TRACE ELEMENTS IN THE ALIMENTARY TRACT OF SVALBARD REINDEER

Sporelementer i fordøyelseskanalen hos Svalbard-rein.

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Abstract: In the alimentary tract of Svalbard reindeer concentrations of Fe and Co were higher in winter than in summer, whereas the concentrations of Mn and Cu were equal in both seasons. Zn concentrations were higher in summer throughout the alimentary tract, but Mo were highest only in the distal part. The general pattern of absorption in the alimentary tract seems to correspond to findings in other ruminants. The very high levels of Fe and Co are emphasized.

Key words: Reindeer, Svalbard, trace elements, alimentary tract.

RANGIFER *5 (2): 15-21*

STAALAND, H. 1985. Sporelementer i fordøyelseskanalen hos Svalbard-rein.

Sammendrag: Konsentrasjonen av Fe og Co i fordøyelsessystemet hos Svalbard-rein var høyere om vinteren enn om sommeren, mens konsentrasjonene av Mn og Cu var like vinter og sommer. Zn konsentrasjonene var høyest om sommeren gjennom hele fordøyelsessystemet, mens Mo konsentrasjonene var høyest i det distale avsnittet. Det generelle absorbsjonsmønster synes ä stemme overens med funn fra andre drøvtyggere. De svært høye niväer av Fe og Co blir fremhevet.

RANGIFER *5 (2): 15-21*

STAALAND, H. 1985. Huippuvuorten peuran ruoansulatuskanavan ilmaisijaelementeistä.

Yhteenveto: Huippuvuorten peuran ruoansulatuskanavassa mitattiin talvella korkeammat Fe- ja Co-pitoisuudet kuin kesällä, kun taas Mn- ja Cu-pitoisuudet olivat samanlaisia kesällä ja talvella. Zn-pitoisuudet olivat korkeimmillaan kesällä koko ruoansulatuskanavassa, kun taas Mo-pitoisuudet olivat korkeimmat kanavan distaaliosassa. Yleinen absorptiomalli näyttää hyvin sopivan yhteen muilla märehtijöillä tehtyjen löydösten kanssa. Tutkimuksessa korostetaan raudan ja koboltin erityisen korkeaa tasoa.

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INTRODUCTION

The trace element content of Svalbard reindeer pasture is high and compared to requirements of other ruminants it should satisfy dietary needs. In particular the vegetation is very rich in iron and cobalt (Staaland et al. 1983, ARC 1980). The distribution of trace elements within the alimentary tract of reindeer is largely unknown. It was therefore assumed that informations on Fe, Co, Mn, Zn, Cu and Mo in the digesta of Svalbard reindeer might add new knowledge about the nutritional ecology of this high arctic ruminant.

MATERIAL AND METHODS

Six Svalbard reindeer, *Rangifer tarandus platyrhynchus* Vrolik were shot in the field in Adventdalen on western Spitsbergen, Svalbard in April and July 1979. The animals collected were: One adult female, BW 49 kg and two adult males, BW 48 and 60 kg, shot April 24-25, and three adult males, BW 75, 90 and 80 kg, shot July 14-16. The April animals were on typical winter pasture and the July animals on typical summer pasture as described by Punsvik et al. (1980). The animals were grazing quietly when killed by a shot through the chest.

Immediately after the animals were shot the whole gastro-intestinal tract was removed and samples of gut content was filled into plastic vials. From the rumen and the caecum representative samples, 0.5 l were taken. The small intestine and the coiled colon were devided into two equal long sections and all material from the proximal and

distal section was filled into the plastic vials. Likewise all material from the omasum, abomasum and distal colon were collected. The distal colon is the section of colon from the terminal part of the coiled colon to the anus (see Staaland et al. 1979).

All samples were stored frozen until processed. Dry matter content was determined after drying representative subsamples for 12 hrs at 105° C. Ash was determined after heating for further 12 hrs at 525°C. The ash was dissolved in 50 ml boiling 2 N hydrochloric acid. The hot solution was filtered through ash free filter paper, and the filter paper with undissolved ash was ashed again at 525° C for 12 hrs. This ash was considered the Acid Insoluble Ash (AIA) fraction (van Keulen & Young 1977). Water content was considered equal to the difference between wet and dry weight.

