Paper presented at The First Arctic Ungulate Conference,
Nuuk, Greenland, 3-8 September, 1991.

# Muskox and caribou adaptation to grazing on the Angujaartorfiup Nunaa range in West Greenland

**Hans Staaland**[1] and **Carsten Riis Olesen**[2]

[1] Institute of Biology and Nature Conservation, Agricultural University of Norway, Pb 14, N-1432 Aas, Norway

[2] Fiilsvej 8, DK-7500 Holstebro, Denmark

*Abstract:* In recent years (1970-90) the caribou population of the Angujaartorfiup Nunaa range has decreased from about 40 000 animals to 2 000. Overgrazing presumably depleted the lichen resources on the range during the population peak. At the same time altogether 27 muskoxen introduced in 1962 and 1965 have proliferated and the muskox population reached 3 000 animals in 1990. At the present monocots dominate the diet for both species. The alimentary tract of both muskox and caribou collected in the fall of 1990 had characteristics of grazing ruminants, e.g. relatively small caecum-colon compared to total alimentary size and large alimentary fill relative to body weight. Caribou had an omasum comparable in size to the grazing Svalbard reindeer whereas the omasum of the muskoxen in size, resembled that of domestic cattle. Both winter and summer samples showed highest ruminal hemicellulose and cellulose concentrations in the muskoxen, whereas lignin and nitrogen were equal in the two species. Conclusively our data suggest adaptation to grazing in both species, but more so in muskoxen than in caribou.

**Keywords:** competition, alimentary tract development, grazing adaptation

**Rangifer,** 12 (2): 105-113

## Introduction

When muskox *(Ovibos moschatus)* and cari-bou-/reindeer *(Rangifer tarandus subspp.)* coexist in the same general area their different habitat and food preferences seem to limit competition (see e.g. Wilkinson *et al.,* 1976; Thomas and Edmonds, 1984; Ferguson, 1987; Vincent and Gunn, 1981). It has, however, been speculated that a growing reindeer population in Svalbard apparently competed the introduced muskoxen to extinction (Klein and Staaland, 1984). Whereas the muskox is characterized as a grazing ruminant (Staaland and Thing, 1991), reindeer and caribou generally are classified as concentrate or quality selectors. The Svalbard reindeer, however, apparently has evolved towards a grazing animal, at least in winter, and opportunistically utilizes all available food resources (Staaland and White, 1991; Klein and Staaland, 1984; Staaland *et al.,* 1992).

In the Kangerlussuaq area of West Greenland the caribou population peaked at about 40 000 animals in the late 1960'es (Thing, 1984). In subsequent years the population crashed and caribou numbered about 2000 in 1990. During the crash, caribou changed migration pattern abandoning overgrazed lichen winter ranges in costal mountains to spending the whole year on steppe like summer ranges close to the inland ice.

At the same time the caribou population crashed, 27 muskoxen (1962 and 1965) were introduced from East Greenland on to the caribou summer ranges. Muskoxen population proliferated and reached about 3000 animals in 1990 (Olesen, 1991a). The inland ranges of Kangerlussuaq are dry, have very little snow, have no lichens and are dominated by monocots and shrubs.

Both caribou and muskoxen therefore subsist throughout the year on a diet dominated by grasses and sedges (Thing, 1984; Olesen 1990 and 1991a). Similarely, Thing *et al.* (1987) found that winterdiet of the indigenous population of muskox in Northeast Greenland mainly contained graminoides, whereas during the growing season the major plant selected for was *Salix arctica.* In comparison with other ruminants food adaptations it appears that the alimentary tract of the muskoxen is developed in accordance with a typical grazer (Staaland and Thing, 1991; Hofmann, 1988).

The rapid increase in muskox population in the Kangerlussuaq area indicates that the range is well suited for muskoxen. The apparent overlap of range use and food selection, in particular during winter, by muskoxen and caribou in this steppe like area could therefore be another case of severe competition between these two species (Olesen, 1991b; Klein and Staaland, 1984).

To elucidate physiologcal possibilities for dietary competition, we have compared the size and structure of the different alimentary pools in caribou and muskox in the Kangerlussuaq area examining to what extend they have adjusted to a year around monocot diet. We have related alimentary morphology and function to the seasonal variation in major food plant quality.

