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Expanded abstract

Intake, digestibility and passage rate of a supplemented hay diet in captive muskoxen

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Muskoxen are large ruminants existing on range often sparsely vegetated and covered by snow, yet they may maintain substantial body fat throughout winter. Relatively little is known of their nutritional requirements and digestive processes.

A small herd of tame muskoxen is maintained at Goodale Farm near Saskatoon, by the University of Saskatchewan. Through fall, winter and spring, these animals have access to a medium-quality grass hay and are given a small daily pellet supplement; in summer a medium-quality pasture is supplemented with hay and pellets. Our objectives were to measure the seasonal voluntary intake of muskoxen given a standard hay diet, and to compare the digestibility and retention time of this diet between winter and summer.

Intake was monitored individually in 6 mature muskox cows (2 hysterectomized cows with intact ovaries, 4 breeding annually) penned individually at 4–7 week intervals from March 1990 to July 1991. Voluntary intake of a locally grown grass-alfalfa hay was measured for 5 days after a 3–4 day habituation. Crude protein (CP) content of the hay varied from 9.3 to 12.8 %, and acid-detergent fiber (ADF) from 37 to 42 %. The 550-g supplement of pellets fed to each animal daily was composed of 50 % oats, 38 % hay, 4 % molasses, 2 % mineral mix, 1 % iodized salt, 2 % phosphate mix, and 3 % barley vitamin mix; CP and ADF were 12–14 % and 13–19 %. Each cow was weighed weekly.

Turnover time of the hay was measured in winter (Feb.–March 1991) and summer (July 1991) in 6 mature muskoxen – 3 castrate males and 3 hysterectomized cows. Prior to the July trial, the 6 were off pasture for two weeks. A 80–90 g packet of chromium (Cr)-mordanted hay was mixed with untreated hay and fed to each animal; feces were collected over the next week and analysed for Cr. Total tract passage rate (Kpt) was calculated from the slope of the decline in fecal Cr (natural log values) and mean tract retention time (MRT) as the reciprocal of this slope (Okine and Mathison 1991)[1]. As two of the animals in March gave unusable results (one cow, one castrate), we used only re-

[1] The calculated MRT would be called rumen retention time by some authors, but Okine and Mathison (1991) found, in cattle fed roughage diets, that the decline in fecal excretion of Cr best approximated total tract retention time, not rumen retention time, which they measured separately. We have followed their notation and calculations.

sults from the other 4 animals. MRT's were compared between trials using a paired t-test.

Digestibility was measured in March and July following the retention-time trials, in the same 6 animals. Muskoxen were given pellets with 2 % chromic oxide for 10 days, hay intake was monitored for 7 days and feces were collected twice daily during the last 5 days. Pellets and a pooled fecal cample from each animal were analysed for chromic oxide. Dry matter digestibility was calculated from the increase in concentration of chromic oxide from feed to feces. Digestibilities and intakes were compared between trials using paired t-tests. All hay used during both sets of trials was from one field cur in July 1990.

Feed intake increased during spring and summer; dry matter intake peaked in July 1990 in one hysterectomized cow (54 gDM/kgBW$^{.75}$) and in the 4 breeding cows (61–70 gDM/kg BW$^{.75}$) with minimal levels from November to April (36–43 gDM/kgBW$^{.75}$ in the one hysterectomized cow and the 4 breeding cows). The other hysterectomized cow showed no clear seasonal pattern. Body weight of the 4 breeding cows averaged 250 kg through winter, dropped to a low of 218 kg following calving (May–June) and increased through fall and early winter. Body weight of the hysterectomized cows averaged 230 kg and varied little with season.

Retention time (MRT) of Cr-mordanted hay decreased substantially ($p < 0.01$) from March to July (Table 1). Dry matter intake increased by 18.9 % ($p < 0.05$) from March to July but digestibility decreased by 13.8 % ($p < 0.01$) (Table 2). Body weight of the 6 muskoxen was stable during these trials.

Muskoxen are well adapted to slow, thorough digestion of graminoid forage in winter. The retention times measured in March were much longer than in red deer and sheep (Milne *et al.*, 1978), longer than in similarly fed cattle (e.g. Okine and Mathison 1991) and are among the longest recorded in any ruminant (cf. Warner 1981). The digestibilities in March were also higher than would be expected in cattle on a similar diet. White *et al.*, (1984) have also shown high digestibilities of various diets in young muskoxen, although Holleman *et al.* (1984) found much shorter retention times in young muskoxen eating high quality diets. Our results are consistent with classification of the muskox as a pronounced grazer; muskoxen are known to have the large rumen and large, well-developed omasum of grazers (Staaland and Thing, 1991).

