Natural salt licks as a part of the ecology of the mountain goat

DARYL HEBERT AND I. MCTAGGART COWAN
Department of Zoology, University of British Columbia, Vancouver, British Columbia

Received December 16, 1970

HEBERT, D., and I. M. COWAN. 1971. Natural salt licks as a part of the ecology of the mountain goat. Can. J. Zool. **49**: 605–610.

Mountain goats (*Oreamnos americanus*) occupying the Rocky Mountain Trench area of southeastern British Columbia use natural earth licks in the spring (males) and early summer (females). Analysis of range vegetation reveals a low sodium content (mean about 0.004% dry weight). Despite low sodium intake from feed, blood sodium values were normal (m = 150.8 meq/liter). Loss of sodium via the fecal route increases abruptly in the spring. This period of increased loss corresponds with the time of use of the natural licks. Mineral constituents of the licks were Ca (1050–85 000 ppm), P (0–25 ppm), and Na (115–5500 ppm). Each animal visited the lick but once during the summer and did so despite increased exposure to hazards of predation. Despite the low soil sodium content the inference is that the goats are eating the earth to compensate for Na deficiency.

The use of natural salt licks by wild ungulates on all continents has been studied intermittently since about 1930. More recently attempts have been made to explain their significance in the ecology of the various species that frequent them.

Those workers who examined licks for their chemical content suggest that sodium compounds are prominent in most licks and appear to be the source of attraction to big game (Knight and Mudge 1967; Beath 1942).

Other investigators, using mineral cafeterias and selection trials (Stockstad 1953; Smith 1954) found that sodium compounds, especially sodium bicarbonate, were preferred by big game animals. Thus it is accepted from both sources of evidence that sodium is the primary source of attraction. This does not exclude the possibility that trace elements may sometimes be important (Beath 1942; Cowan and Brink 1949).

The present study was undertaken to determine the role of natural earth licks in the ecology of the mountain goat (*Oreamnos americanus*) and in particular to examine the likelihood that sodium is deficient in the wild diet of this species at certain times of the year. Evidence was sought in the sodium content of the vegetation, natural earth licks, fecal material, and the blood serum.

Murie (1951) has proposed that the use of salt by wild ungulates is an acquired habit without much nutritional importance. However, field observations suggest that in the Rocky Mountain Trench where our study was undertaken, most, if not all, individuals over a year of age use the licks. Furthermore, the attendance at licks is strongly seasonal, involves stereotyped patterns of movement, differs between the sexes, and is undertaken even though it exposes the animal to increased risk of predator attack. Thus there seem to be grounds for strong inference that the use of licks is not capricious but fills an important physiological role.

Animals seldom present gross symptoms of mineral deficiency so that the absence of overt symptoms in wild mountain goats does not constitute contrary evidence.

Blair-West *et al.* (1968) have shown that in the sodium-deficient areas of Australia several physiological mechanisms develop in herbivorous mammals in adaptation to the inadequacy of supply.

Study Area

The study area is centered in the Rocky Mountain Trench between Cranbrook and Radium Junction (49°30′ to 50°45′ north latitude), British Columbia. Licks are situated in the Purcell range on the west side of the trench and in the Rockies on the east.

Methods and Materials

Soil samples were collected from the Dutch Creek and Toby Creek licks on the west side of the Rocky Mountain Trench and from the Lazy Lake lick on the east side. At Dutch Creek, samples were taken from a primary lick, heavily used by goats, and from a secondary lick, little used by goats. Even on a lick site the animals show preference for specific locations. Our samples were taken from these. Soil samples were analyzed for sodium, calcium, cobalt, and phosphorus at two pH levels, using the methods adopted by Stockstad (1953).

Phosphorus concentrations were determined using the Bray method.

Vegetation

Plants used as forage were collected from May through September 1966. Ten to twenty annual growth stems (including leaves) taken from a random selection of plants of each species were pooled as a sample. Sampling was done in late May at the Toby Creek lick (region 3), in early June from region 2 (a higher elevation site in the vicinity of the lick), and in late June from region 1 (alpine and subalpine). This provided plants at about the same growth stage in each region. Collections were repeated in September at each site.

Analysis for total ash, sodium, and potassium in forage was done as described by Chapman and Pratt (1961).

Blood Serum

Blood samples were taken from the jugular vein using vacutainer tubes and were analyzed for sodium with a flame photometer.

