Digestion of energy and nutrients in Svalbard reindeer

Fordøyelse av energi og næringsstoffer hos Svalbardrein

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Abstract: Feeding trials with 5 male Svalbard reindeer, *Rangifer tarandus platyrhynchus* Vrolik were conducted at the Man and the Biosphere (MAB) Research Station in Adventdalen, Svalbard. Five different diets were used, 1: commercial reindeer food, (RF-71), 2: a mixture of locally harvested grasses and sedges (mainly *Dupontia pelligera* and *Eriphorum scheusczeri),* 3: a pure moss *(Pleurozium scheberi)* diet, 4: a lichen diet using the dominant Svalbard species *Cetraria delisei,* and 5: a mixed diet of RF-71, moss *(P. schreberi)* and lichens (mainly *Cladonia alpestris* and *Cladonia rangiferina).* When fed the RF-71 diet the digestibility by Svalbard and Norwegian reindeer were similar with respect to dry matter (DM) 75 v 74%) and crude protein (CP) 74 v 70% as were the availabilities of P (72 v 76%)a and Ca (18 v 36%) in the diet. The mixture of grasses and sedges was highly digestible with respect to DM ((66,5%) but had low availabilities of Ca (12%), Mg (10%) and P (-11%). DM digestibility of the lichen *C. delisei* was low (33%) however this lichen could constitute a good source of Ca. Moss palatability was very low (174-252 g or 9–13g/kg $^{0.75}$ intake daily). DM, CP and energy digestibilities, respectively 48, 53 and 49%, and the availabilities of P (66%) and Ca (20%) were indicative that they could add to the energy and protein intake while contributing significantly to nutrient balance of Svalbard reindeer when present in a mixed diet.

Key words: Svalbard reindeer, digestibility, minerals, mosses, grasses.

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Sammendrag: Ved MAB-stasjonen i Adventdalen på Svalbard ble det utført foringsforsøk med fem voksne bukker av Svalbardrein, *Rangifer tarandus platyrhynchus* Vrolik. Det ble nyttet fem forskjellige fortyper, 1: pelletert reinfor, RF71, 2: en blanding av gras og siv høstet i Adventdalen (vesentlig *Dupontia pelligera* og Eriophorum scheuchzeri), 3: en ren mosediett (*Pleurozium schreberi*), 4: lav av den vanlige Svalbard-arten, *Cetraria delisei,* 5: en blandet diett av RF71, mose (*P. schreberi*) og lav (hovedsaklig *Cladonia alpestris* og *Cladonia rangiferina*).

Ved foring med reinfor (RF71) ble det funnet samme tørrstoff fordøyelighet hos Svalbardrein som tidligere rapportert fra norsk rein (75 versus 74%). Tilsvarende tall for råprotein var 74 versus 70%, P 72 versus 76% og Ca 18 versus 36%. Blanding av gras og siv hadde en høy tørrstoff fordøyelighet på 66.5%, mens tilgjengeligheten av Ca (12%), Mg (10%) og P (-11%) var lav. Tørrstoff-fordøyeligheten var lav (33%) for *C. delisei,* men denne laven kan likevel være en god Ca-kilde. Smakeligheten av mose var lav (foropptak 174-252 g eller 9–13 g/kg$^{0.75}$ per dag). Fordøyelighet av tørrstoff, råprotein og energi, respektive 48, 53 og 49% og tilgjengeligheten av P (66%) og Ca (20%) indikerer at moser kan være et signifikant tilskudd til mineralbalansen hos Svalbardrein som lever på en blandet diett.

