A note on the manipulation of sodium and potassium concentrations in the rumen of reindeer and the possible effect on digestibility.

Om manipulering av natrium og kalium konsentrasjoner i vomma hos rein og om de mulige effekter på fordøyeligheten.

Hans Staaland[1] and **Torstein Garmo**[2]

[1] Department of Zoology, Agricultural University of Norway, N-1432 Ås-NLH
[2] Department of Animal Science, Agricultural University of Norway, N-1432 Ås-NLH

Abstract: Rumen Na^+ and K^+ concentrations in reindeer were manipulated by introducing 4 M KCl or 4 M NaCl into the reindeer rumen. A positive correlation was found between salivary and ruminal concentrations of Na^+ and K^+. Decreased ruminal Na^+ concentrations seemed to decrease dry matter digestibility in nylon bags incubated in the rumen.

Keyword: Rumen, Na^+, K^+, Dry matter digestibility

Rangifer, 7(2): 33–36

Staaland, H. & Garmo, T. 1987. Om manipulering av natrium og kalium konsentrasjoner i vomma hos rein og om de mulige effekter på fordøyeligheten.

Sammendrag: Na^+ og K^+ konsentrasjoner i vomma hos rein ble regulert ved å gi reinen 4 M KCl eller 4 M NaCl direkte i vomma. Det ble funnet en positiv korrelasjon mellom spytt og vomkonsentrasjoner av Na^+ og K^+. Redusert Na^+ konsentrasjon i vomma synes å redusere tørrstoff-fordøyelighet i nylonposer plassert i vomma.

Rangifer, 7(2): 33–36

Staaland, H. & Garmo, T. 1987. Poron pötsin natrium- ja kaliumkonsentraation kokeellisesta muuttamisesta ja tämän mahdollisesta vaikutuksesta sulavuuteen.

Yhteenveto: Poron pötsin natrium- ja kaliumkonsentraatioita muutettiin antamalla 4 M KCl tai 4 M NaCl suoraan pötsiin. Syljen ja pötsin Na ja K -konsentraatioiden välillä todettiin positiivinen korrelaatio. Alentunut Na -konsentraatio pötsissä näyttää vähentävän kuiva-aineen sulavuutta pötsiin sijoitetuissa nailonpusseissa.

Rangifer, 7(2): 33–36

Material and methods

Two male reindeer Calves, 7–10 months old and weighing about 50 kg were used in this study. The animals were purchased from domestic stocks and kept in indoor stalls at about 10°C. As basic food they were fed a commercial pellet diet, RF-71 (Jacobsen *et al.* 1977) for maintenance, but were adapted to the experimental diets for at least two weeks before trials. Both animals had rumen cannulae. Ruminal sodium and potassium were manipulated by introducing 100 ml 4 M KCL/day (4.8 M in the course of 15 days) or 100 ml 4 M NaCl/day (4 M in the course of 20 days) through the cannulae. Samples of rumen

Table 1. Dry matter disappearance (% disappearance ± S. D., n=4) from nylon bags incubated for different periods in the rumen of reindeer with different Na^+ and K^+ concentrations and fed pure lichen of RF 71 diets.