Fecal Samples

Fecal samples were collected daily from two goats held in captivity. They were stored frozen then ground and analyzed for sodium using a Beckman atomic absorption spectrophotometer.

Results

In general, the use of natural earth licks by ungulates in the Rocky Mountain Trench of B.C. is confined to the summer months. At this time goats appear to prefer dry earth licks but on occasion visit mineral springs. Several other big game species use licks in the study area during the early spring and summer but use by goats is predominant.

The goats had a fairly stereotyped behavior associated with their coming to the lick, and as this exposed them to diversified opportunities for using vegetation that could have different mineral content, it was necessary to rule out this vegetation as the lure giving rise to the behavior. From early spring through the summer the goats range high, feeding at and above timberline. This range was designated region 1. Upon leaving region 1 for the lick they passed rapidly through the timber to special rocky bluff areas, relatively free of timber and not far removed from the lick. This was designated region 2. Here the goats might stay for several days, resting and feeding and making periodic excursions to the lick. The lick itself was termed region 3.

In general, goats begin leaving winter ranges during May to travel to low elevational licks usually situated in the Douglas-fir zone. Licks are used for short periods from May through August. Goats leaving the licks return to alpine summer ranges 2 to 15 mi away. We color-marked several animals when they were at the licks and in no instance did an animal make more than one trip from the uplands to the lick during any one summer.

The topographical location of licks on a bench or levelling off of a slope suggests that each has been an accumulation site for runoff from higher elevations. All licks are composed of a dry brownish to whitish clay and a varying amount of sand and gravel. It has been observed that where there is a choice goats prefer the finer textured lick soils with less coarse material. Highly preferred sites make up about 1 to 5% of the total surface area of the lick but support about 90 to 95% of the actual licking.

TABLE 1

Chemical analyses of three licks, comparing high and low licking sites

Sample No.	Description	NH_4Ac, pH = 7.0, ppm			NH_4Ac, pH = 4.0, ppm			Available P, ppm
		Na	Ca	Co	Na	Ca	Co	
D 5	Good site (1)	185	10 000	2.0	207	21 400	3.0	0
D 6	Skid trail	438	10 400	N.D.	440	85 000	5.0	0
D 7	Good site (1)	207	11 000	2.0	185	24 000	4.0	0
D 8	Good site (2)	169	1 050	N.D.	148	1 050	2	0
T 9	Poor site	160	8 400	2.0	160	29 400	4.0	0
T 10	Good site	160	8 000	2.0	160	29 200	4.0	0
D 11	Poor site (1)	138	11 000	N.D.	115	21 400	4.0	0
D 12	Poor site (2)	115	10 400	2.0	115	18 600	2.0	0
D 14	Good site (2)	160	12 000	N.D.	160	25 000	4.0	0
T 15	Good site	345	7 200	N.D.	345	22 600	3.0	0
L 16	Good site	5 500	47 000	N.D.	4 950	62 000	2.0	25

NOTE: N.D. = None detected.
D = Dutch Creek lick.
T = Toby Creek lick.
L = Lazy Creek lick.
(1) = Main lick.
(2) = Secondary lick.

Such preferred sites contained a large proportion of moist brown clay, were usually among the roots of Douglas-fir trees, and were usually in the B horizon of the soil profile. Sites of lower preference were composed of dry, grey clay, contained more sand and rocks, and were not situated beneath fir trees.

Mineral Content

Lick Soils

The mineral content of three licks is shown in Table 1. At Dutch Creek, samples from highly and less preferred licking sites were obtained from a primary and secondary lick. In both licks the preferred sites have higher sodium values than those of lower preference (compare samples 5 and 7 with 11; and 8 and 14 with 12). Comparison of samples 10 and 15 (high preference) with 9 (low preference) reveals the same situation at Toby Creek lick. Between-lick comparisons also reveal that the primary lick has higher sodium values. Sample 10 was collected at the base of the B layer in the soil profile and sample 15 near the top of this layer. Sample 10 could almost be considered a low licking site because of its position in the profile. The sodium concentration closely approximates that of sample 9. At Lazy Lake a sample was taken from a highly preferred site, which consisted of a white encrustation of the surface of the soil. As shown in Table 1 the sodium concentration of this sample (number 16) was at least 10 times higher than that in other licks. The calcium and phosphorus content was also higher and cobalt lower than most of the samples from other licks.

Calcium and cobalt concentrations from areas of high and low preference do not parallel those of sodium and thus offer no inference that they are involved in the selection of lick sites by goats. Phosphorus in a form available to plants was not found in amounts believed sufficient to attract animals.