## Material and methods

Five muskox (one yearling female and 4 adult males) and 5 caribou (one yearling female and 4 adult males) were collected in the Angujaartorfiup Nunaa range of West Greenland in late August 1990. In addition to analyzing samples from rumen and caecum in these animals, chemical analyses were also carried out on samples from one more muskox collected in July 1989 and 6 muskoxen and 3 caribou collected in the winter seasons (October–April) 1988–1990. These animals were collected in the same general area described above, but due to weather condtions (low temperature) measurements of poole sizes and tissue weights could not be carried out as detailed as for summer collected animals.

All animals were eviscerated as soon as possible after being shot. The gastrointestinal tract was laid out on the ground and sampled according to Staaland *et al.* (1979). The content in every section of the alimentary tract was weighed and representative subsamples taken for chemical and botanical analyses. Samples were taken from the rumen, reticulum, omasum, abomasum, 3 successive sections from the small intestine, the caecum, the section leading from the caecum to the coiled colon, 3 successive sections from the coiled colon and 3 from the distal colon. The samples were transferred to sealed plastic vials and added 5 ml of 40% formol as a preservative. The samples were frozen as soon as possible and stored at -20°C until analyzed. The tissue of the gastrointestinal tract was gently cleaned in water and weighed to the nearest g. All organs and tissues of the animals were weighed and used to calculate total body weights.

Important forage plants, *Kobresia myosuroides, Salix glauca, Betula nana* and mixed monocot samples were collected regularly through the spring and summer season in the area around Søndre Strømfjord from early May to late August 1990. Occasional samples of the same plants were also collected during the winter season. Samples collected before green up in early June were treated together with the winter samples and those after as summer samples. The samples were air dried in paper bags. Further samples were collected in Ørkendalen on August 30 1990 and May 5 1991 and used for *in vitro* dry matter digestibility determination.

### *Chemical analyzes*

All samples of alimentary content were freeze dried to constant weight and the difference between wet and dry weight was considered to equal the water content. Plant samples as well as Rumen and Caecal samples were analyzed by Kjeldahl-N, ether extraction, ashing and the van-Soest methods. These analyzes were carried out at the Chemical research laboratory of the Agricultural University of Norway at Aas.

*In vitro* dry matter digestibility was carried out according to the method of Tilley and Terry (1963) with inoculum from sheep fed a concentrate diet. These measurements were carried out at the Department of Animal Science, Agricultural University of Norway.

## Results

### *Alimentary fill*

The major difference between the two species was relative more content in the omasum among muskoxen than among caribou. Total fill relative to body weight was not significantly different (Table 1). In muskoxen the rumen wall was relatively lighter than in caribou, whereas the omasum weighed twice as much (Table 2). Caribou had a longer intestine than the muskoxen relative to body weight, but the small intestine comprised a lower percentage of the whole intestine in caribou than in muskoxen (Table 3).

### *Seasonal variations in forage quality*

The monocot sampled showed lower content of ether extracts, lignin and nitrogen than the browse species *Betula nana* and *Salix glauca.* Contrary hemicellulose, cellulose and cell wall were higher in the monocots. Consequently the ratio between hemicellulose, cellulose and lignin was much higher for monocot samples (Table 4). We could not detect significant seasonal variations within these two groups, but summer samples had significantly higher nitrogen and lower lignin content than winter samples. Winter samples of *Kobresia myosuroides* were particularly high in hemicellulose and cellulose compared to summer samples (Table 4).