Plant material in nylon bags	Incub. period (hrs)	Diets fed to reindeer and Na^+ and K^+ conc. in rumen liquor mMoles/l±S.D. (n=6) Lichens Na: 121 ± 6 K: 38 ± 4	Lichens Na: 24 ± 8 K: 122 ± 18	RF 71 Na: 114 ± 36 K: 50 ± 7
RF 71	48	78.2 ± 4.7	74.3 ± 2.4	77.8 ± 3.9
	24	67.6 ± 5.3	67.1 ± 2.9	71.2 ± 6.4
	6	59.7 ± 1.4	57.0 ± 0.7	61.9 ± 3.8
Hay (*Phleum pratense*)	48	52.1 ± 3.2	48.3 ± 2.8	53.3 ± 1.8
	24	42.7 ± 2.1	40.9 ± 3.9	49.1 ± 5.8
	6	34.2 ± 1.3	29.2 ± 2.7	34.5 ± 1.2
Aspen (leaves) (*Populus tremulus*)	48	79.3 ± 7.0	68.3 ± 2.0	74.3 ± 3.2
	24	65.4 ± 3.6	56.6 ± 6.4	67.5 ± 4.8
	6	46.1 ± 3.2	39.3 ± 2.9	43.8 ± 0.7
Moss (*Pleurozium schreberi*)	48	22.3 ± 3.0	22.5 ± 2.6	23.2 ± 1.2
	24	25.3 ± 1.3	18.2 ± 1.6	23.0 ± 1.5
	6	22.4 ± 3.8	16.0 ± 3.0	18.9 ± 0.5
Mixed lichens (*Cladonia rangiferina & Cetraria nivalis*)	48	46.5 ± 1.5	38.8 ± 3.8	40.6 ± 6.4
	24	36.9 ± 0.9	34.6 ± 1.2	36.2 ± 6.9
	6	27.7 ± 1.3	22.6 ± 2.9	23.7 ± 0.7
Lichens (*Stereocaulon* sp.)	48	51.4 ± 3.8	38.8 ± 6.5	58.1 ± 3.5
	24	40.8 ± 4.5	27.4 ± 2.5	38.4 ± 13.6
	6	19.2 ± 3.1	15.3 ± 1.6	14.0 ± 1.6
Mean (n=24)	48	55.0	48.5	54.6
	24	46.5	40.8	47.6
	6*	34.9	29.9	32.8

* Mean disappearance of dry matter after 6 hrs of incubation was significantly lower ($P<0.002$) for all diets than disappearance after 24 and 48 hrs (Duncan test, Ray 1982).

content, saliva and blood for chemical analyses were obtained prior to the administration of minerals. The rumen samples were centrifuged at 15 000 rpm for 15 minutes to obtain rumen liquor for chemical analyses. Samples of saliva were collected by the method of Staaland *et al.* (1980). Blood samples were drawn from the jugular vein into Li-heparinized vacuum tubes. Sodium and potassium were determined by flame photometry. Rumen liquor Cl-concentrations were measured by titration (Schales and Schales 1941).

Dry matter digestibility was determined by the nylon bag method (see Person *et al.* 1980). Nylon bags, pore size 32 μm with 1.0 g dried plant material, were introduced into the rumen through the cannulae and incubated for 6, 24 or 48 hrs before removed. All trials were dublicated (*i.e.* two nylon bags were used in each of the two animals used). Dry matter disappearance in different trials was compared using paired t-tests (Ray 1982). Furthermore linear regretion between salivary and ruminal Na^+ and K^+ concentrations were calculated as well as standard deviations from mean values.

Results and discussion

The concentration of potassium in the rumen increased after adding KCl through the cannulae and the sodium concentrations decreased. This could be reversed by feeding the animals sodium-rich food like RF-71 or by introducing NaCl into the rumen. Rumen K^+ and Na^+ concentrations were inversely related (Eq. 1).

Eq. 1. $K(rumen) = -0.71 \times Na(rumen) + 128.64$

$n=42, r=-0.88, P>0.01$

Irrespective of large quantities of Cl^- accompanying the K^+ or Na^+ doses, ruminal Cl^- concentrations remained within the range of 2 – 8 mmole/l rumen liquor (mean value 4.2 ± 1.5 mmole/l, n=43).

Salivary concentrations of K^+ and Na^+ were directly proportional to rumen concentrations (Eqs. 2 and 3).

Eq. 2. $K(rumen) = 1.30 \times K(saliva) + 15.34$

$n=29, r=0.87, P<0.01$

Eq. 3. $Na(rumen) = 1.05 \times Na(saliva) + 2.95$

$n=29, r=0.81, P<0.01$

Thus, the concentrations of K^+ and Na^+ in the saliva give good predictions also of ruminal concentrations. Plasma concentrations of K^+ and Na^+ were 4.2±0.7 and 135.5±7.4 mmol/l respectively (n=30) and did not vary significantly with treatment.