In other representative subsamples the content of trace elements; Fe, Zn, Mn, Cu, Co and Mo were determined. Homogenized material was dried at 10°C for 4 hrs, and was ashed at 500°C for 2 hrs. The ash was dissolved in *aqua regia*. After evaporation the dry residue was dissolved in hydrochloric acid and diluted with deionized water. The concentrations of the elements Fe, Cu, Zn, Mn and Co were determined by atomic absorption spectroscopy whereas Mo was determined colorimetrically after extraction of $Fe(MoO(SCN)_5)$ in isopropylether. Analyses of trace elements were all done at the Chemical Research Laboratory, Agricultural University of Norway. Statistical analyses were carried out by the Students t-test.

To calculate absorption or secretion of trace elements into the alimentary tract the methods described by White et al. 1984 were used. This techique is based on a simple model which assumes that a constant amount of marker (AIA) flow through each section per unit time. Based on measurements of AIA concentrations in each section, and assuming that the AIA entry equals the amount of marker in 1 kg wet rumen content, the volume of wet matter per unit time passing through each section can be calculated. The amounts of water, trace elements etc. entering each section is calculated from this flow rate and the local concentrations. Since the time unit used in the present study is equal to the time it takes 1 kg wet rumen content with marker and trace elements to leave rumen and enter omasum all calculations will be related to the quantities present in that amount of rumen content.

To visualize the activity in each section of the gastrointestinal tract the cumulative nutrient flow from each section was plotted graphically against position in the alimentary tract. This graph thus give a visual documentation of cumulative exchange; *i.e.* absorption or secretion of each nutrient in each section of the tract. A negative slope indicate secretion into the tract and a positive absorption. For further discussions see White et al. (1984).

RESULTS

Acid Insoluble Ash. The content of Acid Insoluble Ash (AIA) increased from the rumen to the distal colon, but was nevertheless higher in the omasum than in the rumen and proximal small intestine (Fig. 1).

Water. Water content in digesta was higher in summer than in winter, but absorption/secretion patterns were similar in both seasons. (Fig. 1). The general trend in water absorption/secretion correspond to previous findings (Staaland et al. 1984; White et al. 1984).

Iron and cobolt. Concentrations of Fe and Co in the gastrointestinal tract were significantly higher in winter than in summer. The concentrations increased from the rumen to omasum and abomasum, were low in duodenum and increased from then on to the anus (Fig. 2). There was an apparent large secretion of Fe into the abomasum in winter, but also significantly more absorption of this element in the small and large intestine in winter animals. Also for cobalt there was a tendency for more cobalt being absorbed in winter than in summer but the differences were not significant (Fig. 3).

Manganese and copper. The concentrations of Mn and Cu followed a similar pattern through the alimentary tract as did Fe and Co. But there were no seasonal differences. Also absorption patterns were similar for the two elements (Figs. 2 & 3).

Zinc and molybdenum. The concentrations of Zn and Mo followed a similar pattern to that of Fe and Co through the gastrointestinal tract, but contrary the summer concentrations were highest. There was also a significantly better absorption in summer than in winter of these elements.

