Use of Roadside Salt Licks by Moose, *Alces alces*, in Northern New Hampshire

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We investigated use of roadside salt licks by 14 transmitter-equipped Moose (*Alces alces*) during June – November 1987 and June – August 1988. Roadside licks formed from runoff of road salt and contained much higher levels of sodium ($\bar{x}$ = 628.5 ppm) than roadside puddles ($\bar{x}$ = 45.9 ppm), or stream water ($\bar{x}$ = 5.2 ppm). Females visited licks more often (8% of telemetry locations) than males (2% of locations) ($P = 0.049$). Frequency of use varied from 6% of telemetry locations during summer (June – August) to 12% of locations during autumn (September – November) for females, and from 1 to 3% among males for the same seasons. The average distance between seasonal centers of activity and roadside licks was approximately 60% greater among males (10.1 km) than among females (6.4 km) ($P = 0.011$). There was no correlation between that distance and the size of seasonal home ranges. However, home ranges of 11 Moose (3 males and 8 females) were elongated and incorporated at least one lick. All home ranges converged on the area containing the roadside licks. Implications associated with roadside licks include increased Moose-vehicle collisions, and potential increased Brainworm (*Parelaphostrongylus tenius*) infections among Moose from White-Tailed Deer (*Odocoileus virginianus*) that also used licks.

Key Words: Moose, *Alces alces*, sodium, salt lick, New Hampshire.

Sodium is essential for maintaining osmotic and pH balance, blood fluid volume, muscle contractions, and nerve transmissions in vertebrates (Robbins 1983). However, sodium is scarce in many ecosystems that do not receive marine aerosols (Botkin et al. 1973). Consequently, herbivores may travel to naturally occurring mineral licks to consume mineral-enriched soil or water in an apparent effort to maintain a positive sodium balance (Weeks and Kirkpatrick 1976; Jones and Hanson 1985). For example, the hunger for sodium has resulted in extensive movements to mineral springs by Moose in Alberta (Best et al. 1977), and influenced habitat-use patterns of Moose in Quebec (Joyal and Scherrer 1978). Other researchers also have observed that Moose may travel long distances to feed on aquatic plants that are rich in sodium (Fraser et al. 1980; Crossley 1985; Leptich 1986).

In northern New Hampshire, we observed Moose using roadside salt licks that formed in low-lying areas from the runoff of road salt. We speculated that roadside licks are an important habitat component and as a result, influenced the movement patterns of Moose in this region. Therefore, the objectives of our study were to examine the frequency of visits by Moose to licks, distance traveled to licks from seasonal activity centers, and the influence of the location of licks on the configuration of seasonal home ranges of Moose.

Study Area

Our study was conducted in northern New Hampshire within the township of Pittsburg (45°10'N, 71°10'W). This region was in the ecotone between coniferous forests to the north and deciduous forests to the south (Westveld et al. 1956). The soil had developed from glacial till of granitic origin, and most of the parent material was low in basic cations (Williams et al. 1943). Broad valleys were interspersed with mountains and wetland areas, and elevations ranged from 396 to 1112 m above sea level. Most of the area was owned by a private timber company and had an extensive network of logging roads. Dominant overstory species on poorly drained sites included spruce (*Picea mariana* and *P. rubens*), Balsam Fir (*Abies balsamea*), Tamarack (*Larix laricina*) and Northern White Cedar (*Thuja occidentalis*). On high elevations, Red Spruce (*P. rubens*) and Balsam Fir were common. Mid-slope areas were dominated by Yellow and White birch (*Betula alleghaniensis, B. papyrifera*), Sugar Maple (*Acer saccharum*), aspen (*Populus tremuloides*), and Beech (*Fagus grandifolia*). The climate was temperate, with an average annual temperature of 3°C (NOAA 1987). Mean daily temperature ranged from –13°C in January, to 17°C in July (NOAA 1987). Annual precipitation in 1987 was 100 cm.