### *In vitro*

Dry matter digestibility of 6 important forage species collected in late August was examined (using inoculum from domestic sheep). The monocots and *Salix glauca* showed a good digestibi-

Table 1. Alimentary fill in muskoxen and caribou collected in West Greenland in August 1990. ± S. D. Data from Svalbard and Norwegian reindeer (Staaland *et al.* 1979) and Norwegian roedeer (Holand and Staaland 1992) included for comparison; * summer animals; ** winter animals.

| Species | Total cont kg | Percent of total content Ru/Re | Om | Abo | S.int. | L.int. | g cont/ kg BW |
|---|---|---|---|---|---|---|---|
| Muskoxen | 44.3 | 73.8 | 4.7 | 2.5 | 9.2 | 9.8 | 169 |
| (n=5) | ±12.9 | ±4.3 | ±0.6 | ±1.0 | ±3.3 | ±2.4 | ±52 |
| Caribou | 24.5 | 75.7 | 1.7 | 1.8 | 9.7 | 11.2 | 214 |
| (n=5) | ±6.8 | ±2.8 | ±0.1 | ±0.4 | ±2.1 | ±1.2 | ±25 |
| | $p<0.05$ | N.S. | $p<0.001$ | N.S. | N.S. | N.S. | N.S. |
| Svalbard | | | | | | | |
| (n=3)* | 14.8 | 77.7 | 1.2 | 2.2 | 9.3 | 9.6 | 214 |
| (n=1)* | 23.4 | 67.6 | 1.2 | 2.3 | 15.7 | 11.3 | 192 |
| (n=1)* | 8.2 | 67.0 | 3.9 | 1.3 | 12.7 | 15.2 | 202 |
| (n=5)* | 19.2 | 75.1 | 1.9 | 2.1 | 10.0 | 10.9 | 236 |
| (n=6)** | 7.2 | 74.9 | 2.9 | 2.8 | 4.9 | 14.5 | 180 |
| Norway | | | | | | | |
| (n=6)* | 15.8 | 76.7 | 1.7 | 2.0 | 10.1 | 9.5 | 176 |
| (n=6)** | 8.9 | 84.0 | 0.9 | 2.4 | 4.7 | 8.0 | 219 |
| (n=5)** | 10.6 | 85.0 | 0.9 | 3.1 | 5.8 | 5.2 | 227 |
| Roedeer | | | | | | | |
| (n=36)* | 24.2 | 61.8 | 1.1 | 4.0 | 15.3 | 17.6 | 93 |
| (n=27)** | 29.8 | 66.2 | 1.5 | 2.6 | 10.9 | 18.8 | 120 |

Table 2. Tissue weights in muskoxen and caribou collected in West Greenland i August 1990. ± S.D. Data fromSvalbard and Norwegian reindeer (Staaland *et al.* 1979) included for comparison; * summer animals; ** winter animals.

| | Muskoxen | Caribou | |
|---|---|---|---|
| n | 5 | 5 | |
| Body weight (kg) | 275±77 | 118±38 | |
| Weight of alimentary tissue (kg) | 10.0±1.7 | 5.7±1.6 | $p<0.01$ |
| *Percent of total alim. tissue:* | | | |
| Rumen | 37.9±5.5 | 47.9±7.4 | $p<0.05$ |
| Reticulum | 5.2±0.9 | 4.3±1.4 | N.S. |
| Omasum | 10.0±1.5 | 5.2±0.8 | $p<0.0001$ |
| Abomasum | 10.2±3.2 | 7.3±1.0 | N.S. |
| Small intestine | 16.9±1.3 | 16.9±2.2 | N.S. |
| Large intestine | 19.8±5.9 | 18.3±3.7 | N.S. |
| g alim. tissue/kg body weight | 38±8 | 50±10 | $p<0.08$ |

| | Svalbard | | | | | Norway | | |
|---|---|---|---|---|---|---|---|---|
| n | 4 | 1 | 1 | 5 | 6 | 6 | 6 | 5 |
| Body weight (kg) | 68* | 122* | 41* | 81* | 40** | 90* | 41** | 47** |
| Weight of alimentary tissue (kg) | 4.8 | 6.7 | 3.4 | 5.4 | 2.0 | 4.7 | 1.5 | 2.3 |
| *Percent of total alim. tissue:* | | | | | | | | |
| Rumen | 50.0 | 48.7 | 47.7 | 49.0 | 37.5 | 53.2 | 45.2 | 47.7 |
| Reticulum | 3.5 | 3.9 | 3.6 | 4.3 | 4.2 | 4.0 | 4.7 | 4.2 |
| Omasum | 3.6 | 3.7 | 6.1 | 5.1 | 5.8 | 3.7 | 4.6 | 3.7 |
| Abomasum | 6.2 | 6.7 | 8.0 | 7.0 | 20.2 | 5.0 | 6.4 | 6.6 |
| Small intestine | 17.4 | 16.0 | 20.4 | 20.1 | 13.2 | 21.4 | 24.7 | 25.1 |
| Large intestine | 19.2 | 21.0 | 15.0 | 14.5 | 29.0 | 12.6 | 14.4 | 12.5 |
| g alim. tissue/kg body weight | 71 | 55 | 83 | 67 | 50 | 52 | 37 | 49 |