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Yhteenveto: MAB:n asemalla Adventdalenissa Svalbardilola tehtiin ruokintakokeita viidellä huippuvuortenpeurauroksilla *(Rangifer tarandus platyrhynchus* Vrolik). Kokeessa käytettiin viitä eri ruokintaa, 1: pelletoitu pororehu, RF 71, 2: heinään ja saran seosta (pääasiassa *Dupentia pelligera* ja *Eriophorum scheuchzeri),* 3: sammalta *(Pleurozium schreberi),* 4: Huippuvuorilla tavattavaa jäkälälajia, *Cetraria delisei,* 5: pororehua (RF 71), sammalta *(P. schreberi)* ja jäkälää (pääasiassa *Cladonia alpestris* ja *Cladonia rangiferina).* Ruokittaessa RF 71 - rehulla huippuvuortenpeuralla kuiva-aineen (DM) ja raaka proteenin (CP) sulavuudet olisivat samat kuin aikaisemmin norjalaisilla poroilla mitatut (74 ja 75%, 74 ja 70%). Fosforin ja kalsiumin saannit olivat vastaavasti 72 ja 76% ja 18 ja 36%. Heinän ja saran seos oli hyvin sulavaa. Kuiva-aineen sulavuus oli 66,5%, mutta kalsiumin, magnesiumin ja fosforin saanit oli alhainen (12, 10 ja 11%) Jäkälän *(C. delisei)* kuiva-aineen sulavuus oli alhainen (33%), mutta se on hyvä kalsiumin lähde. Sammalen sulavuus oli erittäin alhainen (saanti päivittäin 174-252 g eli 9-13 g/kg^{0,75}). Kuiva-aineen, raaka proteiinein ja energian sulavuudet (48, 53 ja 49%) ja fosforin (66%) ja kalsiumin (20%) saannit osoittavat kuitenkin, että sammal voi lisätä huippuvuortenpeuralla energian ja proteiinin saantia ja on siten merkittävä ravintotasapainon kannalta.

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Introduction

In high arctic areas such as the Queen Elizabeth Islands and Svalbard, monocots and bryophytes usually dominate the vegetation. Terrestrial lichens on the other hand are generally less abundant and make up a smaller percentage of the biomass (Rønning, 1979; Bliss, 1981; Bliss and Svoboda, 1984). It is therefore not surprising that peary caribou (*Rangifer tarandus pearyi*) and Svalbard reindeer extensively fed on grasses and sedges as well as mosses (Hjeljord, 1975; Thomas and Kroeger, 1980; Staaland *et al.,* 1983; Klein and Staaland, 1984). The Svalbard reindeer has a large digestive system and a relatively larger cecum/colon complex than mainland Norwegian reindeer (Staaland *et al.,* 1979), which may well serve to maximize digestion and absorption.

In summer and winter the Svalbard reindeer maintain high production of volatile fatty acids in the rumen (White and Staaland, 1983), which usually indicates a high quality diet (Leng, 1970). This occurs when the moss content in the rumen of these animals is high indicating that mosses do not inhibit ruminal fermentation. Moss fiber is considered highly recalcitrant as estimates of *in vitro* dry matter (DM) digestibility is between 2 and 40%, the highest values being obtained with rumen inoculum obtained from high arctic reindeer and caribou (Trudell *et al.,* 1980; Thomas and Kroeger, 1980; Staaland *et al.,* 1983). In addition the rumen micro-flora of Svalbard reindeer is particularly well adapted to digest high fiber diets including mosses (Staaland *et al.,* 1983; Mathisen *et al.,* 1984; Orpin *et al.,* 1985). These observations support the hypothesis that Svalbard reindeer may have an enhanced ability to digest the moss fiber *in vivo.* To date no studies have been made *in vivo* to support or refuse this conjection.

The Svalbard reindeer can synthesis fat during the short summer (Krog *et al.,* 1976; Larsen and Blix, 1984). In late summer/early winter 27-40% of ingesta-free body weight is fat (Reimers *et al.,* 1982), which must be synthesized *de novo* (Mathiesen *et al.,* 1984) from a high intake of plant carbohydrates, in particular those in the viviparous monocot seed heads that are extremely digestible (White and Staaland, 1983; Staaland *et al.,* 1983; Staaland, 1984). This large fat deposite can, however, support only 10-30% of the animals energy requirement for the winter period (Orpin *et al.,* 1985; Tyler, 1987). Svalbard reindeer must obtain a major part of its energy and nutrient requirement in winter from grazing (Tyler, 1987).

This study was made to determine both the ability of Svalbard reindeer to utilize a high quality commercial reindeer fodder RF71, (Jacobsen and Skjenneberg, 1975, 1979), as well as to evaluate the energy and protein digestibility and mineral availability of harvested grasses, mosses and lichens that are major constitutents in the summer and winter diets of this reindeer subspecies.

Material and methods

Five adult male, Svalbard reindeer were caught in spring of 1980. The animals were kept at the Man and the Biosphere (MAB) research station in Adventdalen, Svalbard. During winter, the reindeer were kept indors in stalls constructed in an unheated Nissen hut and were adapted to maintenanced on RF71. RF71 is composed of crushed barley (40%), crushed oats (17%), wheat bran (15%), soybean (3%) and grass meal (25%) and supplies the complete energy, protein and mineral requirements of reindeer (Jacobsen and Skjenneberg, 1979).