Methods

We identified 12 licks along a 25-km section of Route 3 in Pittsburg by repeatedly observing Moose at these sites. We characterized licks as one central site and a 300-m radius around it. The immediate lick area included patches of bare soil or mud, a small area of standing water, and well-worn animal

TABLE 1. Average mineral concentration (ppm) in samples of water from three roadside salt licks, three nearby streams, and three roadside puddles in Pittsburg, NH, during May 1988.

Element	Lick	Puddle	Stream
Na	628.5	45.9	5.2
	(362.5–1126.1)[a]	(19.0–74.9)	(5.0–5.5)
K2.1	0.2	1.4	
	(1.4–3.0)	(0–0.3)	(1.1–1.6)
Ca	21.1	3.9	4.0
	(9.4–37.7)	(2.0–5.2)	(3.6–4.7)
Mg	3.2	0.6	0.6
	(2.6–3.6)	(0.3–1.0)	(0.6–0.7)
P	0.0	0.0	0.0

[a]Range of values.

trails that radiated from it. Most licks contained standing water through October, but several became dry during late summer and early autumn. Unfiltered water samples from three licks were collected monthly from May to October 1988. We obtained samples from a spring source, if present, to minimize contamination by animal urine and care was taken to avoid collecting suspended solid matter (Fraser et al. 1980). During May 1988, samples also were collected from three roadside puddles and three streams in the study area. Roadside puddles were small (usually < 1 m radius), ephemeral accumulations of rainwater that did not receive repeated use by Moose. Sodium, potassium, calcium, phosphorus, and magnesium content were analyzed in all samples by plasma emission spectroscopy (Suburban Experiment Station, Waltham, Massachusetts).

During August – September 1986 and 1987, Moose were located at or near roadside licks along Route 3 and immobilized with xylazine hydrochloride (2 mg/kg estimated body weight) injected by a projectile syringe fired from a capture rifle. Sedated Moose were fitted with motion-sensitive radio transmitters (Telonics Inc., Mesa, Arizona), marked with ear tags, and administered an antagonistic drug (yohimbine hydrochloride, 0.6 mg/kg estimated body weight). We classified each Moose as a yearling or adult according to body size (Peterson 1955).

Movements of transmitter-equipped Moose in relation to licks were monitored from June – November 1987 and June – August 1988. No Moose visits to the licks were recorded during winter (Miller 1989). Triangulation was our major technique of locating marked Moose. All two-bearing locations with an angle of intersection between 45 and 135° were used in the analysis. Otherwise, we used three bearings to estimate the location of a Moose. Accuracy of this method of location was evaluated using a blind test of reference transmitters placed in known locations. The average triangulation error was 215 m ($SE = 27.5$ m, $n = 20$) from the actual location of reference transmitters. Therefore, locations within 0.5 km of a lick site were considered as a lick visit. We monitored transmitter-equipped Moose throughout the day, with 90% of the locations obtained between 0800 and 2400 hrs. Each Moose was located approximately every 2.5 days. In addition, individuals were periodically monitored from 4–8 hrs. However, only locations that were separated by > 8 hrs were considered independent (Miller 1989) and included in the analysis.

Program HOMERANGE (Samuel et al. 1985) was used to estimate seasonal home ranges (minimum convex polygon technique [Odum and Kuenzler 1955] and seasonal centers of activity, harmonic mean [Dixon and Chapman 1980]). The frequency of lick use by Moose was determined on a seasonal basis (summer: 1 June – 15 September, autumn: 16 September – 30 November), and the distance from an activity center of an individual Moose to the nearest roadside lick also was determined for each season.

We compared differences in the number of visits to licks among seasons and between sexes using Kruskal-Wallis and Wilcoxon rank-sum statistics, respectively (Ott 1988). Use-availability analysis of licks was performed using the methods described by Neu et al. (1974). The proportion of the study area that contained licks was estimated by dividing the combined area within a 0.5 km radius of each lick by the study area. The study area was delineated by connecting the outermost locations of all transmitter-equipped Moose. Significance for all tests was assigned at the 0.05 probability level.