During the two summers of field work the goats discovered new lick sites exposed by logging operations. These were in areas where licks were already in use. In one instance the new licks required extensive further travel and exposure to danger. It was pertinent to determine whether they offered higher levels of sodium than those already available. The mineral content of the main lick (samples 5, 7, 8, 11, 12, and 14) was compared to that of the earth from the new area (sample 6) (Table 1). Sodium concentration in the new lick is much higher than in the highly preferred sites of the primary lick.

Vegetation

Because of altitudinal differences in the presence of different plant species it was possible to study only four or five species through all regions. However, to obtain a representative spectrum of the total mineral, sodium, and potassium values available to the goats in their forage, analyses were undertaken of 13 species from region 1, 8 species from the autumn vegetation and 6 from the spring vegetation of region 2, 14 from the autumn and 11 from the spring of region 3. Details of these analyses are given in Tables 2 and 3.

It will be seen that in both spring and autumn the total ash values are higher on region 3. However, despite the higher concentration of sodium and potassium in the soils of the lick, the mean levels of these in the vegetation growing on the adjacent soils is not higher in this region than in the other two. A comparison of the seasonal means of the plant mixtures analyzed shows that the sodium and potassium values are both slightly higher in the spring.

The mean sodium levels for the mixture from regions including both seasons averages 0.0042% on a dry weight basis while the potassium level has a mean of 0.43%. Thus the sodium potassium ratio is 1:174. Four plant samples have sodium values 3 to 10 times the mean. These are *Poa alpina* (0.045%) and *Fragaria* (0.013%) in the September collections from region 1 and *Carex* sp. (0.014%) from the same region in the spring. *Amelanchier* from region 3 in September has a value of 0.016%. In these four the potassium values are not significantly higher and the sodium potassium ratio is reduced to 1:11. These plants may have a capacity to accumulate sodium.

In terms of sodium trends by season on region 1 there is an equal division between plants with higher and lower values in spring than in autumn. On region 3, on the other hand, twice as many plants have higher spring values than autumn values.

Comparison of the regional values reveals that there is no difference between sodium values of the plants of regions 1 and 3 in the spring but region 2 is somewhat higher than the others. The difference could be an expression of site factors or maturity factors or both (Cook and Harris 1950).

Examinations of a sample of eight goats of both sexes (10 observations) in the course of the study revealed that there were no significant differences in serum sodium values between goats coming to the lick for the first time and those that had been using it. Serum sodium values lay between 141 and 160 meq/liter ($m = 150.8 \pm$) and are thus within a normal range for healthy ungulates (Dukes 1955).

Fecal Loss of Sodium

One factor involved in the devotion of goats to the mineral licks in the spring months could be the known influence of a diet of succulent new-growth vegetation upon sodium retention by herbivores. Frens (1958) has shown that a diet of new-growth grass increased the fecal loss of sodium by cattle to the point that symptoms of sodium deficiency were detected.

TABLE 2

September values of ash, Na, and K in forage plants used by mountain goats expressed as percent dry weight

Species	Region 1			Region 2			Region 3		
	Ash	Na%	K%	Ash	Na%	K%	Ash	Na%	K%
Calamagrostis rubescens	9.1	0.0013	0.54	13.1	0.0026	0.65	14.9	0.0021	0.67
Amelanchier alnifolia	5.2	0.0049	1.17	5.8	0.0091	0.86	13.3	0.0160	0.46
Arctoscaphylos uva-ursi	0.4	0.0043	0.53	3.0	0.0035	0.43	2.1	0.0031	0.45
Populus tremuloides	5.1	0.0043	0.64	4.4	0.0051	0.90	4.2	0.0036	0.65
Pseudotsuga menziesii				1.2	0.0030	0.57	1.6	0.0017	0.54
Abies lasiocarpa	2.4	0.0026	0.61						
Vaccinium scoparium	2.3	0.0026	0.42					0.0014	0.24
Salix spp.	4.5	0.0055	0.75				5.1	0.0036	0.64
Shepherdia canadensis	3.6	0.0038	0.70				6.0	0.0055	1.00
Festuca idahoensis	3.9	0.0023	0.52				11.3	0.0014	0.24
Juniperus scopulorum				5.2	0.0041	0.48	4.2	0.0015	0.36
Agropyron dasystachyum	4.4	0.0036	0.86						
Agropyron spicatum				4.3	0.0015	0.36	5.1	0.0012	0.30
Carex spp.	5.5	0.0014	0.38				6.4	0.0017	0.29
Trisetum spicatum	4.4	0.0021	0.64						
Fragaria glauca	7.7	0.0129	0.68				5.2	0.0077	0.81
Stipa comata				3.4	0.0056	0.71			
Stipa sp.							5.7	0.0030	0.53
Means for the mixture	4.5	0.0039	0.65	5.1	0.0047	0.62	6.1	0.0028	0.51

