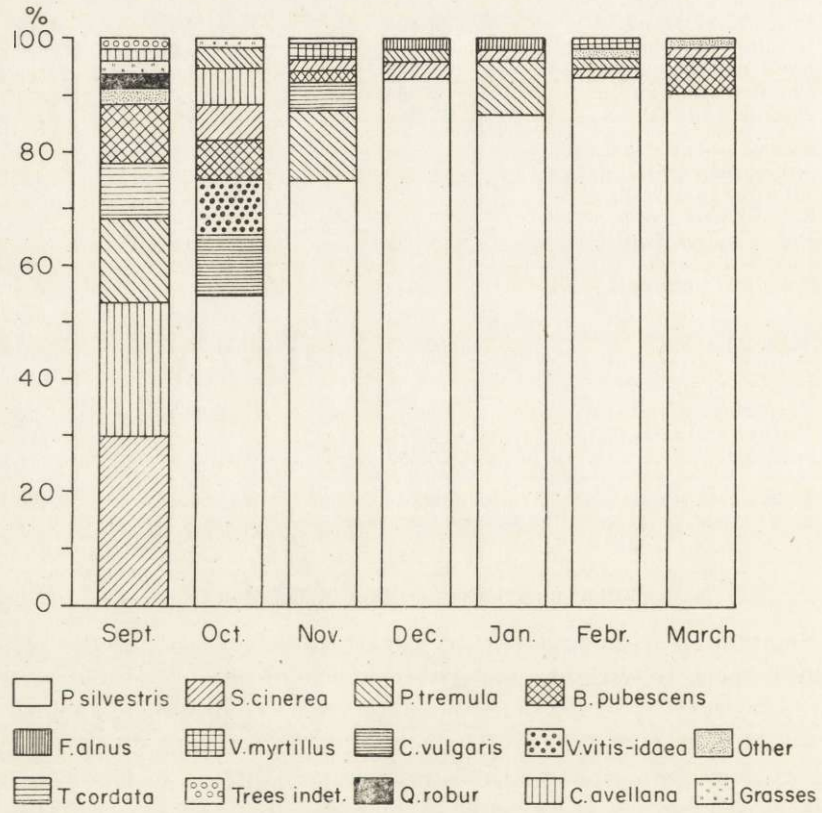

Fig. 1. Variation of diet during individual months of the autumn and winter seasons.

September food composition was based on analyses of 10 rumen samples, for October — 18, November — 11, December diet was based on 3,333 bites, January on 11,902, February — 20,062 bites and analyses of 2 rumen samples, and March diet on 33,219 bites and analyses of 2 rumen samples.

In December pine constitutes more than 92% of diet by weight. The proportion of trembling aspen declines. Gray willow and alder buckthorn occupy 2.7 and 2.0% of diet by weight, respectively.

In January pine occupies 85.3% of diet by weight. The high proportion of shoots and bark of trembling aspen (9.7%) in moose diet attracts one's attention. Shoots of whortleberry take 1% of diet.

In February pine attains its highest level in moose diet according to weight (96.3%). During this month greatest amounts of detached bark

Table 4

Results of testing of hypothesses.

Variation	Sums of squares	Degrees of freedom	S^2	F
Tree-way biased classification	427690.17	155		
Error	137347.60	205	669.99	
General	565037.77	360		
Test of interaction $S \times P$ (season × animal groups)				
For $i+j$ from the estimation of parameters	111837.54	3		
Interaction seasons groups ($S \times P$)	322.98	2	161.49	1
»Biased« variation $S \times P$	112160.52	5		
Test for animal groups (P)				
Biased for seasons	110782.91	1		
Unbiased for animal groups	1054.63	2	527.32	1
For seasons and animal groups from the estimation of parameters	111837.54	3		
Test for seasons (S)				
»Biased« for animal groups	2976.55	2		
For seasons (unbiased)	108860.99	1	54130.49	162.48
For seasons and animal groups from the estimation of parameters	111837.54	3		
Test of interaction seasons of year × species (S × D)				
For seasons of year and species from the estimation of parameters	387119.92	26		
Interaction seasons × species ($S \times D$)	29246.53	25	1169.86	1.75
»Biased« variation $S \times D$	416366.45	51		
Test for species (D)				
For biased variation of season of year	110782.91	1		
Unbiased for species	276337.00	25	11053.48	16.50
For seasons of year and species from the estimation of parameters	387119.91	26		
Test for interaction species × animal groups				
For species and animal groups from the estimation of parameters	370221.49	27		
Interaction species × animal groups $P \times D$	6405.10	50	128.10	1
Biased variation $P \times D$	376626.59	77		

of pine are to be found. The proportion of trembling aspen in diet drops remarkably. Gray willow and alder buckthorn comprise 2%.