Results

During May, mean ± SE levels of sodium were higher at licks (628.5 ± 249.0 ppm) than in puddles (45.9 ± 16.2 ppm) or streams (5.2 ± 0.1 ppm) with smaller differences for potassium, calcium, and magnesium (Table 1). Although roadside puddles contained relatively high concentrations of sodium in comparison to stream samples, we observed Moose to use this source only infrequently. The average sodium concentration at licks ranged from 628.5 ppm

TABLE 2. Average mineral concentration (ppm) in water samples from roadside salt licks collected during May-October in Pittsburg, New Hampshire, 1988

	May	June	July	August	September	October
Na	628.0	225.8	91.5	167.6	136.2	123.0
	(362.5–1126.1)[b]	(119.1–419.4)	(30.5–159.6)	(95.9–277.7)	(76.1–196.3)	(80.7–165.4)
K	21.1	12.9	2.3	5.4	3.5	3.5
	(1.4–3.0)	(5.3–24.6)	(2.1–2.6)	(12.9–7.0)	(1.1–4.6)	(1.4–4.1)
Ca	21.1	28.2	5.6	15.0	9.7	5.0
	(9.4–37.7)	(14.8–52.4)	(3.9–8.2)	(9.7–16.6)	(2.2–14.7)	(2.2–5.1)
Mg	3.2	5.0	1.0	3.0	1.5	1.2
	(2.5–3.6)	(3.3–6.4)	(10.7–1.4)	(1.9–3.6)	(0.5–1.7)	(0.5–1.8)

Three licks were sampled during May through August, and two licks sampled during September and October because a stream inundated one lick.
[b]Range of values.

in May to 91.5 ppm in October (Table 2). This wide variation may have been partly a result of differences in local applications of winter road salt, topography, and rainfall.

Fourteen transmitter-equipped Moose (three males and 11 females) were located 1422 times to provide information on lick use. For all seasons combined, visits to licks comprised a greater percentage of the locations of females (7%) than among males (2%) (Wilcoxon rank-sum test, $Z = 3.86$. $P = 0.049$) and varied from 6% (summer) to 8% (autumn) among females, and from 1 to 3% among males (Figure 1). Based on the availability of lick habitat, use of licks by females was greater than expected during all seasons ($P < 0.05$). Because each Moose was located approximately each 2.5 days, some visits to licks undoubtedly were undetected. The 13 Moose that made known visits to licks used an average of 1.5 licks/animal. Three Moose (two males and one female) used at least two different licks, and one female used up to four lick sites. Trips to licks apparently were made quickly and along direct routes. For instance, female Number 220 (with calf) travelled 7.5 km from the core area of her summer range to a roadside lick in < 8 hrs.

The average distances between seasonal centers of activity and the nearest roadside lick varied between males and females (summer 1987: males = 11.0 km, n = 3; females = 5.6 km, n = 7; autumn 1987: males = 10.2 km, n = 3; females = 6.1 km, n = 10; summer 1988: males = 10.2 km, n = 3; females = 4.7 km, n = 8), but these distances were not significantly different. However, for ll seasons combined, the mean ± SE distance between activity centers and roadside licks among males (10.1 ± 1.2 km)

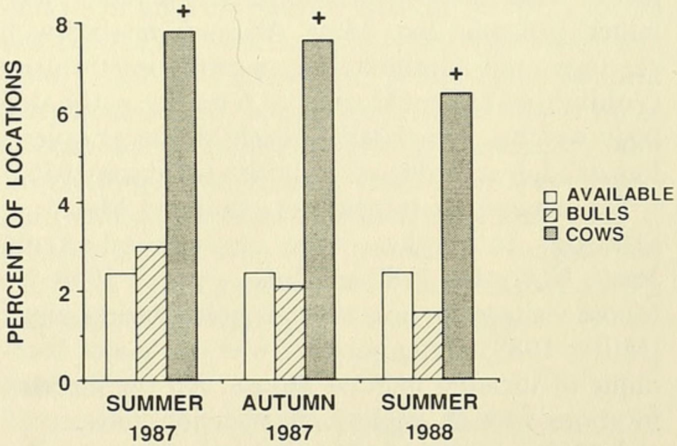

FIGURE 1. Percentage of locations of transmitter-equipped Moose at roadside salt licks and availability of lick habitat in Pittsburg, New Hampshire, 1987-1988. Number of locations among males was: summer 1987 = 110, autumn 1987 = 89, summer 1988 = 134; and among females: summer 1987 = 299, autumn 1987 = 313, and summer 1988 = 346. Use that was greater than availability is indicated (+) (P < 0.05).