Muskoxen also have a relatively slow metabolic rate in winter (Tyler and Blix, 1990); coupled with their thorough digestion of fiber, this has resulted in remarkably low feed intake requirements (Table 3). Based on Crete *et al.* (1991), a caribou weighing 85 kg would require

Table 1. Total tract retention time of Cr-marked hay by muskoxen.

	March	July
n	4	4
Kpt (%/hour)	0.963	1.419
(s.e.)	(0.056)	(0.081)
MRT (hours)	104.9	71.1
(s.e.)	(5.9)	(3.8)

Table 2. Intake and digestibility of hay and pellets by muskoxen.

	March	July
n	6	6
Dry matter digestibility (%)	76.6	62.8
(s.e.)	(1.4)	(0.9)
Body weight (kg)	266.2	252.5
(s.e.)	(20.4)	(22.4)
Daily pellet intake (ration; kg DM/muskox)	0.50	0.50
Daily hay intake (voluntary; kg DM/muskox)	2.08	2.34
(s.e.)	(0.22)	(0.27)
Total daily intake (kg DM/muskox)	2.58	2.84
(s.e.)	(0.22)	(0.27)
Daily intake gDM/kgBW$^{.75}$*	39.8	49.1
(s.e.)	(1.7)	(4.8)

* gDM/kgBW$^{.75}$ = grams dry matter intake, per kg of body weight to the 0.75 power.

Table 3. Voluntary food intake of selected ruminant species in winter and summer, gDM/kgBW$^{.75}$

Species	Winter	Summer	Source	Feeds	Notes
Red deer	57.3 (Nov.)	82.3 (July)	1	dried-grass pellets	young castrates
Caribou	70 (Mar.)	100–110 (July)	2	mixed, high quality	young females
Sheep	71.3 (Nov.)	88.2 (July)	1	dried-grass pellets	young castrates
Muskoxen	39.8 (Mar.)	49.1 (July)	this study	medium quality hay	mature cows & castrates

Sources: 1 – Milne *et al.* 1978; 2 – Crête *et al.* 1991.

1.96 kg of relatively high quality forage daily in winter; a muskox weighing 180 kg would also required 1.96 kg of forage, but not of as high a quality. White *et al.* (1984) found a comparable winter intake for muskoxen in Alaska.

Metabolizable energy requirements of lactating cows increased substantially in summer, but increased minimally in non-breeding animals, since the increased intake was largely offset by decreased digestibility. Poorer digestibility in summer was likely due to more rapid passage, as diet quality was nearly constant (80 % of intake was hay in March, vs. 82.4 % in July). These changes may be the result of an intrinsic (likely photoperiod-related) tendency to increase intake and decrease retention of forage in summer, when natural forage would normally be more digestible. A similar pattern in winter–summer changes in digestibility and retention time has been shown in Soay sheep by Argo (1986).

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References

Argo, C. M. 1986. Photoperiodic control of nutritional and reproductive cyclicity in the Soay sheep. *PhD thesis, University of Aberdeen Bucksburn, Aberdeen, Great Britain.*

Crête, M., Huot, J., Nault, R. and **Patenaude, R.** 1991. Reproduction, growth, and body composition of Riviere George caribou taken into captivity. *(poster).* – *Arctic Ungulate Conference, Nuuk, Greenland, Sept. 1991.*

Holleman, D. F., White, R. G., Frisby, K., Jourdan, M., Henrichsen, P. and **Tallas, P. G.** 1984. Food passage rates in captive muskoxen as measured with non-absorbed radiolabelled markers. – *Biological Papers of the University of Alaska Special Report* No. 4: 188–192.

Milne, J. A., MacRae, J. C., Spence, A. M. and **Wilson, S.** 1978. A comparison of the voluntary intake and digestion of a range of forages at different times of the year by the sheep and the red deer (*Cervus elaphus*). – *British Journal of Nutrition* 40: 347–357.

Okine, E. K. and **Mathison, G. W.** 1991. Reticular contradiction attributes and passage of digesta from the ruminoreticulum in cattle fed roughage diets. – *Journal of Animal Science* 69: 2177–2186.

Staaland, H. and **Thing, H.** 1991. Distribution of nutrients and minerals in the alimentary tract of muskoxen, *Ovibos moschatus.* – *Comparative Biochemistry and Physiology* 98A: 543–549.

Tyler, N. J. C. and **Blix, A. S.** 1990. Survival strategies in arctic ungulates. – *Rangifer, Special Issue* No. 3: 211–230.

Warner, A. C. I. 1981. Rate of passage of digesta through the gut of mammals and birds. - *Nutr. Abstr. Rev. Ser. B,* 51: 789–820.

White, R. G., Holleman, D. F., Wheat, P., Tallas, P. G., Jourdan, M. and **Henrichsen, P.** 1984. Seasonal changes in voluntary intake and digestibility of diets by captive muskoxen. - *Biological Papers of the University of Alaska Special Report* No. 4: 193–194.

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