In March pine takes 93.1% of diet. Until mid-March pine in certain cases was meeting 100% of the daily food demand. Since mid-March the proportion of birch in diet increases. Generally, birch constitutes 5% of the March diet of moose.

Statistical analysis (Table 4) indicated seasonal variation *(S)* in food selection and highly significant dfferentiation in the selection of food plants (*D*) during the seasons of year studied.

V. DAILY CONSUMPTION OF FOOD DURING WINTER

Table 5 illustrates the daily consumption of food by moose during winter. Cows take most food (3.95 kg of dry matter) during day and night, calves consume 3.39 kg of browse and bulls — 3.11 kg. Pine

Table 5

Daily consumption of food during winter in g of dry matter

Species	Bull (15)	Cow (18)	Calf (24)
Pinus silvestris	2,760.6	2,714.3	2,335.0
Betula pubescens	—	796.8	658.1
Populus tremula	144.7	212.9	198.7
Salix cinerea	95.0	85.1	78.5
Frangula alnus	78.4	104.8	63.6
V. myrtillus	39.8	36.6	59.3
Total	3,118.5	3,950.5	3,393.2

constitutes 85% of the diet of bulls, 68.7% — in cows, and 68.8% — in calves, what after conversion amounts to 15.5 kg, 15.2 kg, and 13.1 kg of fresh shoots per day and night, respectively.

VI. FOOD PREFERENCES OF MOOSE DURING WINTER

Research results indicate that one cannot agree with assumptions of certain researchers, who suggest that the consumption of conifers (pine under our conditions) by moose during winter is of compulsory nature. Pine provides a preferred by moose winter food on sites of cowberry, moor grass, whortleberry, eagle fern types of coniferous forest and in moist mixed coniferous forest. Numerous observations of moose feeding grounds in these associations indicated that this species is a prime browse in relation to gray willow and alder buckthorn. In numerous cases the daily diet of moose consisted of shoots and foliage of pine. Pine bark is being stripped most willingly in the cowberry-type coniferous forest.

Gray willow, alder buckthorn, and trembling aspen provide a second rate winter food in moose diet on above mentioned sites. On sites of bog bilberry-type coniferous forest, alder marsh, alderwood, and pine-spruce mixed fresh coniferous forest those plants are more willingly taken than pine.

In January aspen bark is a more preferred food than shoots of this species. Trembling aspen is being debarked most willingly in alderwood.

Whortleberry and birch are seasonally preferred food by moose. When the depth of snow cover permits the grazing of whortleberry twigs, it is sometimes more willingly grazed on sites of bog bilberry and moor grass-types of coniferous forest than pine, gray willow, and alder buckthorn. Birch may be considered as a species reluctantly consumed during winter and sometimes even avoided. It is only in late March when birch is intensively browsed and preferred sometimes above pine, gray willow, and alder buckthorn.

VII. DISCUSSION

1. Composition of Moose Diet during Autumn and Winter

Studies carried out in North America (Peterson, 1955), Europe, and the Asiatic portion of the USSSR (Sainio, 1955; Loisa & Pulliainen, 1968; Dinesman, 1959; Timofeeva, 1965; Petrovskij, 1967) indicated high regional and seasonal variation in moose diet. On the basis of an analysis of papers describing moose diet on the territory of USSR (*e.g.* Kaplanov, 1948; Danilov, 1958; Fedosov, 1959; Knorre, 1959; 1959a; Ustinov, 1964; Červonnyj, 1967; Heptner & Nasimovič, 1967; Chodašova & Eliseeva, 1970; Ivanter, 1970) it was determined that moose consume plants of 355 species, cultivated plants excluding.