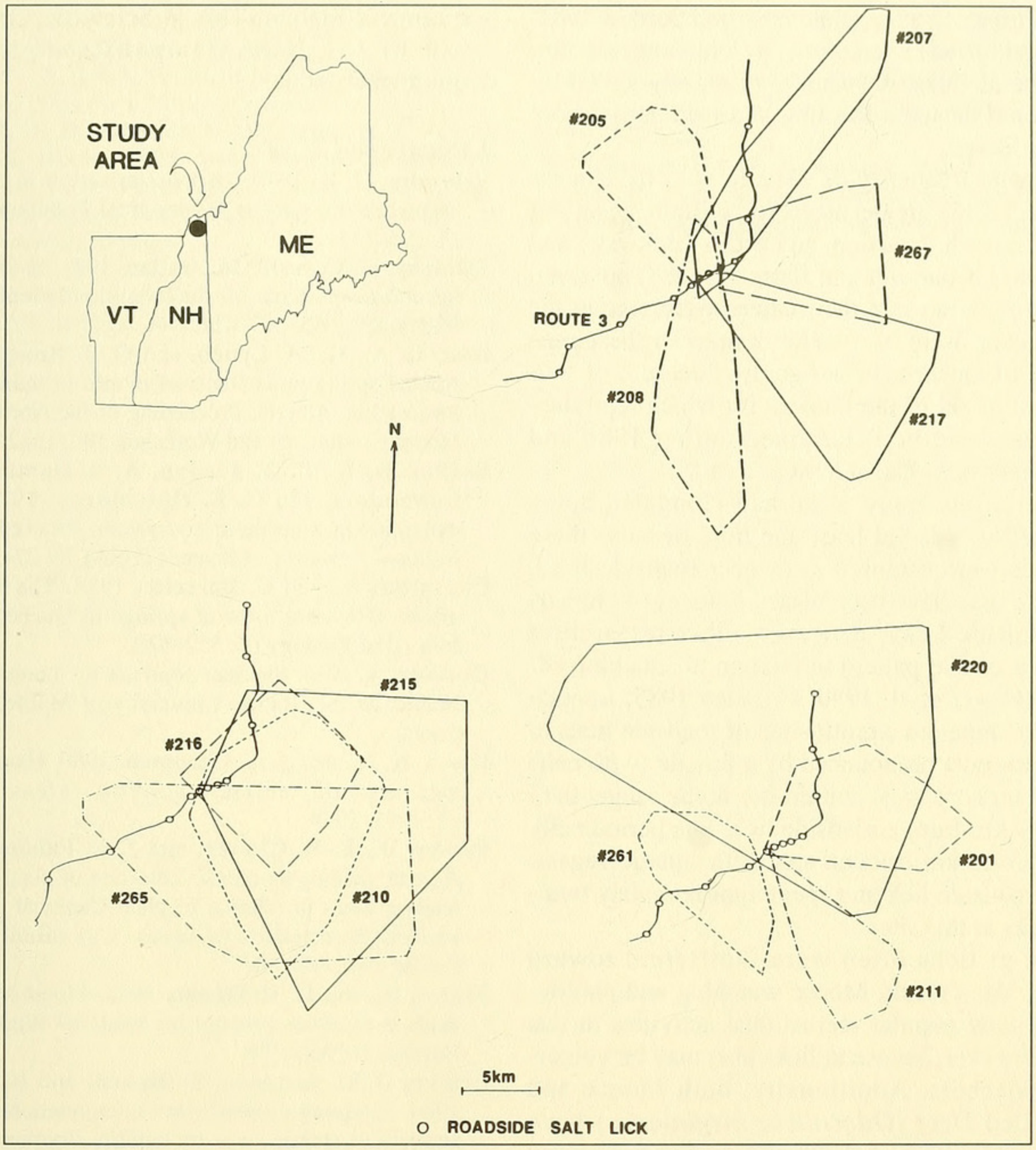

FIGURE 2. Study area location and configuration of summer-autumn home ranges of transmitter-equipped Moose in relation to roadside salt licks, Pittsburg, New Hampshire, 1987–1988. Roadside salt licks along Route 3 are identified with circles.

