Metabolic rate and plasma T_3 in ad lib. fed and starved muskoxen

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Abstract: Resting metabolic rate (RMR) in two 12 yrs., semidomesticated, female muskoxen was 0.86 ± 0.10 $W \cdot kg^{-1}$ in winter, and 1.74 ± 0.27 $W \cdot kg^{-1}$ in summer, ($p < 0.001$). After 6 days of starvation RMR was down to 0.62 ± 0.07 $W \cdot kg^{-1}$ and 0.77 ± 0.03 $W \cdot kg^{-1}$ ($p < 0.001$) in winter and summer, respectively. RMR during starvation in winter was 19 % below predicted RMR for animals of equal body mass. Standing RMR was significantly higher ($p < 0.01$) than lying RMR. Winter plasma levels of T_3 in both animals were 1.1 $nmol \cdot l^{-1}$ when food was freely available, and 1.4 $nmol \cdot l^{-1}$ after 6 days of starvation. Plasma concentration of T_3 in another 8 free ranging semi-domesticated, female muskoxen aged 12 yrs. in March was 0.64 ± 0.20 $nmol \cdot l^{-1}$. Corrseponding value in August was 1.00 ± 0.10 $nmol \cdot l^{-1}$, being significantly higher ($p < 0.01$) than the winter value.

Key words: *Ovibos moschatus*, thyroidal hormones, starvation.

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Introduction

The muskoxen (*Ovibos moschatus*) is the northernmost living mammalian herbivore. Being native to East-Greenland and Canadian North-West Territories this animal has to cope with long periods with low ambient temperatures and sometimes limited access to food during the long winter night.

The maintenance of a constant temperature in a thermoregulated body depends on the overall insulation and the resting metabolic rate (e.g. Scholander, 1950).

In the present study we have measured the metabolic rate of *ad. lib.* fed and starved muskoxen both summer and winter. We have furthermore measured the plasma levels of triiodothyronine (T_3) of both captive and freeranging animals in order to shed some light upon its relationship to nutritional status and metabolism.

Materials and methods

Female muskoxen (*Ovibos moschatus*) aged 12 yrs. were used in this study. All animals were kept outdoor under natural photoperiode at 70°NL (Tromsø, Norway). Two of the animals, which were both barren, were kept in pens and fed a combination of commercial concentrate (Jacobsen and Skjenneberg, 1979) and timothy hay.

In summer (July/August) both animals consumed 5.0 kg of concentrate, while in winter (January/March) only 2.0 kg was consumed pr. day. Resting (lying) metabolic rate (RMR) was measured 7 to 10 hours after removal of the food, when the animals were fed *ad lib.* and at intervals during a 6 day starvation period both summer and winter. In summer the body weight of the animals were 232 and 190 kg when fed *ad lib.*, being reduced to 213 and 178 kg after 6 days of fasting, respectively. In winter the corresponding body weights were 260 and 226 kg, being reduced to 240 and 209 kg, respectively.

During measurements the animals were standing or lying quietly inside an aluminium box. The inside of the box was covered by brown, perforated fiber plates to keep the emmisivity close to unity and thereby avoid reflected thermal radiation. The animals were exposed to the natural environmental temperature which at all times was within their thermoneutral zone. Using an open flow system, outside air was sucked through the metabolic box. The air was warmed and dried before entering an oxygen analyser (S-3A Oxygen Analyser, App. Electrochem. Inc., CA). Flowrate, which was measured with a dry gas meter (Mainz, Mainz-Kaste) varied between 800 and 1000 $l \cdot min^{-1}$. Environmental and chamber temperatures were recorded continuously with copper constantan thermocouples connected to a Fluke Thermocouple Multipoint Selecter, mod. Y-2001 (J. Fluke Co., WA). The flowmeter was calibrated by use of a spirometer. The thermocouples were calibrated against several mercury thermometers, using water baths of different controlled temperatures. The oxygen analyser was calibrated against outside air (20.94% O_2) and pure N_2 (0% O_2). Each experiment lasted until the O_2-level was stable for a period of at least 15 min. The mean O_2-consumption (during the stable period) was calculated and transformed to STPD, converted into $kcal \cdot min^{-1}$, and expressed as $W \cdot kg^{-1}$. Body weight was obtained by use of a crane and calibrated scale (Salter, Shropshire). Blood was collected both from the two experimental animals and from another eight animals of the same age and sex, which were ranging free on an island outside Tromsø, by use of heparinized syringes from the sub-lingual vein 20 to 40 min after the animals had been tranquilized with Rompun®, (xylazin, 60 mg i.m.). Duplicate samples were immediately centrifuged and plasma stored at -20°C until analysis. Commercial kits were used for determination of triiodothyronine (T_3, Diagnostic Products Corp.). The within assay coefficient of variation was 3.7%. Calculations were based on spline function plots (LKB Wallace, 1222 Databox).