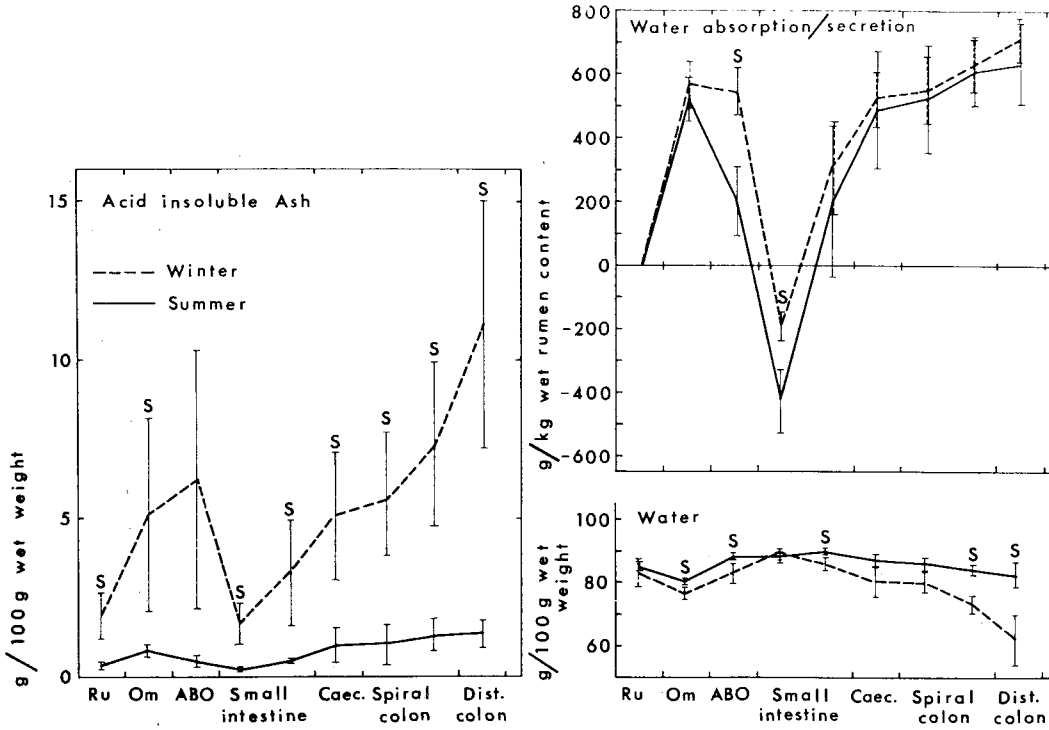

Fig. 1. Content of Acid Insoluble Ash (AIA), and water in digesta from the alimentary tract of Svalbard reindeer. Cumulative water exchange is calculated as described in text. A positive slope on the diagram indicates absorption from and a negative secretion into the alimentary tract. The amounts of water absorbed or secreted are calculated in relation to the quantities of water in 1 kg wet rumen content. Negative values thus indicates that more water has been added to the digesta than originally present when it passed from the rumen to the omasum. Vertical bars show standard deviation of the means and S indicates significant differences ($P<0.05$) between winter and summer animals (t-test). Ru: Rumen, Om: Omasum, Abo: Abomasum.

Fig. 1. Innhold av Ikke Løselig Aske (AIA) og vann i tarm og mageinnhold fra Svalbard-rein. Kumulativ vann-utveksling er beregnet som beskrevet i teksten. En positiv helningsvinkel på diagrammet indikerer absorbsjon fra og en negativ sekresjon inn i fordøyelsessystemet. Mengden av vann absorbert eller sekreert er beregnet i forhold til mengden av vann i 1 kg vått vom-innhold. Negative verdier vil derfor indikere at det er sekreert mer vann inn i tarminnholdet enn det var da det passerte ut fra vom til bladmage. Loddrette linjer indikerer standardavvik og S indikerer signifikante forskjeller ($P<0.05$) mellom vinter- og sommer-dyr (t-test). Ru:vom, Om:bladmage, Abo: Løype.

DISCUSSION

It is assumed that the AIA fraction of the ash is composed of material that is not absorbed and therefore can be used as a natural marker in digestibility trials or for the study of absorption or secretion into the alimentry tract (van Keulen and Young 1977). Although large individual variations, the content of AIA in the alimentary tract is apparently significantly higher in winter than in summer (Fig. 1). It should however be emphasized that the number of animals in each group is small. It is therefore necessary to be careful when interpreting differences between winter and summer reindeer.