From April to September 1981 the animals were kept in outdoor corrals where limited grazing was available in addition to the RF71 diet.

Two lichen sources were used. *Cladonia alpestris* and *Cladonia rangiferina* collected in northern Norway were used as ingredients in the mixed diet in trial 1. *Cetraria delisei,* the abaundant lichen on Brøggerhalvøya (Svalbard), was collected locally and used in trial IV. Mosses, mainly *Pleurozium schreberi,* were hand-picked in southern Norway. Grasses and sedges, mainly *Dupontia pelligera* and *Eriophorum scheuchzeri,* were harvested on wet meadows near the MAB station and were used in trial IV.

Prior to digestion trials the reindeer were taken into the Nissen hut and animals were adapted to the test diet for at least 3 wks. During a trial, animals were fed approximately 1 kg dry matter once daily each morning. Orts from the previous day were collected at the same time each day and weighed. During feeding trials the reindeer were equipped with bags to collect feces, which were weighed each morning. Daily subsamples of forage, orts and feces were taken for determination of DM content by drying at 105°C for 12 hours. Urine was not collected. Samples for chemical analysis were kept frozen (-20°C) in sealed plastic bags until analyzed.

Chemical analyses were performed on a single 4 or 6 day pooled fecal sample. Feed samples for chemical analysis were taken randomly throughout the experimental period. Proximate food analysis (modified Weender analyses, Van Soest, 1982) were performed according to standard procedures. For chemical analyses of minerals, dried samples were ashed for 2 h at 500°C and the ash was dissolved in *aqua regia.* After evaporation, the dry residue was dissolved in hydrochloric acid and diluted with deionized water. Na and K concentratiaons were determined by flame photometry and Ca and Mg by atomic absorption (Perkin Elmer 306). P was determined colorimetrically by the Molybdovanadophosphoric acid method (Boltz and Howell, 1978). All chemical analyses were carried out at the Chemical Research Laboratory of the Agricultural University of Norway. In addition, caloric values of feed, orts, and feces were determined by bomb calorimetry at the University of Oslo.

Statistical treatment of data includes calculation of mean values and the standard deviation, as well as calculatiaons of the median and the median of the absolute deviation. Mean digestibility comparsion between different diets were compared by a single degree of freedom contrasts Student's t-test (Montgomery 1984).

Results

Chemical composition of food

The mainland mixed lichens were characterized as low in crude protein (CP) and in all minerals analyzed Table 1. In contrast, *C. delisei,* the lichen collected on Svalbard, was high in Ca and Mg. The RF71, harvested grasses and sedges as well as the mixed diet were generally high in CP and minerals. Mosses were moderately low in CP and minerals except for Ca, which was as high as in the RF71, grasses/sedges and mixed diet. Crude fiber (CF) content of mixed lichens and mosses was higher than the grasses/sedges, mixed diet and RF71. Lowest CF estimates were found for *C. delisei.* Estimates of nonfat extractables (NFE) were essentially inverse to CF with very high levels in *C. delisei,* and moderate levels in the RF71, mixed lichen and the mixed diet.

Food intake and body weight trends

The reindeer accepted the RF71, lichens and the grass/sedge mixture harvested from Adventdalen. One animal (no. 20) in two trials, accepted about 200 g moss per day (Table 2), whereas others ate too little moss to carry out

Table 1. Proximate analyses and mineral content of various food types used in feeding trials with Svalbard reindeer (± SD)

Tabell 1. Proximate analyser og mineral innhold i ulike fortyper nyttet under foringsforsøk med Svalbardrein (± SD).