Table 3. Comparison of length of alimentary tract in muskoxen and caribou collected in West Greenland in August 1990. ± S. D. Data from Svalbard and Norwegian reindeer (Staaland *et al.* 1979) included for comparison; * summer animals; ** winter animals.

| | Total length m | Percent of total S.int. | L.int. | Total length cm/kg BW |
|---|---|---|---|---|
| Muskoxen (n=5) | 40.6±2.5 | 67±1.4 | 32.4±1.4 | 16.0±5.6 |
| Caribou | 32.4±4.3 | 62.6±1.3 | 37.4±1.3 | 30.4±11.1 |
| (n=5) | $p<0.01$ | $p<0.001$ | $p<0.001$ | $p<0.05$ |
| Svalbard | | | | |
| (n=4)* | 21.0 | 58.6 | 41.4 | 30.7 |
| (n=1)* | 23.6 | 55.1 | 44.9 | 19.4 |
| (n=1)* | 19.6 | 63.8 | 36.2 | 48.4 |
| (n=5)* | 24.3 | 61.7 | 38.3 | 29.9 |
| (n=6)** | 17.0 | 60.0 | 40.0 | 42.4 |
| Norway | | | | |
| (n=6)* | 30.3 | 67.7 | 32.3 | 33.7 |
| (n=6)** | 20.0 | 64.5 | 35.5 | 49.1 |
| (n=5)** | 20.1 | 64.7 | 35.3 | 43.0 |

Table 4. Chemical composition of important food plants from West Greenland. (g/kg dry matter ± S.D.).

| n | Ash | EterE | Hemic | Cellu | Lign | Sili. | Nitro |
|---|---|---|---|---|---|---|---|
| *Kobresia myosuroides* | | | | | | | |
| Summer (11) | 162 | 20 | 309 | 264 | 20 | 12 | 10 |
| | ± 84 | ± 3 | ± 34 | ± 19 | ± 5 | ± 9 | ± 3 |
| Winter (10) | 119 | 20 | 341 | 310 | 28 | 10 | 7 |
| | ± 60 | ± 5 | ± 33 | ± 21 | ± 10 | ± 5 | ± 1 |
| | NS | NS | < 0.05 | < 0.001 | < 0.05 | NS | < 0.01 |
| *Betula nana* | | | | | | | |
| Summer (6) | 55 | 90 | 113 | 136 | 156 | 3 | 15 |
| | ± 19 | ± 12 | ± 6 | ± 20 | ± 49 | ± 1 | ± 3 |
| Winter (5) | 55 | 99 | 108 | 152 | 222 | 8 | 12 |
| | ± 27 | ± 10 | ± 5 | ± 7 | ± 20 | ± 2 | ± 1 |
| | NS | NS | NS | NS | < 0.05 | < 0.05 | < 0.06 |
| *Salix glauca* | | | | | | | |
| Summer (10) | 80 | 54 | 88 | 141 | 71 | 2 | 27 |
| | ± 19 | ± 10 | ± 10 | ± 20 | ± 27 | ± 1 | ± 10 |
| Winter (7) | 55 | 60 | 107 | 178 | 134 | 2 | 17 |
| | ± 24 | ± 14 | ± 14 | ± 23 | ± 41 | ± 1 | ± 11 |
| | < 0.05 | NS | < 0.05 | < 0.01 | < 0.01 | NS | < 0.06 |
| Pooled samples (monocots) | | | | | | | |
| Summer (6) | 164 | 21 | 328 | 244 | 26 | 11 | 13 |
| | ± 74 | ± 3 | ± 10 | ± 9 | ± 3 | ± 10 | ± 2 |
| Winter (5) | 150 | 20 | 347 | 288 | 29 | 13 | 7 |
| | ± 111 | ± 2 | ± 41 | ± 51 | ± 9 | ± 12 | ± 2 |
| | NS | NS | NS | NS | NS | NS | < 0.001 |
| *Calamagrostis langsdorfii* | | | | | | | |
| Summer (1) | 59 | 17 | 349 | 303 | 11 | 9 | 7 |
| Winter (1) | 41 | 25 | 381 | 391 | 25 | 6 | 4 |
| *Eriophorum scheuzeri* | | | | | | | |
| Summer (1) | 47 | 30 | 357 | 248 | 25 | 5 | 10 |
| Moss | | | | | | | |
| Winter (1) | 176 | 25 | 274 | 272 | 65 | 8 | 18 |