was approximately 60% greater than among females (6.4 ± 1.1 km) (Z = 2.56, P = 0.011).

Seasonal home ranges were estimated for 10 Moose (three males and seven females) during summer 1987, 13 Moose (three males and 10 females) during autumn 1987, and for 11 Moose (three males and eight females) during summer 1988 (Miller 1989). There was no correlation between the size of seasonal home ranges and the distance between the nearest lick and seasonal centers of activity home ranges (χ^2 = 0.03, P = 0.37). However, all Moose, except four females (whose centers of activity were < 0.75 km to the nearest lick), had elongated home ranges during summer and/or autumn that encompassed at least one lick (Figure 2). All home ranges converged on the area that contained the licks.

Discussion

Moose in our study area used roadside licks in spite of an availability of ponds that contained aquatic plants. The average distance to a potential aquatic feeding site (any beaver flowage, lake, or slow moving river) from each telemetry location of Moose was 783 m (range = 652–960 m, Miller 1989). Although aquatic plants contain high amounts of sodium in comparison to terrestrial plants (Botkin et al. 1973; Fraser et al. 1984; Crossley 1985), the use of licks may be advantageous because licks may provide a more efficient means of obtaining sodium or other minerals than aquatic plants. Belovsky (1978) calculated that a Moose at a lick ingested sodium 15 times faster than at an aquatic feeding site. Also, aquatic plants have a lower energy content than terrestrial browse species (Belovsky and Jordan 1981, Fraser et al. 1984). Therefore, by obtaining sodium from mineral licks, the time and energy saved by Moose could be spent locating and feeding on more nutritious forage.

The greater frequency of visits to licks by females may reflect their greater need for sodium, resulting from calf growth, lactation, and estrus (Belovsky and Jordan 1981). Couturier and Barrette (1988) observed that lactating cows and their calves were among the most frequent users of mineral springs in the Gaspe Peninsula of Quebec. In our study, three out of four and six out of six of the females for which reproductive status could be determined during 1986 and 1987, respectively, had at least one calf.

Moose in our study often had elongated home ranges that included at least one lick. Because these individuals were captured at or near roadside licks, our sample may have been biased in favor of animals using roadside licks. However, other researchers observed a similar pattern in relation to aquatic feeding sites (Fraser et al. 1980; Crossley 1985; Leptich 1986). The apparent significance of roadside licks to Moose was most pronounced by a female (with calf) that had two core areas within her home range, 0.75 km and 19 km from a roadside lick. She periodically traveled 13–15 km from an area with aquatic vegetation to a roadside lick and spent approximately two - three weeks at this site.

Moose at licks often were indifferent toward observers. As a result, Moose watching and photography are now popular recreational activities in this region. However, Moose at licks also may be vulnerable to poachers. Additionally, both Moose and White-tailed Deer (*Odocoileus virginianus*) have been seen at the same lick. Therefore, the probability of Brainworm infections (*Parelaphostrongylus tenius*) among Moose may increase. Fraser and Thomas (1982) also demonstrated that the presence of roadside licks increased the frequency of Moose-vehicle collisions. In Ontario, property damage was estimated at $1500 per accident during 1977-1980 (E. R. Thomas, unpublished data cited in Fraser and Hristienko [1982]). As a result, roadside licks may be considered as both beneficial and detrimental to local Moose populations.

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Literature Cited

Belovsky, G. E. 1978. Diet optimization in a generalist herbivore: the moose. Theoretical Population Biology 14: 105–134.