Diet	DM (g/100 g wet weight	Proximate analysis (g/kg DM)					Mineral content (mM/kg DM)					Energy
		CF	NFE	EE	CP	Ash	P	Ca	Mg	Na	K	(cal/g DM)
RF-71 (n=5)	87.0 ± 0.4	106.8 ±13.2	623.7 ± 7.5	56.0 ± 5.2	162.2 ± 9.0	51.4 ± 6.8	150 ± 14	121 ±111	78 ±16	42 ± 4	220 ± 11	4478 ± 92
Harvested grasses/sedges (n=4)	15.5 ± 1.6	183.3 ± 15.9	558.0 ± 13.8	25.1 ± 2.9	110.0 ± 16.6	123.7 ± 21.1	68 ± 10	132 ± 29	83 ±16	57 ±18	419 ± 66	4175 ± 132
Mosses (n=19)	27.2 ± 5.2	279.4 ± 25.7	549.8 ± 40.6	15.5 ± 2.7	99.0 ± 23.0	56.3 ± 7.3	41 ± 4	129 ± 28	34 ± 6	14 ± 2	90 ± 20	4583 ± 76
Lichen* (n=4)	29.4 ± 0.6	95.7 ± 7.2	727.4 ± 10.8	15.9 ± 2.3	49.0 ± 0.9	112.1 ± 3.2	22 ± 1	487 ± 21	75 ± 3	15 ± 1	49 ± 2	3848 ± 96
Mixed lichens** (n=5)	40.0 ± 1.9	306.4 ± 14.6	611.1 ± 17.4	22.3 ± 2.3	40.5 ± 7.8	19.7 ± 16.0	15 ± 6	25 ± 8	11 ± 2	6 ± 2	27 ± 11	4410 ± 35
Mixed diet*** (n=6)	58.5 ± 3.9	167.3 ± 8.7	614.2 ± 5.4	41.1 ± 1.4	134.5 ± 1.9	42.8 ± 0.5	101 ± 5	151 ± 7	65 ± 3	30 ± 1	168 ± 5	4425 ± 3

**Cetraria delisei*, **Lichens used in mixed diet mainly *Cladonia alpestris* and *Cladonia rangiferina*, ***Chemical composition of mixed diet (RF71 + lichens + mosses) calculated from chemical composition of the different food components and their relative proportion in diet eaten (Table 2). DM dry matter, EE ether extract, CF crude fiber, CP crude protein, NFE nitrogen free extracts.

Table 2. Feeding trials, animals and diets fed to Svalbard reindeer during trials (± SD). Values given are based on pooled samples from 4 - 6 days experimental periods, and values in parenthesis are the number of pooled samples.

Tabell 2. Foringsforsøk utført med Svalbardrein, dyr som ble brukt samt forsammensetning under forsøkene (± SD). Verdiene som er gitt stammer fra samleprøver av 4 - 6 dagers varighet. Verdiene i parentes er antall samleprøver.

Experiment No.	Experimental period	Animal No.	Median body weight in trial (kg)	Body weight change during trial (kg)	Dry matter intake (g/day) RF71	Lichen	Moss	Harvested grases/ sedges	Total	Daily DM intake ($g/kg^{.75}$)
I	Dec 15 - 25, 1980	17 (3)	68.2	- 2.3	681±41	0	0	0	681	28.7
	—	18 (3)	53.2	- 1.9	556±132	0	0	0	556	28.2
	—	16 (3)	69.4	- 2.8	436±3	169±11*	35±14	0	640	26.6
	—	19 (3)	58.6	- 2.7	436±2	186±13*	95±4	0	717	33.8
II	Mar 3 - 17 1981	17 (3)	62.6	+0.6	537±160	0	0	0	537	24.1
		18 (3)	44.6	+0.3	623±168	0	0	0	623	36.0
III	Feb 27 - Mar 17,	20 (3)	51.6	- 3.7	0	0	252±33	0	252	13.1
	May 26 - June 12 1981	20 (3)	51.6	- 4.9	0	0	174±23	0	174	9.0
IV	Aug 27 - Sep 3	20 (2)	41.2	- 1.5	0	677±31**	0	0	677	41.6
	Aug 27 - Sep 5	16 (2)	55.6	+2.0	0	0	0	903±238	903	44.3
	Aug 27 - Sep 3 1981	19 (2)	52.8	+0.3	0	0	0	777±228	777	39.7

* Mixed lichens, mainly *Cladonia alpestris* and *C. rangiferina.*

***Cetraria delisei.*

a digestion trial and they were transferred to other diets. Moss was also accepted as food in the mixed diet, *i. e.*, with RF71 and lichens.

Excluding the two trials with the pure moss diet, average daily DM intake for the 9 individual estimates in 3 trials was 33.7 ± 7.2 g/kg$^{0.75}$ (Table 2). The two daily DM intakes for moss were 9 and 13 g/kg$^{0.75}$.

Reindeer gained in body weight in 3 of 11 trials when RF71 or mixed grass/sedge diets were fed. Highest weight loss was recorded when mosses were fed and the 3.7 to 4.9 kg losses took place over the 8 and 17 day duration of each trial.