The general trend in concentration variations of trace elements through the gastrointestinal tract in the Svalbard reindeer is similar to that of macrominerals like Ca, Mg, P but differ from that of Cl, Na and K (Staaland et al. 1984). Although

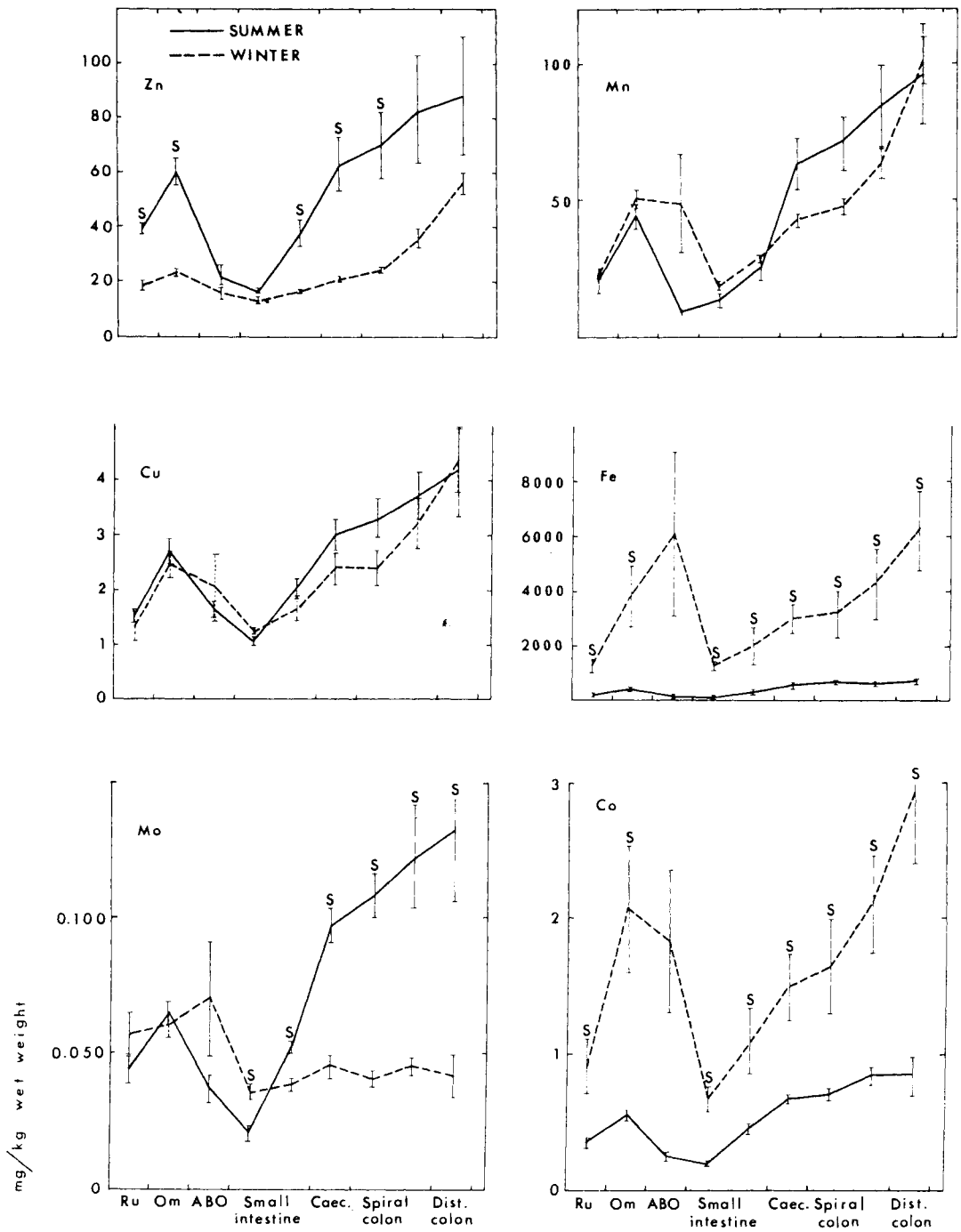

Fig. 2. Concentrations of trace elements in the gastrointestinal tract of Svalbard reindeer. For further explanations see fig. 1.

Fig. 2. Sporstoffkonsentrasjoner i fordøyelsessystemet hos Svalbard-rein. For videre forklaring se fig. 1.