Belovsky, G. E., and **P. A. Jordan.** 1981. Sodium dynamics and adaptations of a moose population. Journal of Mammalogy 62: 613–621.

Best, D. A., G. M. Lynch, and **O. J. Rongstad.** 1977. Annual spring movements of moose to mineral licks in Swan Hills, Alberta. Proceeding of the North American Moose Conference and Workshop 13: 215–228.

Botkin, D. B., P. A. Jordan, A. S. Dominski, H. S. Lowendorf, and **G. E. Hutchinson.** 1973. Sodium dynamics in a northern ecosystem. Proceedings of the National Academy of Science (USA) 70: 2745–2748.

Couturier, S., and **C. Barrette.** 1988. The behavior of moose at natural mineral springs in Quebec. Canadian Journal of Zoology 66: 522–528.

Crossley, A. 1985. Summer pond use by moose in northern Maine. M. Sc. thesis, University of Maine, Orono. 39 pages.

Dixon, K. R., and **J. A. Chapman.** 1980. Harmonic mean measure of animal activity areas. Ecology 61: 1041–1044.

Fraser, D., E. R. Chavez, and **J. E. Paloheimo.** 1984. Aquatic feeding by moose: selection of plant species and feeding areas in relation to plant chemical composition and characteristics of lakes. Canadian Journal of Zoology 62: 809–887.

Fraser, D., and **H. Hristenko.** 1982. Moose-vehicle accidents in Ontario: a repugnant solution? Wildlife Society Bulletin 10: 266–270.

Fraser, D., E. Rearden, F. Dieken, and **B. Loescher.** 1980. Sampling problems and interpretation of chemical analysis of springs used by wildlife. Journal of Wildlife Management 44: 623–631.

Fraser, D., and **E. R. Thomas.** 1982. Moose-vehicle accidents in Ontario: relation to highway salt. Wildlife Society Bulletin 10: 261–265.

Jones, R. L., and **H. C. Hanson.** 1985. Mineral licks, geophagy, and biochemistry of North American ungulates. Iowa State University Press, Ames. 301 pages.

Joyal, R., and **B. Scherrer.** 1978. Summer movements and feeding by moose in western Quebec. Canadian Field-Naturalist 92: 252–258.

Leptich, D. J. 1986. Summer habitat selection by moose in northern Maine. M.Sc. thesis, University of Maine, Orono. 42 pages.

Miller, B. K. 1989. Seasonal movement patterns and habitat use of moose in northern New Hampshire. M.Sc. thesis, University of New Hampshire, Durham. 63 pages.

NOAA (National Oceanic and Atmospheric Administration). 1987. Climatological Data Annual Summary, New England. 99: 13.

Odum, E. P., and **E. J. Kuenzler.** 1955. Measurement of territory and home range size in birds. Auk 72: 128–137.

Ott, L. 1988. An introduction to statistical analysis and data analysis. PWS-Kent Publishing Co., Boston. 835 pages.

Peterson, R. L. 1955. North American moose. University of Toronto Press, Toronto. 280 pages.

Robbins, C. T. 1983. Wildlife feeding and nutrition. Academic Press, New York. 343 pages.

Samuel, M. D., D. J. Pierce, E. O. Garton, L. J. Nelson, and **K. R. Dixon.** 1985. Users manual for program HOMERANGE. Forestry, Wildlife, and Range Experiment Station Technical Report 15. University of Idaho, Moscow. 70 pages.

Weeks, H. P., Jr., and **C. M. Kirkpatrick.** 1976. Adaptations of white-tailed deer to naturally occurring sodium deficiencies. Journal of Wildlife Management 40: 610–625.

Westveld, M. R., R. I. Asham, H. I. Baldwin, R. P. Holdsworth, R. S. Johnson, J. H. Lambert, H. J. Lutz, L. Swain, and **M. Standish.** 1956. Natural forest vegetation zones of New England. Journal of Forestry 54: 332–338.

Williams, B. H., W. H. Coates, and **P. N. Scripture.** 1943. Soil survey, Coos County, New Hampshire. U. S. Department of Agriculture Services, 1937, Number 5.

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