Food and snow intake, body mass and rumen function in reindeer fed lichen and subsequently starved for 4 days

T. H. Aagnes* and **S. D. Mathiesen**

Department of Arctic Biology and Institute of Medical Biology, University of Tromsø, Breivika, 9037 Tromsø, Norway.

* corresponding author

Abstract:
Food and snow intake, body mass, rumen fluid volume, rumen fluid turnover time and ruminal dry matter content were examined in four female rumen fistulated reindeer which were first fed lichen *ad libitum* in 14 days and then starved for 4 days in March. When the animals were eating lichen median daily dry matter food intake was 15.7 g/kg (range 12.2-19.9 g/kg), while median daily snow intake only amounted to 0.6 g/kg (range 0-3.3 g/kg). The median body mass decreased from 67.5 kg (range 62.5-69.5 kg) to 63.5 kg (range 60.5-68.5 kg) during this period, and dropped further to 62.5 kg (range 57.5-66.0 kg) after four days of starvation. Rumen fluid volume and fluid turnover time were fairly constant in individual animals, but varied between animals fed lichen *ad libitum*. Neither of these parameters changed significantly ($P > 0.05$), but ruminal dry matter decreased, while snow intake rose conspicuously in reponse to starvation. Thus, aside from the latter, which mitigate the reduction of total rumen volume, we have failed to expose any special adaptions aimed at the maintenance of ruminal integrity in starving reindeer.

Key words: *Rangifer tarandus tarandus*, fasting, Arctic

Rangifer, 14 (1): 33—37

Introduction

Reindeer (*Rangifer tarandus tarandus*) and Muskdeer (*Moschus moschiferus*) are the only ruminants which feed mainly on lichen during winter (e.g. Skogland, 1975; Green, 1987). Lichen differs from vascular plants, in that it contains almost only carbohydrates, of which hemicellulose is dominant (Person *et al.*, 1980). However, in the Arctic the access to the winter range is often restricted by deep snow or overicing, and reindeer then have to cope with a much reduced food intake, or even acute starvation.

In a sheep, which was starved for 4 days, both water intake, rumen fluid flow rate and rumen dry matter content decreased, whereas rumen fluid volume was kept constant (Hyden, 1961). Hecker *et al.* (1964), on the other hand, found a reduction in rumen fluid volume in another group of sheep already after 2-3 days of starvation.

It is conceivable that a reduction in rumen fluid flow rate in the sheep will reduce the wash out of rumen micro-organisms when substrate is in short supply. If so, it is to be assumed, that reindeer, which are frequently subjects to starvation, have developed even more spectacular adaptations to enable them to cope with this ordeal. Accordingly, we have presently studied rumen function in reindeer which were starved for 4 days after being fed lichen for 2 weeks.

Material and methods

Animals, feed and experimental procedure

Four adult female semi-domesticated reindeer (*Rangifer tarandus tarandus*) from a herd in northern Norway (69° N, 23° E), were equipped with permanent rumen cannulas (Jarrett, 1948; Dougherty, 1955) and familiarised with frequent handling. Prior to the experiments the animals were offered commercial reindeer feed (RF-80; Bøe and Jacobsen, 1981) *ad libitum*, and were therefore inoculated with 500 ml fresh rumen fluid from free-living reindeer. Thereafter the animals were fed a diet of mixed lichens, mainly *Cladonia stellaris* with some *Cetraria nivalis*, *Cladonia arbuscula* and *Cladonia rangiferina*, for five weeks. During this period the animals were kept in individual snow-covered paddocks which communicated with pens with slatted floors. The pens offered minimal protection against the weather and the animals were exposed to a natural photo period allowing expression of their normal seasonal appetite (Larsen *et al.*, 1985).

After this five week period, the animals were kept in individual pens with regular access to the connecting individual paddocks every fourth day. Then, they were first offered the mixed lichen and snow *ad libitum* for fourteen days and thereafter starved with access to snow for four days. The animals were subsequently given free access to their paddocks and again offered lichen and snow *ad libitum*.

Food (dry matter) intake was measured daily in each animal. Snow intake was measured daily during the periods when the animals were kept in the pens. Lichen and snow were offered twice a day in plastic tubs and the left-over weighed and removed before each new meal. Salt blocks were available both when the animals were fed and during the starvation period. The experimental period took place in March, when ambient temperature was between -7.0 and +8.3°C.