From the above data it results that along with an increase in abundance and diversity of vegetation (in the direction from north to south) there increases also the number of plant species in moose diet. Moose are opportunists in feeding, *i.e.* they eat whatever available.

Only about 40 plant species are basic in moose diet according to above mentioned authors. While analyzing the composition of diet during individual seasons those authors arrive at the conclusion that the division of food plants into exclusively winter and exclusively summer ones does not hold true. It is only the degree of utilization of individual species that varies due to changes in palatability, and mostly in availability of food.

Results characterizing the composition of moose diet in the Augustów Forest obtained with the use of two techniques (analyses of rumen

content samples and winter tracking in snow) obviously deviate from data secured by above mentioned authors. This indicates a high variation in diet, not only seasonal, but also regional one. During autumn and winter seasons the diet in the Augustów Forest consists of 37 species of food plants.

Seasonal variation in food selection by moose manifests itself first of all by the size of individual groups of food plants — trees, shrubs, dwarf-shrubs, herbaceous plants, pteridophytes, and fungi (autumn) and trees, shrubs, and dwarf-shrubs (winter). For, these two seasons certain species are common, *e.g.* pine, trembling aspen, birch, alder buckthorn, gray willow — although their percentual proportion and consumed portions (foliage, shoots, bark) varies.

2. Daily Food Consumption during Winter

Daily consumption during winter in the study area amounts on average for cows — to 19.5 kg, calves — 17.0 kg, and bulls — to 16.0 kg of fresh shoots (after conversion from dry matter). As one can note, results

Table 6

Daily requirement of moose for food (kg of fresh matter)

Authority	Average daily consumption, kg
Andersson (1971)	7.07
Kaleckij (1967, 1969)	7.7 (Yearlings); 11.2 (2 years old); 12.9 (Adults)
Knorre (1959)	10.5—13.5
Mech (1966)	12.2
Peterson (1955)	18.0—22.5

obtained on the area of the Augustów Forest deviate somewhat from data obtained by other authors (Table 6). It is characteristic that yearling moose on the study area reveal higher food requirement than bulls.

3. Food Preeferences of Moose during Winter

Data on food preferences in relation to palatability and availability of food have been obtained in the course of tracking after moose in feeding places. This way of the determination of preferences seems more reliable than those used in other methods. During tracking one can record species composition of vegetation in relation to food plants occurring in a given area and the selection of habitat by moose in order to feed on definite tree and shrub species (M o r o w, 1975).

Differences in food selection by moose during winter may be explained by a various biochemical content of shoots of individual species (and even between various shoots within the same species), which seems to

be dependent upon the degree of insolation and certainly depends upon the quality of soils in various forest types.

In the course of winter tracking of moose it was noted that the insolated browse was more willingly consumed than that grown in shade. In connection with difficulties in moving in dense pine thickets, moose most frequently browse pine shoots near roads, compartment lines, glades, etc., where shots were insolated. When they fed inside thickets, they browsed only leaders and shoots of the upper verticil. Preferring of shoots and foliage of pine on sites of cowberry, moor grass, whortleberry, eagle farn types and in the moist mixed coniferous forest may be explained by the fact that pine (shoots and foliage) has there higher nutritional value and higher palatability than shoots of other tree and shrub species occurring also abundantly on these sites, which are not consumed in such quantities as pine.

Stalfelt (1970, after Markgren, 1969) characterizes moose as »nitrogen collecting species«. Protein level is always higher in juvenile plants or in their young shoots, as well as in insolated food. This can account also for the preference of insolated browse by moose, above that grown under conditions of poorer illumination.