TABLE 3

Spring values of ash, Na, and K in forage plants used by mountain goats expressed as percent dry weight

Species	Region 1			Region 2			Region 3		
	Ash	Na%	K%	Ash	Na%	K%	Ash	Na%	K%
Calamagrostis rubescens	9.9	0.0032	1.00	10.6	0.0060	2.36	11.3	0.0032	1.14
Amelanchier alnifolia	4.4	0.0066	0.87	6.2	0.0063	0.91	4.6	0.0039	0.97
Arctostaphylos uva-ursi	2.4	0.0043	0.36	2.6	0.0085	0.32	1.8	0.0023	0.31
Populus tremuloides	4.4	0.0045	1.09	7.0	0.0051	1.41	7.5	0.0050	1.36
Pseudotsuga menziesii				2.2	0.0027	0.57	2.2	0.0020	0.55
Abies lasiocarpa	2.2	0.0024	0.44						
Vaccinium scoparium	3.2	0.0028	0.45				6.4	0.0035	0.16
Salix spp.	3.1	0.0035	0.83						
Shepherdia canadensis	4.1	0.0049	1.23				4.6	0.0041	1.18
Festuca idahoensis	6.6	0.0015	0.64				11.1	0.0028	0.48
Juniperus scopulorum									
Poa alpina	5.3	0.0041	1.09						
Agropyron spicatum							11.0	0.0060	0.77
Carex (Northwestern)	8.0	0.0140	0.29	6.2	0.0053	0.49	6.8	0.0018	0.35
Fragaria glauca	5.2	0.0071	1.07						
Stipa comata							9.9	0.0040	0.48
Carex sp.	7.0	0.0050	2.04						
Means for the mixture	5.0	0.0049	0.88	5.6	0.0056	1.01	7.0	0.0036	0.70

During the summer of 1966 goats coming to Toby Creek lick had diarrhoea. The fecal matter was entirely of plant material and no clay was found in the droppings. Under these conditions abnormal loss of salt by the fecal route can be expected.

A brief test of the influence of a diet of succulent vegetation upon loss of sodium in the feces was undertaken with a yearling female and an adult male mountain goat. The animals were trapped for marking and while held in captivity for 10 days they were placed upon a diet of field-dried forage (about 10% moisture).

The mean and extreme fecal sodium values in ppm ($N = 14$) were 138 (110–175). By contrast, when they were then placed on succulent forage the values were ($N = 3$) 299 ppm (250–370).

Discussion

Sodium values of food plants used by mountain goats are low. The mean value for the mixture of plants on the ranges studied here (0.0042% dry weight) are similar to those found on sodium-deficient soils in Australia where Blair-West *et al.* (1968) found summer and autumn levels between 0.0021 and 0.0038%. In comparison plants growing close to the Australian coast had values of from 0.156 to 0.61% Na, and *Atriplex* from the arid desert lands reached an Na content of 5.06% while a mixture of desert plants had 0.46%.

Jones *et al.* (1964) have shown that domestic sheep were unable to maintain salt balance when fed a diet of Timothy hay with a sodium content of 0.04%, 10 times the mean value of the goat forages.

Herbivorous mammals using the Na-deficient ranges of Australia were shown to have several forms of adaptation to survival under the circumstances imposed on them. It seems most probable that the eating of sodium-rich soils by mountain goats is such an adaptation. We did not examine our species for the morphological and physiological adaptations revealed by Blair-West *et al.* (1968).

In our study, even though the sodium content of wild feeds used by the goats was as low as it is in other areas where mammals are known to suffer from salt deprivation, there is no evidence of sodium deficiency in the serum and the sodium–potassium ratio is within normal limits.

It is known that serum sodium levels are maintained by some species even after dietary deficiency has led to a craving for the mineral. For example, Smith and Aines (1959), working with dairy cattle, found that unsupplemented cows developed salt hunger in about 2 weeks even though serum sodium values remained normal. There was no difference in serum sodium between supplemented and unsupplemented groups after 13 months or between the first collection period at 1 month and the last collection period at 13 months. Beilharz *et al.* (1962), working with sheep, stated that the appetite for sodium and the plasma concentration can vary almost independently.