lity whereas the digestibility of *Betula nana* and *Vaccinum uliginosum* was only about 30% (Table 5). Winter samples of *Calamagrostis langsdorfii* were apparently less digestible than summer samples, whereas summer and winter samples of *Kobresia myosuroides* appeared to have similar digestibility.

*Rumen and caecum nutrient content*

The major difference between the two species was higher levels of hemicellulose and cellulose in the rumen content of muskoxen versus caribou. Lignin content was equal in the two species. This resulted in a higher hemicellulose, cellulose to lignin ratio in the muskoxen. Caecal nutrient concentrations were equal in the two species (Table 6).

## Discussion

*Sampling technique*

We are familiar with objections that can be rised against the methods used in the present study. Field slaughter gives far from ideal condtions for sampling the alimentary tract. Some time will elaps before samples can be taken and meanwhile microbial activity will continue and degradation of foodparticles and production of VFA's continue etc. Weighing and washing of tissue as well as measuring gut lengths may give only approximate values of functional sizes of different sections of the alimentary tract. Shedding of gastrointestinal tissue may give erroneous values for nutrient content of alimentary tract content. However, also the use of tamed

Table 4b. Chemical composition of important food plants from West Greenland. (g/kg dry matter ±S.D.).

| n | Cell wall | Hemi/lig | Cellu/lig | Sili/lig |
|---|---|---|---|---|
| *Kobresia myosuroides* | | | | |
| Summer (11) | 599±30 | 16.1±4.0 | 13.6±2.5 | 0.6±0.5 |
| Winger (10) | 674±39 | 14.1±5.8 | 12.9±5.6 | 0.3±0.2 |
| *Betula nana* | | | | |
| Summer (6) | 405±66 | 0.8±0.3 | 0.9±0.2 | <0.05 |
| Winter (5) | 480±25 | 0.5±0.0 | 0.7±0.0 | <0.05 |
| *Salix glauca* | | | | |
| Summer (10) | 304±30 | 1.3±0.3 | 2.2±0.7 | <0.05 |
| Winter (7) | 467±51 | 0.8±0.2 | 1.4±0.4 | <0.05 |
| Pooled sample (monocots) | | | | |
| Summer (6) | 610±18 | 12.6±1.4 | 9.3±0.8 | 0.4±0.4 |
| Winter (5) | 648±53 | 13.6±6.2 | 11.5±5.8 | 0.4±0.3 |
| *Calamagrostis langsdorfii* | | | | |
| Summer (1) | 671 | 32.8 | 28.5 | 0.8 |
| Winter (1) | 803 | 15.1 | 15.5 | 0.2 |
| *Eriophorum scheuchzeri* | | | | |
| Summer (1) | 635 | 14.6 | 10.1 | 0.2 |
| Moss | | | | |
| Winter (1) | 619 | 4.2 | 4.2 | 0.1 |

Cell wall = Hemicellulose + cellulose + lignin + silicon.

muskoxen and caribou with e.g. rumen or intestinal fistula will influence the function of digestive processes in addition to being extremly difficult or impossible to perform on Greenland ranges. Furthermore tamed animals accustomed to other diets may chose a different diet than free ranging animals. In spite of these or other objections we assume that our study gives some information of value for the understanding of muskoxen and caribou nutritional ecology on the present range. Hopefully the results from our study can initiate studies employing other techniques supplementing our findings.