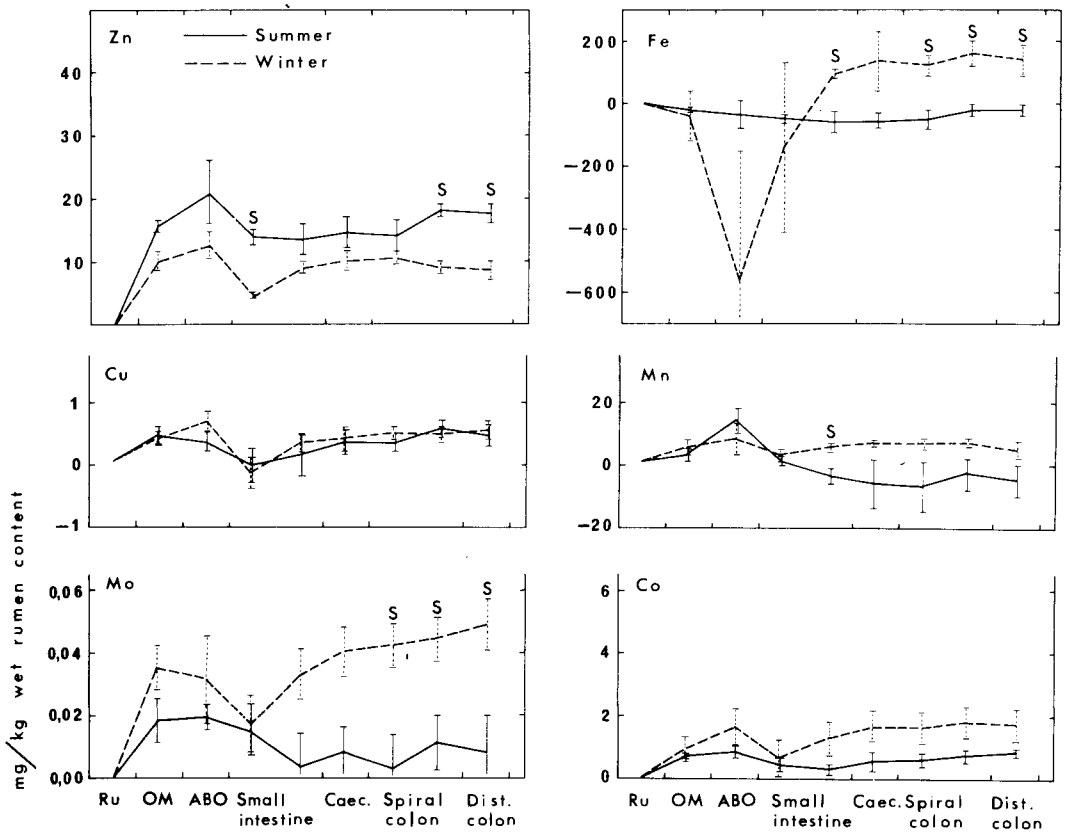

Fig. 3. Cumulative absorption of trace elements in the gastrointestinal tract of Svalbard reindeer. For further explanations see fig. 1.

Fig. 3. Kumulativ absorbsjon av sporstoffer i fordøyelsessystemet hos Svalbard-rein. For videre forklaring se fig. 1.

seasonal/dietary differences excist, concentrations mostly increase from rumen to omasum, and decrease from omasum through the abomasum and duodenum. Except for Fe there is a calculated absorption from rumen to omasum/abomasum, but secretion into the proximal small intestine. It should, however, be remarked that the slaughter technique used in the present study may overestimate the role of omasum in absorbing water and components partitioning in the water phase. This artifact is due to the preferential movement of the liquid phase through the omasum. Mean retention time of liquid was 36 minutes versus 150 minutes for solids in sheep (Engelhardt & Hauffe 1975). Faichney (1975) has, however, reported reliable results when using the slaughter/marker technique to evaluate the absorption/secretion in the segments distal to omasum; see also White et al. (1984) for further discussion.

