THE IMPORTANCE OF SALT LICKS AND OTHER SOURCES OF SODIUM IN THE ECOLOGY OF THE USSURI MOOSE (*Alces alces cameloides*)

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ABSTRACT: The most important sources of sodium for moose (*Alces alces*) in Sikhote–Alin are: (1) freshwater aquatic vegetation (river, lake, and bog); (2) marine water and algae; and (3) sodium–saturated ground waters and soils at salt licks. The distribution of local sources of sodium essentially determines the spatial and temporal structure of moose populations. Salt licks play an important role in the ecology of moose as a factor promoting their regular distribution under conditions of the mountain–taiga landscape and also affecting breeding activity; i.e., increasing the probability of encounters of mating partners. The latter is of particular importance where population density is low.

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The access of herbivorous animals to sodium sources is of particular importance in sodium–deficient ecosystems. The latter are known to include the majority of mountain, mountain–forest, and also some forest and tundra landscapes in temperate and high–latitude zones on the Earth. The mountain Sikhote–Alin, the ancient place of origin of the Ussuri moose (*Alces alces cameloides*), is no exception in this respect.

The present paper is an attempt to reveal the primary sources of sodium used by moose in Sikhote–Alin, with special reference to the role of natural salt outcropping in the ecology of these animals.

STUDY AREA AND METHODS

The investigations were conducted in the Sikhote–Alin State Biosphere Reserve, mainly in the upper reaches of the Kolumbe River, and also in the basin of the upper reaches of the Bikin River (the Zeva Bolshaya and Malaya Svetlovodnaya Rivers) Territory, which is thought to be the southern edge of moose range. The average population density there is hardly 1 individual per 1,000 ha. The work was based on collection and investigation of the chemical composition of the essential forage plants and detailed observations of the seasonal movements of moose and their behavior at salt outcrops. Among the forage plants, chemical composition was studied in *Salix rosida*, the conifer *Larix komarouvii*, and also the graminoids *Carex phychophysa*, and *Calamagrostis landsdorfii*. The following aquatic plants were studied: *Potamogeton perfoliatus, Ranunculus eradicatus, Sparganium stenofillum*, and also some species of blue–green algae. The plant samples were taken in early summer (May–June) and during early autumn (September). Preparation and analysis of the samples was performed in the Laboratory of Geochemistry, Pacific Institute of Geography. The total number of hours of observations at salt licks over 1980–1990 was 2,774. Visual observations

at the salt licks recorded the sex, approximate age, and the time spent at the lick, as well as the duration of the consumption of salt lick substances and the forms and duration of exploratory and social behavior. Individual recognition of the majority of individuals was possible from differences in the shape of antlers, fur coloration, molt patterns, etc. Annual observations of 7 animals (5 males and 2 females) were conducted in the region of the Kaplanovsky salt licks. All the salt licks under investigation were studied for mineral and chemical composition of the substances used by the animals. Some of the results of these studies have already been published (Panichev 1987).

RESULTS AND DISCUSSION

The concentration of sodium and potassium in the summer diet of Ussuri moose differs only slightly from that of moose dwelling in northern European Russia, as demonstrated by the chemical composition of terrestrial forage (Table 1). The experience of giving such foods to moose in captivity indicates that these foods are unable to provide a positive sodium equilibrium in the body (Kochanev et al. 1981). In boreal ecosystems, the sodium deficiency in terrestrial plants can be compensated for by moose through consumption of sodium–rich aquatic plants, which was demonstrated in a number of studies by North–American

Table 1. Concentration of important chemical macronutrients in summer forage of the Ussuri, European, and American moose (g/kg dry matter).

