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Expanded abstract

Seasonal changes in weight, condition and nutrition of free-ranging and captive muskox females

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Wild muskoxen calve several weeks before snowmelt and begin costly lactation without access to green forage; retaining substantial body fat until late winter may be essential to reproductive success. Captive muskox females tend to regain body weight rapidly at the end of summer (White *et al.*, 1989) but little is known of seasonal changes in body reserves of wild muskoxen. We began a study of weight and body composition in female muskoxen in 1989, on Victoria Island, Northwest Territories (NWT). Our objectives were to assess seasonal changes in nutrition and body reserves of females, and to relate these changes to reproductive status, particularly to early lactation in late winter.

The University of Saskatchewan keeps a small herd of tame muskoxen at Goodale Farm near Saskatoon. These animals are maintained through fall, winter and spring on grass hay supplemented with oat-hay pellets. In summer they graze a poor-medium quality pasture supplemented with hay and pellets. Our objective in this study was to determine whether an intrinsic seasonal cycle of weight change persisted in captive females despite nearly constant diet quality. Here we make a comparison of seasonal changes in wild and captive females.

Collections on Victoria Island were conducted in April, May, August and November 1989, April, May, July, September and November 1990, and April and May 1991. Approximately 20 muskoxen, mostly adult females and calves, were shot by Inuit hunters during each collection. Measurements and notes on each animal included body weight, dressed carcass weight, depth of back fat (DBF), gastrocnemius muscle weight (an index of lean body mass), and reproductive status. Captive muskoxen at Goodale Farm were weighed weekly and the weekly weights were averaged for each month.

Diet quality in wild muskoxen was estimated from analysis of nitrogen (N) in freeze-dried samples of rumen contents from shot animals. During studies of captive muskoxen, diet quality was kept constant by using the same quality of hay and pellets for 7–10 days prior to and during feed intake trials (Adamczewski *et al.*, 1991) and during blood sampling. Hay used during all trials was locally grown grass hay; it va-

ried in crude protein from 9–12 % and in acid-detergent fiber from 37–42 %. The pellets varied little in composition (Adamczewski *et al.*, 1991).

Serum levels of insulin-like growth factor 1 (IGF-1) are known to correlate strongly with the rate of lean body growth in mammals (Blair *et al.*, 1988; Kerr *et al.*, 1991), and are very sensitive to nutritional status (Teale and Marks, 1986; Breier *et al.*, 1988). Blood (serum) was collected from wild muskoxen following death. Blood samples were collected from captive females every 4–7 weeks from March 1990 to July 1991. Serum IGF-1 was extracted with acid-ethanol followed by cryo-preservation (Brier *et al.*, 1991); the radioimmunoassay followed Kerr *et al.*, (1990) and was validated for muskox serum.

Values for wild females were summed for each month (1989–91) since there was little between-year variation (e.g. April data for 1989, 1990, 1991 are used together). Seasonal values for wild and captive females were compared by season, using one-way analysis of variance (ANOVA).

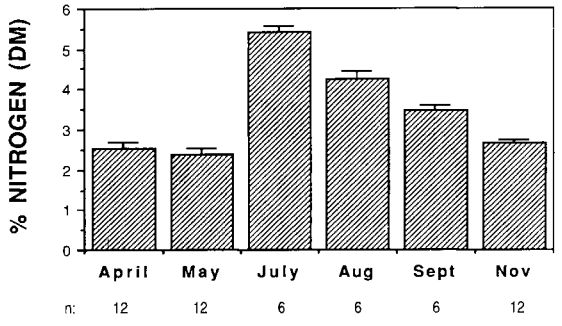

Fig. 1. An index of seasonal changes in diet quality in Victoria Island muskoxen: % nitrogen in freeze-dried rumen contents. Means and standard errors.

Diet quality varied markedly with season ($p < 0.01$) on Victoria Island, with a peak in July followed by a rapid decline (Fig. 1). Serum levels of IGF-1 varied significantly with season ($p < 0.01$) with peak levels in summer and fall (Fig. 2a). Lactating females tended to have lower IGF-1 in summer and fall than non-lactating females but the difference was significant only in November ($p < 0.01$). IGF-1 levels in captive muskox females were consistently higher than in wild ones (Fig. 2b) and showed only a fall peak.