The secretion of trace elements into the proximal small intestine, *i.e.* duodenum, is ascribed to the secretion of bile (Fe, Co, Cu, Mn and Zn) and probably pancreatic and other fluids (Grace 1975; Bertoni et al. 1976; Church 1979).

The apparent large secretion of Fe into the abomasum in winter animals could, however, also be explained by bleeding or by the occurance of parasites in this organ.

The observed absorpotion in the distal small intestine (ileum/jejunum) is also described before in ruminants. Although the absorption in the small intestine can be relatively large, the net absorption in this part of the intestine may balance each other (Grace 1975). A considerable absorption of Zn, Co, Cu and Mn has been reported from the large intestine (Grace 1975). In the present study a slight absorption through the caecum and colon can also

Table 1. Trace elements (mg/kg dry matter ± S.D.) in reindeer forage plants from Adventdalen, Svalbard. (From Staaland et al. 1983.

Tabell 1. Sporstoffer (mg/kg tørrstoff ± S.D.) i reinbeiteplanter fra Adventdalen, Svalbard. (Fra Staaland et al. 1983).

	Fe	Cu	Mn	Zn	Co	Mo
Winter (n=7)	7899 ±4053	7.3 ±2.5	230 ±115	97 ± 76	3.4 ±1.8	<0.06-0.47
Summer (n=14)	3671 ±2313	9.4 ±1.3	227 ±149	101 ±106	3.5 ±2.8	<0.06-0.90

be observed for some elements (Figs. 2 & 3). The most efficient absorption seems to be for Mo in winter animals.

Except for Cu and Mn there are apparent seasonal/dietary differences in gastrointestinal concentrations and absorption patterns (Figs. 2 & 3). The mechanisms behind these differences are obscure. Notable is Mo which has similar concentrations in the stomach region winter and summer, but very low concentrations in the intestine during winter caused by an efficient absorption (Fig. 3). It is also notable that Fe and Co concentrations are significantly higher in winter than in summer throughout the gastrointestinal tract, and both seemes to be more efficiently absorbed at that time of the year. Contrary Mn and Cu exhibit no seasonal differences. The seasonal differences may not be explained by differences in dietary levels winter and summer since only Fe concentrations appear different (Table 1).

The results from the calculations of absorption/secretion patterns of trace elements in the alimentary tract of the Svalbard reindeer are summarized in Table 2. These results mostly correspond to findings in other ruminans. It is, however, to be emphasized that the total absorption in the gastrointestinal tract is low, and frequently there are antagonistic effects between one element and another, e.g. between copper and molybdenum, and that absorption may depend on and be regulated by body need as for iron (ARC 1980; Church 1979). The possible effect on nutritional physiology of high concentrations and large seasonal fluctuations of Co and Fe in the alimentary tract of Svalbard reindeer is unknown, and needs further studies.

Acknowledgements

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Table 2. Comparison of absorption/excretion patterns of trace elements in the alimentary tract of Svalbard reindeer with the general pattern found in other ruminants. S.I. = small intestine, L.I. = large intestine. Parenthesis = slight indication of absorption/secretion.

Tabell 2. Sammenlikning av absorbsjon/sekresjonsmønsteret for sporelementer i fordøyelseskanalen hos Svalbard-rein med det generelle mønster hos andre drøvtyggere. S.I. = tynntarm, L.I. = tykktarm, Parantes = svak indikasjon på absorbsjon/sekresjon. Bile = galle.

	Ruminant*		Reindeer	
	Absorption	Secretion	Absorption	Secretion
Fe	S.I. ?	?	S.I. (L.I.)	Abomasum
Co	S.I. ?	Bile, gut	Abomasum S.I.	S.I.
Mn	S.I.	Bile, S.I.	Abomasum S.I.	S.I.
Cu	S.I., L.I.	Bile Abomasum	Abomasum S.I.	S.I.
Zn	S.I.	Abomasum Bile. S.I.	Abomasum S.I., L.I.	S.I. (L.I.)
Mo	Abomasum	?	S.I., L.I.	S.I.

* From Church, 1979.

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