Digestibility

Estimation of the median absolute deviation showed approximate symetric distributions around the median values for digestion coefficients for different feed types. Single degree of freedom contrasts comparison showed that DM digestibility (DMD) was significantly higher ($P < 0.01$) for the RF71 diet than for the other diets. Most DMD was attributable to the NFE component which was over 70% digestible in all feeds except the mosses (52%) and *C. delisei* (39–46%). CF was significantly ($P < 0.01$) more digestible in the grass/sedge (71%) than in the other diets where CF digestibility was below 40%. The negative CF digestibility in *C. delisei* was also associated with a negative digestibility of CP. CP digestibility was highly related to DMD. Apparent digestibility of ether extract (EE) was uniformly high (>60%) except for *C. delisei*, which was low at 43 and 51% (Table 3). Apparent digestibility of energy (DE) was highly correlated with apparent DMD.

Table 3. Mean apparent digestibility and nutrient availabilities (% of intake ±SD) of diets fed to Svalbard reindeer. Each experimental period (n) represents pooled samples from 4 - 6 days.

Tabell 3. Gjennomsnittlig fordøyelighet og mineral tilgjengelighet (% av opptak ± SD) for ulike fortyper gitt til Svalbardrein. Hver forsøksperiode (n) representerer samleprøver fra en periode på 4 - 6 dager.

Diet	DM	CF	NFE	EE	CP	Ash
RF-71 (n=12)	74.8 ± 2.9	38.1 ± 9.3	82.1 ± 2.3	86.2 ± 3.3	74.0 ± 3.1	51.3 ± 10.6
Harvested grasses/ sedges (n=4)	66.5 ± 4.2	70.8 ± 6.1	75.6 ± 3.3	57.9 ± 1.9	64.0 ± 5.9	15.0 ± 18.5
Mosses (n=6)	48.1 ± 10.3	39.8 ± 9.5	52.0 ± 9.9	60.0 ± 6,2	52.8 ± 11,2	40.1 ± 17.7
Lichens (n=2)*	32.5;33.7	- 23.1;46.4	39.5;46.4	43.2;51.0	- 8.3;0.3	5.1;11.1
Mixed diet (n=6)**	61.5 ± 3.7	31.8 ± 7.8	70.5 ± 3.3	81.6 ± 3.5	59.6 ± 4.2	38.1 ± 10.2
RF-71 (n=6)***	73.6 ± 2.3	36.8 ± 8.6	80.3 ± 1.1	88.9 ± 2.0	69.7 ± 2.3	63.6 ± 3.3
RF-71 (n=13)****	70.9 ± 2.2	—	—	—	—	—

Diet	Energy	P	Ca	Mg	Na	K
RF-71 (n=12)	75.1 ±2.7	72.0 ±5.7	18.4 ±38.6	2.6 ±17.1	84.4 ±14.4	95.8 ±1.0
Harvested grasses/ sedges (n=4)	70.7 ±2.6	- 11.2 ±15.1	11.9 ±8.3	9.7 ±10.2	85.9 ±7.9	92.3 ±3.4
Mosses (n=6)	49.1 ±9.7	66.0 ±7.0	20.3 ±15.6	25.8 ±21,3	- 15.1 ±86.7	- 9.0 ±48.8
Lichens (n=2)*	22.1;32.6	- 26.1;-4.6	6.7;25.9	18.2;24.5	- 2.4;19.1	- 33.7;-39.0
Mixed diet (n=6)**	62.0 ±4.4	71.4 ±2.1	25.4 ±33.0	31.1 ±11.5	39.7 ±18.3	83.1 ±8.8
RF-71 (n=6)***	—	75.5 ±5.1	36.1 ±11.5	28.0 ±2.0	—	—
RF-71 (n=13)****	—	—	29 ±7	29 ±6	85 ±3	75 ±4

* *Cetraria delisei*, ** RF-71 + lichens + mosses (see Tables 1 and 2), *** Norwegian reindeer (Jacobsen and Skjenneberg 1979), **** Staaland *et al.* 1986; statistics ± SE.

The availability of P in RF71, mosses and the mixed diets was high ($\geqq$ 66%) whereas negative availability was obtained in the grass/sedge diet (significantly different from other diets $P < 0.01$) and the *C. delisei*. No significant between diet differences were found for Ca availability, which was moderately high at 18–25%. Availability of Mg appeared highly variable between diets and was significantly ($P < 0.05$) higher in the mixed diet 31% than in the other diets. Also moss diet had high availability of Mg (26%). The availability of the monovalent cations Na and K were high in the RF71, grass/sedge and the mixed diets. Negative digestibility ($P < 0.01$) was noted for the moss and also for the *C. delisei* (n.s.) diets.