Disappearance of dry matter in the nylon bags increased with time of incubation ($P<0.002$). There was no significant difference in dry matter disappearance in the reindeer fed only lichens or only RF-71 diet, provided the K^+ and Na^+ concentrations were the same (Table 1). Dry matter disappearence from the nylon bags were significantly reduced at low Na^+ and high K^+ concentrations (Table 2).

The influence of Na^+ and K^+ on microbial growth and digestive processes in the rumen are not well understood (Thomson *et al.* 1978, Duran and Kawashia 1980). It is assumed that $NaHCO_3$ added to the diet may improve utilization of nitrogene and increase ruminal digestibility (Phillip 1983, Hubbert *et al.* 1958, Wedekind *et al.* 1986). Addition of sodium improve growth in cattle fed low sodium diets (Horrocks 1964).

However, sodium and potassium may influence the metabolism of other minerals (see e.g. Rogers *et al.* 1982, Mees *et al.* 1985, Greene *et al.* 1986, Staaland *et al.* 1986).

Sodium deficiency is common among northern herbivores in spring and summer (Weeks and Kirkpatrick 1976, Staaland and Sæbø 1986). One possible cause, besides low levels of this mineral in the forage, is high levels of potassium in the vegetation. Where no extra sodium is available, e.g. from salt licks, sea water or aquatic vegetation (see e.g. Fraser *et al.* 1984, Staaland *et al.* 1986), shifts in ruminal sodium/potassium concentrations may occur. Such shifts might therefore also influence on energy metabolism of wild ruminants like the reindeer.

It is evident from this study that salivary concentrations of Na^+ and K^+ can be used to predict rumen values of these ions. In reindeer, like sheep (Warner and Stacy 1972), intake of forage with a high K^+ concentration can alter salivary and ruminal concentrations of Na^+ and K^+ .

Table 2. Paired comparison t-test between differences in dry matter disappearance from nylon bags incubated for different periods in the rumen of reindeer with different Na^+ and K^+ concentrations and for animals fed pure lichen of RF 71 diets (n=6). See table 1 for further explanations.

	Differences between mean dry matter disappearance		
	Periods of incubations (hrs)		
Na^+ and K^+ concentrations and diets compared	6	24	48
Lich. (high Na) - Lich. (low Na)	5.0 ± 1.5 P<0.01	5.7 ± 5.0 P<0.05	6.5 ± 4.9 P<0.05
RF 71 (high Na) - Lich. (low Na)	2.9 ± 2.6 P<0.05	6.8 ± 3.8 P<0.01	6.1 ± 6.8 P≈0.08
RF 71 (high Na) - Lich. (high Na)	–2.1 ± 2.8 n.s.	1.1 ± 3.5 n.s.	–0.4 ± 4.6 n.s.

Change in ruminal concentrations of these ions may affect the energy metabolism of reindeer.

However, it should be kept in mind that the method used for measuring digestion in this study (the nylon bag technique) indicates only what happens with forage in the rumen and does not measure digestion further down in the alimentary tract.

References

Durand, M., & Kawashima, R. 1980. Influence of minerals in rumen microbial digestion. – In: Ruckebusch, Y., and Thivend, P. (Eds.). *Digestive Physiology and Metabolism in Ruminants. Proc. 5th Intern. Symp. Rum. Physiol., Clermont – Ferrand 3rd – 7th Sept. 1979:* 375 - 408.

Fraser, D., Chavez, E. R., & Paloheimo, J. E. 1984. Aquatic feeding by moose: Selection of plant species and feeding areas in relation to plant chemical composition and characteristics of lakes. – *Can. J. Zool.* 62: 80 - 87.

Garmo, T. H. 1986. Kjemisk innhald og in vitro fordøyelsesgrad av planter innan ulike plantegrupper frå fjellbeite. – *Rangifer* 6: 14 - 22.