Body mass

Body mass was measured before feeding in the morning, four times during the feeding period and daily during starvation, using an electronic weight (Sauter com-systems typ. AZ/NZE no. 0101834).

Ruminal dry matter content and rumen content weight

Samples of rumen contents were taken by aspiration through the rumen cannula from five widely separated parts of the rumen, bulked and sub sampled in the morning, just before feeding, and at the same time of the day, after one and four days of starvation.

The rumen content was dried for 17 h at 106°C. Rumen wet content weight was calculated based on rumen fluid volume and rumen dry matter content.

Rumen fluid volume and fluid turnover time

Rumen fluid volume, and rumen fluid turnover time were measured, according to Hyden (1961). In *ad libitum* fed animals a 300 ml dose of a liquid-phase chromium-EDTA marker (Binnerts *et al*, 1968) with a known concentration was introduced into the rumen in the morning, just before feeding. Rumen samples were taken regularly from 2 h till 58 h after dosing. For measurements during the starvation period a 50 or 100 ml dose of the same chromium-EDTA was infused daily in each animal and rumen samples were taken for up to 9 h after dosing. The rumen samples were centrifuged (40.000 g for 10 min), and the supernatant collected and stored at -20°C. After thawing, the chromium concentration in the supernatant was determined by atomic absorption spectroscopy with nitrous oxide-acetylene combustion (Binnerts *et al.*, 1968). Chromium concentration at zero time was calculated from a semi-logarithmic regression line model using the least squares method. Correlation cofficients (r) of the wash out of chromium from the rumen exceeded 0.96 in all cases. Rumen fluid volume, and rumen fluid turnover time were calculated according to Hyden (1961).

Statistical methods

The results are given as median values and range. Changes in rumen fluid volume, rumen fluid turnover time, rumen dry matter content and rumen wet content weight during *ad libitum* feeding and subsequently during the starvation period were examined using Friedman two-way analysis of variance (Siegel, 1956).

Results

Body mass and food intake

The median body mass declined from 67.5 kg (range 62.5–69.5 kg) to 63.5 kg (range 60.5–68.5 kg) when the animals were fed lichen, and fell further to 62.5 kg (range 57.5–66.0 kg) after four days of starvation (Fig. 1.). The median daily dry matter lichen intake prior to the starvation period was 15.7 g/kg (range 12.2–19.9 g/kg). The water content of the lichen was 56% which implies a median daily water intake of 18.0 g/kg (range 18.1–24.9 g/kg). The median snow intake was only 0.6 g/kg (range 0–3.3 g/kg) when the animals were eating lichen (Fig. 1.). When feeding was discontinued the median snow intake increased conspicuously to 25.3 g/kg (range 20.9–35.8 g/kg) on the fourth day of starvation (Fig. 1.).

Rumen dry matter content and rumen content weight

The median ruminal dry matter content was 14.0 % (range 10.9–14.8 %) when the animals were fed lichen ad libitum. After one and four days of starvation it had decreased significantly ($P<0.05$) to 9.2 % (range 8.2–10.0 %) and 3.4 % (range 1.8–4.5 %), respectively. Median wet rumen content weight was 7.3 kg (range 5.1–10.2 kg) when the animals were fed lichen, and 5.6 kg (range 3.9–6.9 kg) and 5.7 kg (range 5.0–9.1 kg) after one and four days of starvation, respectively. The values obtained after one and four days of starvation were not significantly different ($P>0.05$).

Rumen fluid volume and turnover time

Both rumen fluid volume and turnover time were fairly constant in individual animals fed lichen, but varied considerably between individuals (Table 1.). There was no significant correlation between the rumen fluid volume and body mass ($P>0.05$). The correlation coefficients (r) was 0.23. In response to starvation, there was an initial drop both in rumen fluid volume and turnover time, whereafter both parameters were fairly stable (Table 1). However, when the data for all animals were grouped, the values obtained during starvation did not differ significantly ($P>0.05$) from those of the lichen feeding period.

Discussion

This study has confirmed previous findings of Jacobsen and Skjenneberg (1975), Bøe and Jacobsen (1981), and Ryg and Jacobsen (1982) that reindeer calves eating only lichen loose

Table 1. Rumen fluid volume and rumen fluid turnover time in four reindeer over 3-day periods at day 1–3, 7–9 and 11–13 of a 14 day period when the animals were fed lichen ad libitum, and at 3 intervals during a subsequent starvation period.