4. Food Carrying Capacity of Plant Associations for Moose

While calculating resources of available browse, food demand, and the utilization of natural food by known numbers of animals, one can estimate food carrying capacity of individual habitats occupied by deer. Such studies were carried out for penned moose (*e.g.* Knorre, 1959; Kaleckij, 1967, 1969) and therefore results seem to be underestimated, when compared with those obtained in the course of the present work. According to our calculations bull consumes about 320 kg of dry mater of browse (including 285 kg of pine) during winter (on average 104 days — duration of snow cover prevalence), cow — 410 kg (282 kg), and calf — 350 kg (242 kg) — table 5. In order to calculate the extent of the utilization of available food resources by moose, the browse situated within feeding zone has been appraised (*e.g.* Dinesman, 1959; Kaleckaja, 1959; Nikiforov & Gibet, 1959; Kozlovskij, 1961 and 1965; Kaleckaja & Kudinov, 1967). The weight of browse available per area unit was calculated. Results have been compiled in so-called yield tables. The highest number of moose, at which damage in forest management is not caused and good in qualitative respect status of population is maintained is considered as permissible density of moose (Kozlovskij, 1961).

Results of studies by the above authors indicated that when browse resources amounted to no less than threefold demand of moose inhabiting

the area, the damage inflicted by moose was of no economic significance.

Pine is the most valuable species in our forests and at the same time provides main component of moose diet during winter. Dzięciołowski (1971) evaluated, among other things, the current growth of twigs of trees and shrubs situated within the range of feeding by deer. Studies were carried out in 5 forest associations developed on four forest site types prevailing in respect to acreage in this country.

Since on the area of study these forest site types occupy 68% of area and there are no other data, it was accepted that the pine stand in the I age class produces in the zone up to 3.0 m (the stratum of moose feeding) on average 6.0 g of dry matter per m^2 (60.0 kg/ha). On the study are pine stand in the Ist age class occupies 15.2% of area, *i.e.* provides the moose population with circa 135 tons of dry matter of browse. Moose, while utilizing during winter 92.4% of young plantations and thickets (Morow, 1975), have access to 125.1 tons of food during that time. Moose start to use intensively pine during the second half of October on the study area. During this month pine occupies 57.2% of diet and more than 74% in November. From calculations it results that an individual consumes on average about 370 kg of dry matter of pine shoots during autumn and winter and the population utilizes circa 30 tons or 1/4 of pine browse resources, what constitutes about 1/5 of the entire bulk of current year growth of a pine stand in the Ist age class. These are serious economic losses. Losses occur at the density of 5.3 individuals per 1000 ha of forest area (circa 27 ha of pine stand in the Ist age class falls to 1 moose) — therefore, this index may be considered too high.

During years of 1969—1970, when the study area was inhabited by 45—60 moose (3—4 individuals per 1000 ha of forest area — 35—45 ha of pine stands in the Ist age class fell to 1 individual) losses were of no practical importance.

It is suggested, therefore, to consider on average 3—4 individuals per 1000 ha of forest area as a maximum (optimum for forest and wildlife management) moose density in forest management units. This corresponds with 40—45 ha of pine stand in the Ist age class falling to one moose. The determination of the permissible moose density in forests should not be valid within the entire area of its occurrence. In the face of not uniform moose distribution it is necessary to determine population size for individual forest districts.

The population inhabiting the study area is a young one, which attained a high rate of growth owing to very favourable environmental conditions. Low numbers of red deer, very low number of roe deer and, therefore, a lack of competitors for food may contribute to a further rapid increase

in moose numbers. Then the damage caused by moose will become even more severe.

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ZWYCZAJE POKARMOWE ŁOSI W PUSZCZY AUGUSTOWSKIEJ

Streszczenie

Badania prowadzono na terenie Puszczy Augustowskiej w latach 1971—1973, używając dwóch metod w celu ustalenia składu pokarmu — analizy zawartości próbek żwaczy i zimowych tropień żerujących zwierząt.

Lista florystyczna pokarmu łosia w okresie jesienno-zimowym na terenie badań składa się z 37 gatunków, w tym: 13 drzew, 6 krzewów, 3 krzewinek, 5 roślin zielnych, 1 trawy, 1 situ, 2 paproci, 3 grzybów, 3 mchów.

Stwierdzono wyraźną zmienność sezonową w składzie pokarmu łosi (Rys. 1). Dieta łosi w okresie jesieni (Tab. 2) składa się z 32 oznaczonych gatunków roślin, z których 9 (w kolejności malejącego znaczenia): sosna, łoza, osika, brzoza, kruszyna, lipa, wrzos, borówka czarna i dąb stanowią najważniejszą grupę roślin w pokarmie łosi. Zajmują one ponad 94%.