Greene, L. W., Schelling, G. T., & Byers, F. M. 1986. Effects of dietary monesin and potassium on apparent absorption of magnesium and other macroelements in sheep. – *J. Anim. Sci.* 63: 1960 - 1967.

Horrocks, D. 1964. Sodium and potassium balances and growth on high and low sodium diets. The feeding of protein rich concentrates in addition to sodium. – *J. Agric. Sci.* 63: 373 - 375.

Hubbert, F. jr., Cheng, E., & Burroughs, W. 1958. Mineral requirement of rumen microorganisms for cellulose digestion in vitro. – *J. Anim. Sci.* 17: 559 - 585.

Jacobsen, E., Bjarghov, R. S., & Skjenneberg, S. 1977. Nutritional effect on weight gain and winter survival of reindeer calves (*Rangifer tarandus*). – *Meldinger fra Norges Landbrukshøgskole* 56: 1 - 12.

Mees, D. C., Merchen, N. R., & Mitchel, C. J. 1985. Effects of sodium bicarbonate on nitrogen balance, bacterial protein and sites of nutrient digestion in sheep. – *J. Anim. Sci.* 61: 985 - 994.

Person, S. J., Pegau, E., White, R. G., & Luick, J. R. 1980. In vitro and nylon-bag digestibilites of reindeer and caribou forages. – *J. Wild. Manage.* 44: 613 - 622.

Phillip, L. E. 1983. Effect of sodium bicarbonate on nitrogen utilization and feed intake by lambs. – *Can. J. Anim. Sci.* 63: 613 - 621.

Poe, J. H., Greene, L. W. Schellings, G. T., Byers, F. M., & Ellis, W. C. 1985. Effects of dietary potassium and sodium on magnesium utilization in sheep. – *J. Anim. Sci.* 60: 578 - 582.

Ray, A. A. 1982. *SAS users guide: Statistics.* – SAS Institute Inc., Cary, NC, USA.

Rogers, J. A., Davis, C. L., & Clark, J. H. 1982. Alteration of rumen fermentation, milk fat synthesis and nutrient utilization with mineral salts in Dairy cows. – *J. Dairy Sci.* 65: 577 - 586.

Schales, O., & Schales, S. 1941. A simple and accurate method for determination of chloride in biological fluids. – *J. Biol. Chem.* 140: 879 - 884.

Staaland, H., Hove, K., & White, R. G. 1986. Mineral absorption in relation to nutritional ecology of reindeer. – *Rangifer, Special Issue No.* 1: 279 - 287.

Staaland, H., & Sæbø, S. 1987. Seasonal variations in mineral status of reindeer calves from the Elgaa reindeer herding district, Norway. – *Rangifer* 7: 27 - 28.

Staaland, H., White, R. G., Luick, J. R., & Holleman, D. F. 1980. Dietary influences on sodium and potassium metabolism of reindeer. – *Can. J. Zool.* 58: 1728 - 1734.

Thomson, D. J., Beever, D. E., Latham, M. J., Sharpe, M. E., & Terry, R. A. 1978. The effect of inclusion of mineral salts in the diet on dilution rate, the pattern of rumen fermentation and the composition of rumen microflora. – *J. Agric. Sci., Camb.* 91: 1 - 7.

Warner, A. C., & Stacy, B. D. 1972. Intraruminal and systemic responses to variations in intake of sodium and potassium by sheep. – *Quart. J. Exp. Physiol.* 57: 89 - 102.

Wedekind, K. J., Muntifering, R. B. & Barker, K. B. 1986. Effects of diet concentrate level and sodium bicarbonate on site and extent of forage fiber digestion in the gastrointestinal tract of wethers. – *J. Anim. Sci.* 62: 1388 - 1395.

Weeks, H. Jr., & Kirkpatrick, C. M. 1976. Adaptations of whitetailed deer to naturally occurring sodium deficiencies. – *J. Wildl. Manage.* 40: 610 - 625.

Manuscript received 14. April 1987