Forage Species[1]	Collection Site	Na^+	K^+	Ca^{2+}	Mg^{2+}
TERRESTRIAL PLANTS					
Calamagrostis landsdorffii (5)	Kolumbe River	0.19	13.40	1.75	1.02
Carex phychophysa (2)	Flood plain and	0.13	8.43	1.44	1.11
Leaves of willow (2)	slopes of Sikhote–Alin	0.11	7.69	3.76	1.63
Fir conifers (2)		0.13	6.93	2.16	1.18
Herb mixture	Komi Republic	0.14	23.74	16.24	4.99
Birch leaves	(Kochanov et al. 1981)	0.29	6.86	8.50	3.43
Willow and birch leaves		0.17	10.72	17.04	2.85
Bird cherry leaves	Shore of Lake Superior,	0.051	16.0	9.90	2.80
Poplar leaves	Canada (Fraser et al. 1984)	0.059	11.0	9.70	2.00
Willow leaves		0.050	13.6	10.0	2.10
AQUATIC PLANTS					
Potamogeton perfoliatus (1)	Creeks and lakes of	3.80	3.41	1.62	3.40
Ranunculus eradicatus (11)	Kolumbe and Bikin Rivers	1.70	4.62	1.44	1.92
Sparganium stenofillum (2)	(Sikhote–Alin)	4.42	2.97	1.35	2.51
Algae (4)		2.85	4.92	1.58	3.25
Potamogeton perfoliatus (9)	Shore of Lake Superior,	4.10–	14.5–	10.9–	3.00–
	Canada (Fraser et al. 1984)	10.7	38.2	19.8	6.30

[1] Number of samples analyzed in parentheses.

investigators (Botking et al. 1973, Belovsky and Jordan 1981, Fraser et al. 1984). Data collected from aquatic plants in numerous creeks and crescent lakes of the rivers Bikin and Ussurka, and also in freshwater lakes and bogs of the Zeva mountain plateau, demonstrate that in the Sikhote–Alin, moose dwelling where there is sufficient aquatic forage available do not utilize salt licks. At any rate, in terms of the quantity of sodium, the aquatic diet of the Ussuri moose is comparable to that in their North American counterparts.

Along with freshwater plants, moose living in the coastal Sikhote–Alin rely on marine water and algae for sodium. According to interview data, mass migrations of moose to the sea during summer are common north of Terney, particularly in the region of the Edinka village.

In the vast areas of mountain Sikhote–Alin, in particular, in rough country and forested areas, the sources of aquatic vegetation are normally small. Under these conditions, the main sources of sodium for the animals are sodium–saturated ground water or soil. Active visitation of such sources develops natural salt lick complexes. In the Sikhote–Alin Mountains they are numerous and have been previously investigated (Panichev 1987).

As known from our detailed observations in the upper reaches of the Kolumbe and Svetlovodnaya Rivers (territories where moose dwell in summer and where salt licks are the only sodium source), moose travel dozens of kilometers from the salt licks in winter, migrating downhill to the sparse fir or deciduous forests with undergrowth of willow, birch, and rhododendron. In this case, the autumn migration of moose from densely forested mountain areas, where spruce (*Picea* sp.) and fir (*Abies* sp.) predominate, is especially well–defined. In winter and spring, before green forage appears and the onset of the molting season, moose do not show particular interest in salt licks, although they occasionally come out to the salt licks closest to their winter grounds. With the onset of molting (mid–to late May), moose come close to the salt licks. Late May–early July marks the beginning of salt lick visitation by moose in the mountains of Sikhote–Alin. In late June–early July there is a peak of salt–licking activity, after which the salt–licks are visited less often until early September. In September there is another peak of salt–licking activity that coincides with the rutting season. In some years (e.g., 1986) the autumn peak of visitation may be higher than in summer. During periods of salt–licking activity, the density of moose in the salt–lick area increases dozens of times. For example, daily visitations of the Bolshoi Kaplanovsky salt–lick exceeded 50 individuals. The density of animals in salt–lick regions can for some time remain at 10 individuals per 10,000 ha or more.

At some salt licks of Sikhote–Alin, for instance, in the upper reaches of the Kolumbe River, moose prefer drinking mineralized water from ground sources. At others, for example, in the upper reaches of the rivers Pescherka, Losevka, and Maaka, moose willingly consume hard salt–lick substances (normally these are clay or clay–ceolith mineral substances). The preference for particular salt–lick substances is determined by the closeness of particular salt licks to the summer feeding grounds and also the content of sodium in these substances. Because summer habitats of moose occur on flood plains of creeks and rivers, moose can most often be seen at water salt licks, normally formed on the flood plains. The latter are mostly weakly mineralized in Sikhote–Alin, the most important chemical mixtures of sodium and hydrocarbons predominating (Panichev 1987).