Although we could only carry out feeding trials with the lichen *C. delisei* for a short period of time, this diet seemed to be the least digestible (Table 3). Notable was the negative digestibility of CP and the negative availabilities of P, Na and K.

Discussion

The apparent DM, CP and CF digestion of RF71 fed to Svalbard reindeer was similar to estimates when fed to Norwegian reindeer (Jacobsen and Skjenneberg, 1979; Table 3). Therefore the potential of Svalbard reindeer to utilize a high quality food is equal to the Norwegian reindeer. For the mineral component of RF71, P availability was similar while ash, Ca and Mg were of lower availability to Svalbard than to Norwegian reindeer. Therefore the enlarged cecum/colon of Svalbard reindeer (Staaland *et al.*, 1979), which is a major site of water, Mg, Na and K absorption in Norwegian reindeer (White *et al.*, 1984), does not convey an advantage over that in Norwegian reindeer when these nutrients are present in high concentration.

Grasses and sedges harvested from Adventdalen were highly digestible (Table 3), and except for P, the availability of minerals was also high. The meadows of *D. pelligera* and *E. scheuchzeri* are important summer habitats for growth and fattening of the Svalbard reindeer (Punsvik *et al.* 1980). However, a major limitation of grasses and sedges is the negative digestibility of P (Table 3, Staaland *et al.*, 1983), the reason for which is obscure because the P contents of freshly harvested grass-/sedge was moderately high (Table 1).

In previous studies highly preferred lichen species such as *C. alpestris* (see Nordfeldt *et al.*, 1961; Jacobsen and Skjenneberg, 1976) were more highly digested than *C. delisei* in our study, and this may partially explain its low preference. This hypothesis is supported by the observation that another lichen of low preference, *Sterocaulon paschale,* is digested to about the same extent as *C. delisei* (Jacobsen, 1981). *In vitro* DMD estimates of *C. delisei,* using rumen liquor og Peary caribou is considerably higher at 60% (Thomas and Kroeger, 1980), than 33% in the present *in vivo* study (Table 3). Due to their low biomass in most of Svalbard, lichens are relatively unimportant dietary components. *C. delisei* is also of low preference ranking, as in areas where lichens are more abundant, (e.g., Brøggerhalvøya on north west Svalbard), reindeer consume lichens such as *Cetraria nivalis,* avoiding the more abundant *C. delisei* (Persen *et al.*, 1983): The current findings may therefore suggest that the Svalbard reindeer used in this study were not sufficiently adapted to the *C. delisei* diet. Person *et al.* (1975) report that up to 6 wks was required to adapt dietary naive reindeer to an all lichen (mainly *C. alpestris*) diet.

Contrary to lichens, mosses are an important winter dietary component of Svalbard reindeer, and rumen samples can contain 25% or more of mosses (Hjeljord, 1975; Staaland *et al.*, 1983). Similarly, Peary caribou in the Canadian high-arctic (Thomas and Edmonds, 1983) and reindeer in far northern Soviet Union (Shaposhnikoff, 1955) ingest large quantities of mosses. *In vitro* DMD of mosses are usually low at 1–24%, (Trudell *et al.*, 1980; Staaland *et al.*, 1983) using inoculum from Norwegian and Alaskan reindeer, and 1–40% (Thomas and Kroeger, 1980) for several moss species using inoculum from Peary caribou. The mean apparent DMD found in our *in vivo study (48%) was higher than in vitro* estimates (Table 3). The CP in moss was of similar digestibility (53%) to the DMD and only the negative availability of Na and K in these mosses negated their potential to contribute nutritionally to the animal (Table 3).

Our results show that moss could be important to the maintenance of mineral-balance since they contain high levels of Ca, moderately high levels of P and Mg (Table 1) and the availabilities of Ca, P and Mg are high compared with other dietary sources (Table 3). Although mosses previously have been highlighted as a possible mineral supplement in arctic rodents (Batzli, 1975; Batzli *et al.*, 1980) the present study shows that a combination of moss and lichen could significantly raise the availability of Mg from 2.6 to 31% (Table 3) in a high quality diet such as RF71. Also, the possibility is strong that natural dietary supplementation with mosses could increase P absorption when grasses and sedges constitute bulk of the diet as the availability of P in these grasses and sedges was unusually low.

The unexpected high digestibility found for the pure moss diet could, however, be explained by low food intake. It has been shown that low food intake increase retention time and digestibility (van Soest 1982). Therefore further studies on the utilization of moss by the Svalbard reindeer and other moss eating animals like lemmings are badly needed.

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