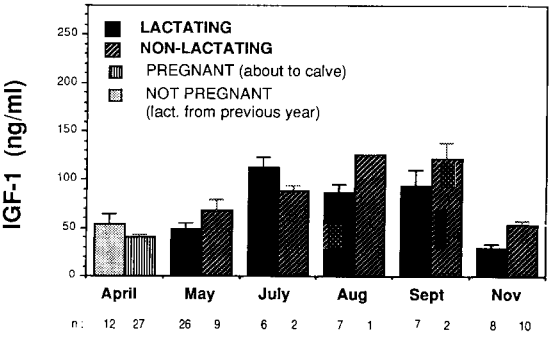

Fig. 2a. Serum IGF-1 levels in Victoria Island muskox females (3 years old or older). Single samples from individual animals; means and standard errors.

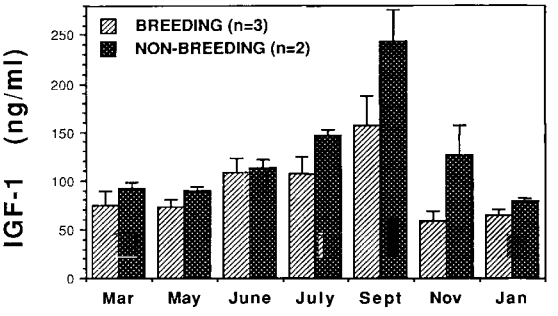

Fig. 2b. Serum IGF-1 levels in captive muskox cows, Saskatoon (all at least 5 years old). Repeated samples from 5 individuals. Means and standard errors.

Lactating wild females tended to regain weight lost during winter with a rapid surge in August, while non-lactating females regained it throughout summer and were clearly fatter by November (Figs. 3a, 4 and 5). Mean carcass weight loss from September to May was 40 %; this included substantial losses of fat and muscle. Lactating cows lost fat much more rapidly after giving birth than during pregnancy, but there was no clear association between reproductive status and gastrocnemius weight. Captive muskox females maintained higher body weights than wild ones all year, but mean weight of the 4 breeding cows did decrease from a winter peak of 250 kg to a low of 218 following calving (Fig. 3b).

The pregnancy rate in 62 mature wild cows (4 years +) in April and Noveber was 63 % (39/62 – summed for 1989–1991). Of 33 mature cows in April, 12 were not pregnant and were still lactating from the previous year; the other 21 were pregnant but were not lactating from

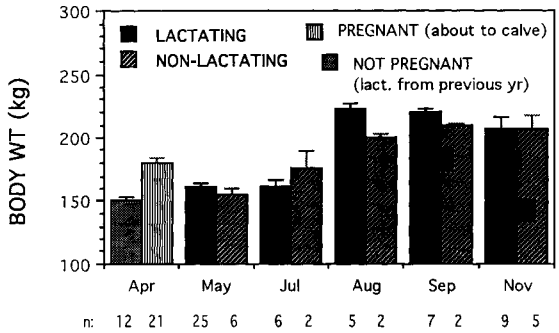

Fig. 3a. Body weights of Victoria Island muskox females (4 years old or older). Single measurements from individual animals; means and standard errors.

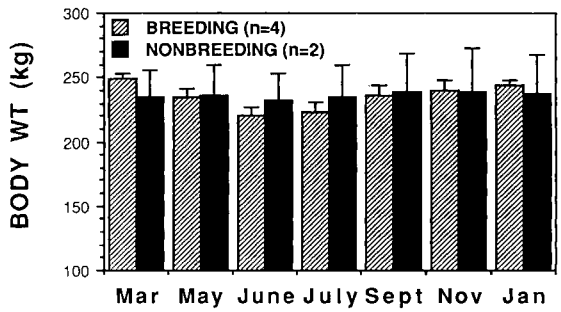

Fig. 3b. Body weights of captive muskox cows, Saskatoon (all at least 5 years old). Repeated measurements from individual animals; means and standard errors.

the previous year. Eight of 29 mature cows in November were both pregnant and lactating.