An example is found in the preference

of moose for salt licks depending on their chemical composition and water flow (Table 2). The most visited within the salt–licking site Kaplanovsky are the salt licks with the highest content of sodium and abundant water. The poor visitation by moose of the "dry" salt lick is explained by the fact that the source water flow is very low there; additionally, there is very little assimilable sodium in the salt–lick clays – only 2 g/kg of the clay, while in the salt licks of the Pescherka River, where moose prefer consuming the clay, the quantity of sodium consumed is at least 10 times higher (Panichev 1990).

The sex and age differences in the visitation of salt licks are associated with the physiological conditions of the animals and the remoteness of the sites used for calving and feeding. In fact, at the Kaplanovsky salt licks in June, the main visitors to the salt licks were adult bulls (75%). They begin molting earlier than cows and their antlers develop actively. In addition, the cows at that time are busy with young. During the first half of June, adult females and young under 3 years of age predominate (66% and 30%, respectively). In late summer it is mostly lactating cows (94%) that come to the salt licks, which is accounted for by the increasing loss of sodium with milk production. In this case, we recorded that cows during that period consume the salt–lick substances more than any other group. During the rutting season, in which the peak of autumn salt–licking activity occurs, it is males who most often come to the salt licks (69%). In this case the relative duration of drinking behavior by them is 26 $\pm$ 10% of the time they stay at the lick, and in females 39 $\pm$ 10%. In early summer this index in males and females was roughly similar (58 $\pm$ 13% and 64 $\pm$ 11%, respectively).

The duration of social interactions in summer and in autumn in different sexes at

Table 2. Chemical composition of spring water, characteristics of the size of salt licks, and site indices of visitation by moose at salt licks of the Kaplanovsky area as of July 1987 (macronutrients in mg/l, micronutrients – Si and thereafter in mg/l). Visitation was determined by averaging the total number of visits over the period of concurrent visitation at salt licks from spring through the summer peak of "salt lick activity".

Collection Site	Open Area (m^2)	Visits (per hour)	Water Flow (l/hr)	pH	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-	SO_4^{2-}	Si	Fe	Mn	Cu	Pb	Zn	Al	Ag	Cd
Salt lick 1 Bolshoi	375	0.1	1	7.27	32.1	2.9	4.5	1.6	144.9	0.6	144.0	12.1	6.0	2.2	1.0	2.5	32	20	1.0	0.2
Kaplanovsky	13,800	0.9	10	7.58	120.8	4.9	1.6	0.7	363.6	0.4	42.0	7.6	10.2	0.7	72	33.5	754	<10	0.8	1.3
Maly Kaplanovsky	2,240	0.7	10	7.73	80.4	3.4	0.4	0.4	163.0	1.6	49.6	17.0	31.9	3.1	50	100	634	<10	0.8	1.3
Salt lick "dry"	700	0	0.1	7.61	81.2	10.2	0.4	0.4	168.4	4.0	28.8	12.0	19.4	4.2	25	136	363	60	0.8	1.2

salt licks was as follows: in bulls it changed from 4% in summer to 50% in autumn, and in cows from 8% to 30%, respectively. The characteristic feature of the behavior of moose at salt licks in autumn was the fact that the animals showed active interest in their mating partners. The time spent on sexual behavior in all adult animals at salt licks was clearly in excess of that spent on the use of salt–lick substances. That fact leads us to conclude that under conditions of the mountain taiga area, in addition to their role as a source of mineral substances, salt licks are also centers for the breeding activity of moose.

CONCLUSIONS

Sources of extra sodium for moose in the Sikhote–Alin are: (1) freshwater plants of crescent lakes and creeks, lakes, and high and low bogs; (2) marine algae and oceanic water; and (3) mineralized sources of water and soil enriched by exchange sodium. The distribution of local sources of sodium over the territory essentially determines the spatial and temporal structure of the populations of the Ussuri moose. Salt licks, serving as sources of important mineral substances, primarily sodium, promote a regular settlement by moose of mountain areas. Besides, they largely play the role of centers for breeding activity, which undoubtedly is of importance where moose populations are sparse.

The great number of salt licks and attachment of moose to them in the Sikhote–Alin is indicative of a long period of adaptation by these animals to living in that landscape's geochemical and climatic conditions. Ussuri moose evolved in a mountain landscape with a humid climate wherein sodium is quickly leached from the soils. The bedrock in the region is formed from volcanic rock with a high content of silica and limited occurrence of calcium and phosphorus (major bone–forming elements), largely promoting the formation of the Ussuri strain of moose characterized by small body size and weak deer–like antlers.

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