The use of licks by male mountain goats begins in April, at the time when the animals are changing from their winter diet of twigs and sun-dried grasses to the lush new growth. This change in diet is accompanied by a change in feces from hard dry pellets to soft amorphous masses or to diarrhoea and is assumed to give rise to increased loss of sodium by the fecal route. In early June the females give birth and begin to appear on the licks. Use of the licks therefore occurs when the animals are known to be under sodium stress. The delay in use by the females (Hebert 1967) probably results not from a sex difference in need, but from strong behavioral tendencies that keep the females on higher, more remote ranges until after the young are born.

It has been shown that sodium values on the plants of the lower elevation are no greater than those of alpine plants; thus the possibility of the sodium content being the attractant can be ruled out.

Kindel (1958) and Knight and Mudge (1967) have discussed possible adaptive social function provided by attendance at the licks. No evidence of this has been seen in the present study.

It is concluded that the goats in the Rocky Mountain Trench area, though on a diet very low in sodium, are able to meet their needs through most of the year. During the spring and summer period of increased loss and increased demand they seek the additional sources supplied by sodium-rich lick soils.

BEATH, O. A. 1942. Biological significance of mineral licks. *In* A Wyoming bighorn sheep study. *Edited by* R. F. Honess and N. M. Frost. Wyo. Game Fish Comm. Bull. 1.

BEILHARZ, S., D. A. DENTON, and J. J. SABRINE. 1962. The effect of concurrent deficiency of water and sodium on the sodium appetite of sheep. J. Physiol. **163**: 378–390.

BLAIR-WEST, J. R., J. P. COGHLAN, D. A. DENTON, J. F. NELSON, E. ORCHARD, B. A. SCOGGINS, R. D. WRIGHT, K. MYERS, and C. L. JUNQUEIRO. 1968. Physiological, morphological, and behavioural adaptation of a sodium-deficient environment by wild native Australian and introduced species of animals. Nature (London), **217**: 922–928.

CHAPMAN, H. D., and P. F. PRATT. 1961. Methods of analysis for soils, plants and water. University of California, Division Agricultural Sciences, pp. 60–61.

COOK, C. W., and L. E. HARRIS. 1950. The nutritive value of range forage as affected by vegetation type, site and state of maturity. Utah Agr. Exp. Sta. Bull. 344.

COWAN, I. MCT., and V. C. BRINK. 1949. Natural game licks in the Rocky Mountain national parks of Canada. J. Mammalogy, **30**(4): 379–387.

DUKES, H. H. 1955. The physiology of domestic animals. Comstock Publications Association, Ithaca, N.Y.

FRENS, A. M. 1958. Physiological aspects of the nutrition of grazing cattle. Eur. Ass. Anim. Prod. Publ. **6**: 93–104.

HEBERT, D. M. 1967. Natural salt licks as a part of the ecology of the mountain goat. M.Sc. Thesis, University of British Columbia.

JONES, D. I. H., D. G. MILES, and K. B. SINCLAIR. 1967. Some effects of feeding sheep on low sodium hay with and without sodium supplements. Brit. J. Nutr. **21**: 391–397.

KINDEL, F. J. 1958. Salt in the management of elk in the Lower Selway River Drainage Idaho. M.Sc. Thesis, University of Idaho, Moscow, Idaho.

KNIGHT, R. R., and M. R. MUDGE. 1967. Characteristics of some natural licks in the Sun River Area, Montana. J. Wildlife Manage. **31**(2): 293–298.

MURIE, O. J. 1951. The elk of North America. Stackpole Co., Harrisburg, Pennsylvania, and Wildlife Management Institute, Washington, D.C.

SMITH, D. R. 1954. The bighorn sheep in Idaho, its status, life history, and management. Idaho Fish Game Dep. Wildlife Bull. 1.

SMITH, S. E., and P. D. AINES. 1959. Salt requirements of dairy cows. Cornell Agr. Exp. Sta. Bull. 938.

STOCKSTAD, D. S. 1953. Chemical characteristics of natural licks used by some big game animals in Western Montana. Trans. N. Amer. Wildlife Natur. Resour. Conf. **18**: 247–258.

WILLIAMS, T. R. 1962. The significance of salt and natural licks in elk management. M.Sc. Thesis (Unpublished), University of Idaho, Moscow, Idaho.