### *Development of the alimentary tract*

The muskox alimentary tract is similar to that described for animals collected on Jameson Land in East Greenland (Staaland and Thing, 1991) *i.e.* a large omasum and moderatly high fill in the large intestine. Concentrate selectors

Table 5. *In vitro* dry matter digestibility of caribou and muskox forage from Greenland. Samples collected in Ørkendalen August 30. 1990. Rumen liquor from sheep fed a concentrate diet. Included are also 2 winter samples of *Kobresia* and *Calamagrostis* collected on May 5. 1991.

| Species | % Dry matter disappearance |
|---|---|
| *Kobresia myosuroides* (Winter sample) | 59.7 |
| *Kobresia myosuroides* (Summer sample) | 61.6 |
| *Calamagrostis langsdorfii* (Winter sample) | 46.3 |
| *Calamagrostis langsdorfii* (Summer sample) | 58.2 |
| *Salix glauca* | 52.4 |
| *Eriophorum scheuchzeri* | 61.5 |
| *Betula nana* | 30.8 |
| *Vaccinum uliginosum* | 31.0 |
| "Hay Norway" | 58.6 |

Table 6. VanSoest analyses of rumen and caecum content of muskox and caribou from West Greenland (±S.D.).

| | RUMEN | | CAECUM | |
|---|---|---|---|---|
| | Winter | Summer | Winter | Summer |
| Muskox n | 6 | 6 | 6 | 6 |
| Caribou n | 3 | 5 | 3 | 5 |
| Dry matter (g/100 g wet w.) | | | | |
| Muskox | 17.5±1.1a | 14.8±1.9b | 16.6±2.0ab | 12.6±1.9c |
| Caribou | 14.7±1.5b | 13.9±0.6b | 17.1±0.6a | 13.5±2.3bc |
| Kjeld-N (g/kg wet w.) | | | | |
| Muskox | 4.0±0.5ab | 4.6±0.6a | 1.9±0.3a | 2.2±0.4ab |
| Caribou | 3.4±0.6b | 4.5±0.5a | 2.1±0.2a | 2.7±0.4b |
| Hemicellulose (g/kg wet w.) | | | | |
| Muskox | 40.6±6.7 | 48.7±11.4 | 25.1±5.6 | 29.2±7.8 |
| Carib | 34.3±5.5 | 35.9±13.4 | 27.6±4.1 | 23.1±5.7 |
| Cellulose (g/kg wet w.) | | | | |
| Muskox | 36.3±5.7a | 26.7±3.9b | 20.5±5.3 | 19.0±5.1 |
| Caribou | 25.9±6.5b | 21.2±4.6b | 19.0±2.2 | 16.4±3.0 |
| Lignin (g/kg wet w.) | | | | |
| Muskox | 14.9±5.1 | 12.9±4.0 | 13.5±3.3 | 13.1±2.9 |
| Caribou | 14.0±0.4 | 14.8±4.6 | 14.4±4.6 | 17.6±6.4 |
| Silicon (g/kg wet w.) | | | | |
| Muskox | 2.4±1.2 | 2.4±1.5 | 10.6±9.3ab | 5.5±2.5b |
| Caribou | 4.9±3.3 | 2.8±3.8 | 15.9±8.3a | 6.4±3.2b |
| "Cell wall" (g/kg dm) | | | | |
| Muskox | 613±46 | 689±94 | 444±94a | 603±66b |
| Caribou | 602±59 | 619±145 | 439±50a | 560±132ab |
| Hemicellulose/lignin | | | | |
| Muskox | 3.3±1.9 | 4.0±1.4 | 2.0±0.9 | 2.3±0.7 |
| Caribou | 2.4±0.4 | 2.5±0.9 | 2.0±0.5 | 1.4±0.3 |
| Cellulose/lignin | | | | |
| Muskox | .2.9±1.8 | 2.2±0.8 | 1.6±0.7 | 1.5±0.5 |
| Caribou | 1.8±0.5 | 1.5±0.4 | 1.5±0.7 | 1.0±0.2 |
| Silicon/lignin | | | | |
| Muskox | 0.2±0.2 | 0.2±0.2 | 1.0±1.2 | 0.4±0.2 |
| Caribou | 0.3±0.2 | 0.3±0.4 | 1.1±0.4 | 0.4±0.2 |
| Nitrogen/lignin | | | | |
| Muskox | 0.31±0.15 | 0.38±0.10 | 0.15±0.04 | 0.17±0.03 |
| Caribou | 0.24±0.05 | 0.33±0.10 | 0.15±0.04 | 0.16±0.05 |

