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Ruminal degradation increases with seasonal hyperphagia in muskoxen (*Ovibos moschatus*): a preliminary report*

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ABSTRACT

We used repeated measures of castrated adult muskoxen during spring, autumn and winter to describe responses to a consistent diet. Increased feed intakes between spring and autumn were accompanied by increases in ruminal rates of in situ degradation for cellulose in hay and for protein in supplements. Microbial counts in ruminal fluid increased between spring and autumn but declined in winter. Total concentration of short chain fatty acid in the rumen also increased with feed intake but the proportions of individual acids varied between seasons. Microbial activity can change independently of diet quality in grazers from highly seasonal arctic regions.

KEY WORDS: arctic, herbivore, fibre, microbial fermentation, protein, muskoxen

INTRODUCTION

Muskoxen (*Ovibos moschatus*) consume fibrous diets such as sedges in the high arctic where plant growth is highly seasonal. Nutrients and energy must be accrued rapidly from a low-quality diet to meet demands for survival and reproduction through the ensuing 9 months of winter and spring (Rombach et al., 2002, 2003). Muskoxen therefore increase *ad libitum* feed intake during autumn when graminoid plants are most abundant (Peltier et al., 2003). Autumn hyperphagia did not however, reduce the apparent digestibility of dietary dry matter (DM), gross energy, neutral detergent fibre (NDF) and crude protein over

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the whole tract of muskoxen (Peltier et al., 2003). This finding was surprising because ruminal fermentations may be unsuited to seasonal hyperphagia, that is, digestion of high loads of fibre may be constrained by ruminal capacity, digesta flow, and by the activity of microbes. We therefore tested the hypothesis that autumnal hyperphagia is sustained by alleviating one or more of the constraints on ruminal degradation and fill in muskoxen.

We present a preliminary report of this study for the International Symposium on Ruminant Physiology. A complete presentation of these data will be published elsewhere.

MATERIAL AND METHODS

We used repeated measures of castrated adult muskoxen (n=8) during spring (April - May), autumn (August - September) and winter (February - March) to describe responses to a seasonally consistent diet of hay and supplements. We fed grass hay (*Bromus* sp.) *ad libitum* (7.2 to 15.3 g N, 598 to 620 g NDF and 18 MJ per kg DM) with one of two supplements (21.2 or 40.8 g N, 241 or 240 g NDF and 17 or 16 MJ per kg DM, respectively) at 5.0 g/kg$^{0.75}$/d in spring and winter, and at 5.7 g/kg$^{0.75}$/d in autumn. Hay was the primary source of ingested energy (92%), N (70-90%) and Ca (92%) whereas supplements were the principal source of Na (78%) and trace minerals across seasons (Peltier et al., 2003). This feeding regime therefore mimics the energy and protein concentration of the wild diet of sedges, forbs and browse without limiting the supply of other nutrients such as minerals (Barboza et al., 2003; Peltier and Barboza, 2003; Peltier et al., 2003).

In situ degradation of feeds were measured as their disappearance from permeable bags inserted into ruminal fistulas and withdrawn at intervals of 6, 24 and 48 h. Fractional outflow and fill of ruminal fluid were estimated from concentrations of Co following a single ruminal dose of Co-EDTA. Chemical analyses of feeds were performed by the procedures of Peltier et al. (2003). Ruminal microbes from the fluid phase of digesta were fixed in formol saline for counts under light microscopy. Short chain fatty acids produced by fermentation were assayed by gas liquid chromatography.

RESULTS

Muskoxen increased intakes of dry matter by 74% between spring (2.75± 0.54 kg/d) and autumn (4.75±0.74 kg/d) as body mass increased from 239 to 260±37 kg. Mass gains were primarily associated with body fat which increased by 58% from spring to winter (Peltier et al., 2003).

The fluid capacity of the rumen increased by 30% between spring and autumn without changing the fractional outflow of solutes. Ruminal fill was maintained

from autumn to winter but ruminal outflow declined by 19% in winter. Ruminal substrate loads of cellulose and protein were increased by 59 and 135%, respectively, from spring to autumn. Fractional rates of *in situ* degradation in the rumen increased with feed intake from spring to autumn by 103% for cellulose in hay and by 72% for protein in supplements. Microbial counts in rumen fluid increased by 30% between spring and autumn but declined by 45% between autumn and winter. Total concentration of fermentation acids also increased with feed intake between spring and autumn but the proportions of individual acids varied between periods. Ruminal pH decreased as fermentation acids increased in concentration within 6 h of feeding supplements. Microbial counts did not change within 6 h of supplementation.

DISCUSSION

Elevated rates of microbial degradation in autumn allow muskoxen to increase their feed intakes much more than the change in ruminal capacity alone. *In situ* measures of degradation reflect seasonal changes in maximal activity of ruminal microbes independent of ruminal outflow. Although variations in microbial activity probably reflect changes in the microbial population, those activities may also indicate shifts in the diversity of the microflora. This suggestion of a change in microbial diversity is supported by seasonal changes in the proportions of individual fermentation acids before and after feeding supplements.

Decreases in microbial number and *in situ* degradation rates in winter may be partly related to low feed intakes and slow turnover of the ruminal substrate pool. The suggestion of limited microbial substrates is supported by changes in fermentation acids and pH following supplementation. Post supplemental increases in fermentation products were most pronounced for spring and winter. Microbial populations may also be constrained by reductions in basal energy expenditure of muskoxen during winter that may be associated with reduced maintenance of ruminal conditions.

CONCLUSIONS

Microbial activity can change independently of diet quality in this highly seasonal grazer, probably as a result of interactions between microbial species, feed intake, and secretions from the host. Increased fermentative capacity in autumn maximize net gains of energy and protein from fibrous forages and therefore maximize utilization of the small home ranges occupied by muskoxen.

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