A strong seasonal cycle of changes in weight and nutritional status occurs in wild female muskoxen; changes in fat are primarily related to reproductive status. Substantial changes in body protein also occur annually, although there was no clear association with reproduction. Newly-lactating females lose more of their fat in the last 5–6 weeks of winter than during the previous 4–5 months, and lactating females compress much of their compensatory growth into late summer and fall, past the peak of forage quality, as found by Thing *et al.* (1987). This tendency persists in captivity in Saskatoon, as it does in Fairbanks (White *et al.*, 1989), although the seasonal variation is much reduced. This pattern may reflect priorities which change with season: initially (May-July) priority is given to calfsupport, and later to maternal tissues. Weight gain despite reduced food quality is possible in muskoxen due to their very efficient digestion of graminoid forage and low metabolic rate (Adamczewski *et al.*, 1991).

Serum IGF-1 levels in wild muskoxen tended to be higher in summer, when forage quality was higher, although high IGF-1 levels persisted in wild muskoxen in the fall despite plant senescence. The strong seasonal pattern in captive muskoxen did not reflect their nearly constant diet; these results suggest an intrinsic predisposition to high IGF-1 levels and weight gain in fall. Such a photoperiod-induced effect has been suggested in reindeer (Suttie *et al.*, 1991). The pattern in wild females may thus reflect two influences: IGF-1 levels are elevated in early summer due to forage quality, and are high in late summer due to a photoperiod-induced surge. The combination of these two influences produces a «plateau» of elevated IGF-1. In captive muskoxen fed a constant diet, only the second «surge» apparently exists.

The low pregnancy rate among muskox cows on Victoria Island indicates that few cows are currently calving in successive years, although this can occur in wild muskoxen (Reynolds, 1989; Rowell, 1989). This may reflect the large

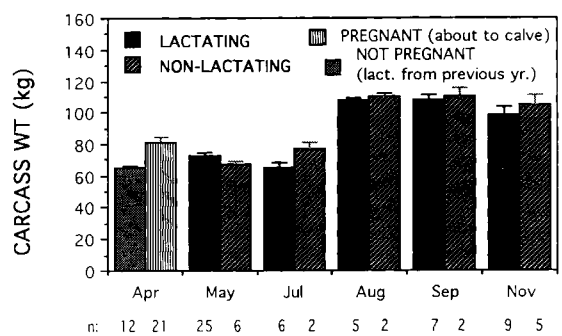

Fig. 4. Carcass weights of Victoria Island muskox females (4 years old or older). Single measurements from individual animals; means and standard errors.

energetic cost of lactation, particularly in the initial weeks before spring, when fat stores are depleted rapidly. Nursing females apparently do not catch up to non-lactating cows in condition during the fall weight surge, in this population. Should this poorer condition coincide with poor nutrition in fall or early winter, conception or early pregnancy might be adversely affected.

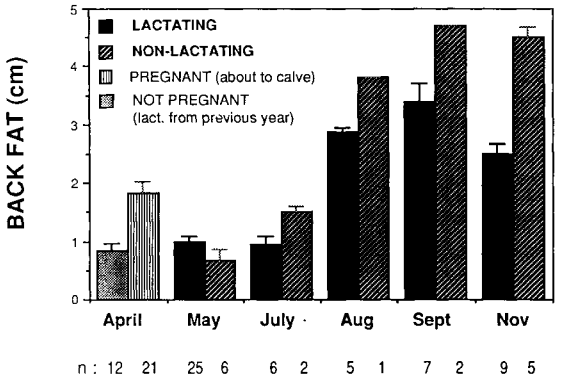

Fig. 5a. Seasonal changes in back fat (DBF) of Victoria Island muskox females (4 years old or older). Single measurements from individual animals; means and standard errors.

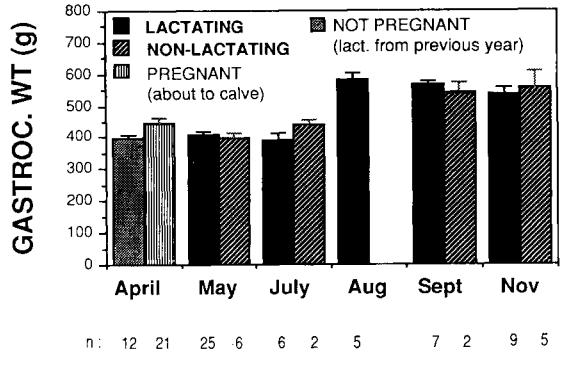

Fig. 5b. Seasonal changes in weight of the gastrocnemius muscle in Victoria Island muskox females (4 years old or older). Single measurements from individual animals; means and standard errors.

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