Statistical analysis were carried out by the use of Student t-test. P values less than 0.05 were considered significant.

Results

The metabolic rates of the 2 adult experimental animals are given in Table 1. Resting (lying) metabolic rate (RMR) in winter was 0.86 ± 0.10 $W \cdot kg^{-1}$ when the animals were fed concentrate and hay *ad libitum.* Metabolic rate in the standing animals was at the same time significantly higher ($p < 0.01$), being 1.09 ± 0.09 $W \cdot kg^{-1}$. The RMR of muskoxen fed concentrate and hay *ad libitum* in summer was 1.74 ± 0.27 $W \cdot kg^{-1}$, dropping to a stable level of 0.78 ± 0.07 $W \cdot kg^{-1}$, and 0.77 ± 0.03 $W \cdot kg^{-1}$, respectively, after 5 and 6 days starvation. The corresponding values after 4 and 6 days of starvation in winter were 0.60 ± 0.03 $W \cdot kg^{-1}$ and 0.62 ± 0.07 $W \cdot kg^{-1}$, respectively. These values are significantly lower ($p < 0.01$) than the summer values.

In winter the plasma levels of T_3 in the 8 free-ranging animals were 0.64 ± 0.20 $nmol \cdot l^{-1}$. The values for the same animals in summer were significantly higher, being 1.0 ± 0.1 $nmol \cdot l^{-1}$, ($p < 0.001$). In the two captive muskoxen plasma T_3 level after 6 days of starvation in winter was 1.4 $nmol \cdot l^{-1}$, while the T_3 level was only 1.1 $nmol \cdot l^{-1}$ in the same animals when they were fed ad lib.

Table 1. Food regime and resting (lying) metabolic rate in 2 female 12 yrs. old muskoxen. Values in parentheses represent number of experiments.

Food intake	Resting metabolic rate ($W \cdot kg^{-1}$) (Summer)	(Winter)
ad lib.	1.74 ± 0.27 (10)	0.86 ± 0.10 (4)
4 days starvation	0.78 ± 0.07 (11)	0.60 ± 0.03 (9)
6 days starvation	0.77 ± 0.03 (5)	0.62 ± 0.07 (13)

Discussion

This study has shown that the resting metabolic rate (RMR) of adult muskoxen is reduced to only 49% of the summer value during winter. However, this study has also shown that, like reindeer (Nilssen *et. al*, 1985), muskoxen reduced their ad lib. food intake substantially during winter. It is therefore likely that the reduce winter metabolic rate in these creatures, in part, reflects the different heat increment of feeding. Even so, at the end of the 6 day starvation period in summer RMR was still 30% higher and significantly different ($p > 0.001$) from RMR after 6 days of starvation in winter. The latter, being 0.62 $W \cdot kg^{-1}$ is moreover 19% below the value predicted for animals of the same body weight (Kleiber, 1975). These results may indicate that the well insulated muskoxen may respond to the austerity of the high Arctic winter, with a down regulation of cellular metabolism, in order to save energy when food is likely to be in short supply. In our muskoxen standing increased metabolic rate 26% above RMR. This increase is comparable with that of pronghorn (Wesley *et. al*, 1973) and roe deer (Weiner, 1977), but more than twice the value commonly used for cattle (Blaxter, 1967). The reason for this discrepancy between wild and domestic ruminants is presently unknown.

It is generally agreed that thyroidal hormones of mammals have thermogenic effects and increase oxygen consumption. Accordingly, in our free-ranging animals T_3 was significantly ($p < 0.01$) lower in winter than in summer. In the two experimental animals, however T_3 after 6 days of starvation in winter was 27 % higher than when food was available *ad libitum*. It is therefore doubtful if a causual relationship between thyroidal hormone concentrations and metabolism/nutritional level exists in these animals.

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References

Blaxter, K. L. 1976. *The energy cost of ruminants.* Hutchinson and Co., London.

Jacobsen, E. & Skjenneberg, S. 1979. Experiments with different diets to reindeer. – *Sci. Rep. of the Agric. Univ. of Norway*, 58: 1–11.

Kleiber, M. 1961. *The Fire of life.* Wiley, London.

Nilssen, K. J., Sundsfjord, J. A. & Blix, A. S. 1984. Regulation of metabolic rate in Svalbard and Norwegian reindeer. – *Am. J. Physiol.* 247. R837–R841.

Scholander, R. F., Hock, R., Walters, V. & Irving, L. 1950. Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature, insulation, and basal metabolic rate. – *Biol. Bull.* 99: 259–271.

Weiner, J. 1977. Energy metabolism of the roedeer. – *Acta Thierol.* 23: 3–24.

Wesley, D. E., Knox, K. L & Nagy, J. G. 1973. Energy metabolism of pronghorn antelopes. – *J. Wildl. Manage.* 37: 563–573.

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