	Fluid volume (l)				Fluid turnover time (h)			
	Reindeer				Reindeer			
	A	B	C	D	A	B	C	D
Lichen fed day 1–3	5.7	7.2	5.3	10.8	26.0	23.9	26.4	69.0
Lichen fed day 7–9	5.7	6.2	3.8	9.9	33.9	24.9	23.4	64.7
Lichen fed 11–13	7.0	5.9	3.9	6.7	40.2	22.5	24.2	49.3
Starved 24–48 h	5.3	6.2	3.6	5.0	30.3	40.3	24.2	31.6
Starved 48–72 h	5.7	6.0	3.8	8.1	36.6	21.0	26.4	39.1
Starved 72–96 h	–	5.5	4.9	8.9	–	31.5	27.9	39.7

–: not measured.

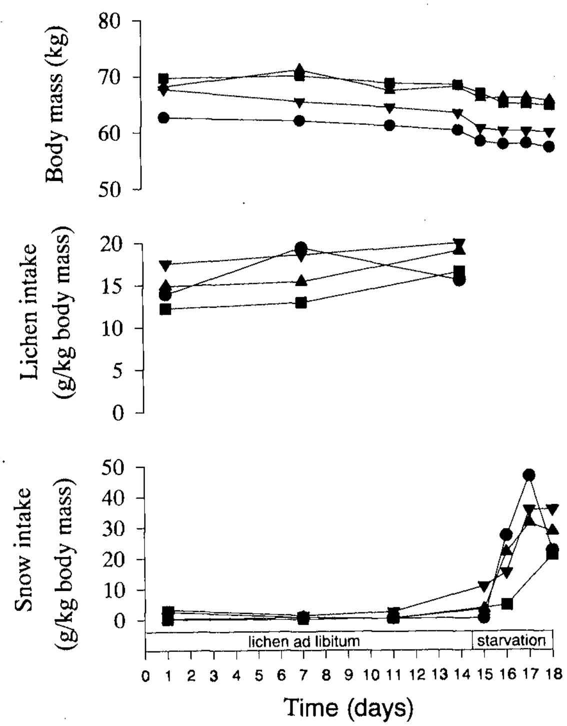

Fig. 1. Body mass, daily lichen (dry matter) and snoe intake of four reindeer fed lichen ad libitum (day 1–14) and during 4 days of starvation (day 15–18). Animal A(●); B(▼); C(■) and D(▲).

body mass even when lichen is offered *ad libitum.* This is mainly due to the fact that lichen is very low in nitrogen. It is known that reindeer are able to some extent to recycle nitrogen (Hove and Jacobsen, 1975), which mitigate the loss of nitrogen and hence reduce the loss of lean body mass. Still, reindeer do loose body mass, and it is questionable if reindeer are able to maintain themselves on lichen alone for an extended period. It follows that the validity of the «fact» that reindeer depend on lichen during the long Norwegian winter night is also questionable. In fact, the present study has shown that the loss of body mass during acute starvation (not including the first day) is not significantly different ($P > 0.05$) from the loss of body mass when the animals are eating lichen *ad libitum.* It is to be expected, however, that the loss of body mass would have been significantly different if the starvation period had continued, but obviously there is a limit to how long experimental animals should be subjects to starvation. Even so, our results strongly suggest that reindeer are likely to depend on supplements of plant items other than lichen during winter. It is even possible that an important role of the lichen in addition to its contribution to the animals energy budget, is to maintain the integrity of the ruminal microbial system when more nutritious plants are in short supply during winter. This aspect is clearly suggested by the finding of Mathiesen *et al.* (1984) that the number of rumen bacteria in reindeer is drastically reduced from $4.7 \times 10^{10} \pm 2.7$/ml rumen fluid to $5.5 \times 10^{8} \pm 2.0$/ml rumen fluid after 3 days of starvation.

In the present study we have failed to expose any obvious adaptations aimed at the protection of the rumen bacteria during acute starvation. Thus, rumen fluid volume and turnover time differed between animals, but were fairly constant in individual animals eating lichen *ad libitum,* and did not change significantly ($P > 0.05$) in response to starvation, mainly due to a conspicuous increase in snow intake. This intake of snow did not exceed, but matched by and large the water intake caused by the previous intake of wet lichen during the ad libitum lichen intake period. This naturally reduced rumen dry matter content during starvation. The reasons for the animals desire to maintain ruminal volume by intake of water, on the expense of the maintenance of the population of ruminal microbes is presently unknown. It is possible, however, that the stretching of the ruminal wall which follows the intake of water stimulates ruminal contractions (Reid, 1963) and, hence, mitigate the sense of hunger.

Acknowledgement

This work was supported by the Reindeer Research Fund under the auspices of the Norwegian Ministry of Agriculture.

References

Binnerts, W. T., Van't Klooster, A. Th. & Frens, A. M. 1968. Soluble chromium indicator measured by atomic absorption in digestion experiments. – *Veterinary Record* 82: 470.

Bøe, U. B. & Jacobsen, E. 1981. Trials with different feeds to reindeer. – *Rangifer* 1 (1): 39–43.

Dougherty, R. W. 1955. Permanent stomach and intestinal fistulas in ruminants: some modification and simplification. – *Cornell Veterinary* 45: 331.

Green, M. J. B. 1987. Diet compostion and quality in Himalayan musk deer based on analysis. – *J. Wildl. Manage.* 51 (4): 880–892.

Hecher, J. F., Budtz-Olsen, O. E. & Ostwald, M. 1964. The rumen as a water store in sheep. – *Aust. J. Agric. Res.*, 15: 961–968.

Hove, K. & Jacobsen, E. 1975. Renal excretion of urea in reindeer, effect of nutrition. – *Acta Vet. Scand.* 16. 513–519.

Hyden, S. 1961. Determination of the amount of fluid in the reticula-rumen of the sheep and its rate of passage to the omasum. – *Kungl. Lantbrukshøgskolans Annalyser. Institute of Animal Physiology.* Uppsala. 27: 51–79.

Jacobsen, E. & Skjenneberg, S. 1975. Some results from feeding experiments with reindeer. – *In: Proceedings of the First International Reindeer and Caribou symposium*, p. 342–353. (Luick, J. R., Lent, P. C., Klein, D. R. and White, R. G. editors). *Biological Papers of The University of Alaska. Special Report No 1.*

Jarett, I. G. 1948. The production of rumen and abomasal fistulae in sheep. – *In Journal of the Council for Scientific and Industrial Research*, p. 311–315 (Noble, N. S., editor) Commonwealth of Australia.

Larsen, T. S., Nilsson, N. Ö. & Blix, A. S. 1985. Seasonal changes in lipogenesis and lipolysis in isolated adipocytes from Svalbard and Norwegian reindeer. – *Acta. Physiol. Scand.* 123: 97–104.

Mathiesen, S. D., Rognmo, A. & Blix, A. S. 1984. A test of the usefullness of a commercially available mill «waste product» (AB-84 as feed for starving reindeer. – *Rangifer* 4 (1): 28–34.

Person, S. J., White, R. G. & Luick, J. R. 1980. Determination of nutritive value of reindeer-caribou range. – *In: Proceedings of the 2nd International Reindeer and Caribou Symposium*, p. 224–239. (Reimers, E., Gaare, E., Skjenneberg, S. editors) Direktoratet for vilt og ferskvannsfisk, Trondheim.

Reid, C. S. W. 1963. Diet and the motility of the forestomachs of sheep. – *Proceedings of the New Zealands Society of Animal Production.* 23: 169–188.

Ryg, M. & Jacobsen, E. 1982. Seasonal changes in growth rate, feed intake, growth hormone, and thyroid hormones in young male reindeer. – *Can. J. Zool.* 60: 15–23.

Siegel, S. 1956. *Non-parametric statistics for the behavioural sciences.* McGraw-Hill Kogakusha, Ltd. Japan.

Skogland, T. 1975. Range use and food selectivity by wild reindeer in southern Norway, p. 342–353. – *In: Proceedings of the First International Reindeer and Caribou Symposium*, p. 342–353. (Luick, J. R., Lent, P. C., Klein, D. R. and White, R. G. editors). *Biological Papers of The University of Alaska. Special Report No. 1.*

Manuscript accepted 25 February, 1994.