Cell wall = hemicellulose + cellulose + lignin + silicon. Figures not followed by any letter or by the same letters are not significantly different ($p > 0.05$). Duncan test.

like the roe deer, usually have low alimentary fill relative to body weight, small omasum and large caecum-colon (Table 1). Grazers contrary, have large alimentary fill, large omasum and smaller caecum-colon. The fndings therefore show muskoxen adaptation to a monocot diet. The caribou omasum is smaller than the muskoxen's but resembles that of Svalbard reindeer *i.e.* it exceeds in size that of norwegian reindeer (Staaland *et al.*, 1979) (Tables 1-3). Also the apparent large caecum-colon of the Kangerlussuaq caribou has similarities to findings on

Svalbard winter reindeer. Similar developments in caribou of the Kagerlussuaq population could indicate adaptations towards a monocot diet like that of the Svalbard reindeer. A large caecum-colon found in winter animals from Svalbard could be important for volatile fatty acid production and for nonproteion N and mineral absorption (Staaland and White 1991).

Based on size and development of different alimentary pools (see e.g. Hofmann, 1988) the muskoxen should be better adapted to monocot grazing than the caribou.

*Forage selection*

Dietary selection of muskox and caribou in the Kangerlussuaq area is very similar. The lichens which were important in the winter diet of the caribou are missing in Angujaartorfiup Nunaa. The caribou is forced into a winter diet dominated by monocots. In spite of a higher summer differentiation in the caribou diet than in the muskox diet monocots (primarely *Kobresia myosuroides*) are dominant year around. Only in a very short period in summer are muskoxen observed to ingest large quantities of *Salix spp.* (Thing, 1984; Olesen, 1991b).

*Forage quality*

A monocot diet should therefore be high in cellulose and hemicellulose and relatively low in lignin compared to a typical browse diet (Table 4). Since high lignin inhibit digestion of other cellwall constituents and also dry matter (van Soest, 1982) this diet could yield a high energy output both to muskoxen and caribou. The *in vitro* studies do not directly show the capability of muskoxen and caribou to digest the important forage species of the Angujaartorfiup Nuna range (Trudell *et al.*, 1980), but indicate that these forage species are highly degradable by a bioassay method. The *in vitro* measurements therefore in our opinion indicate higher digestibility of the monocots than the browse species and although data are few quality of winter forages of monocotes seems to be maintained (Table 5). The browse species, however, are higher in nitrogen (Table 4).

Analyses of rumen content indicate higher concentrations of hemicellulose and cellulose in muskox than in caribou (Table 6). In the caecum these differences disappear also relatively to the lignin content. This finding might indicate differences in food intake. It could be assumed that a higher intake of monocots would give higher ruminal levels of hemicellulose and cellulose. Rumen nitrogen levels are slightly lower in the caribou, which can be explained by e.g. a physiological compensation by increased recycling of endogeneous nitrogen (Klein and Schønheyder, 1970).

According to feeding standards for sheep and cattle (ARC, 1980) the findings indicate marginal protein levels for maintenance on both summer and winter ranges without browse and forb supplement to a monocot diet (Table 4). Wether differences in hemicellulose and cellulose concentrations in the rumen of the two species reflects differences in diet composition or differences in rumen physiology is uncertain. In the caecum, however, the concentrations of these cellwall components are equal in both species.

*Conclusion*

Although our data are not fully conclusive we believe that differences in population growth and decline between muskoxen and reindeer in the Kangerlussuaq area can to some extend be explained by muskoxen being more highly adapted to a monocot diet than the caribou and therefore has competitive advantages on this type of range. However, further studies are needed to compare diets and nutrient utilization in the two speces.

## References


**ARC,** 1980. *The nutrient requirements of ruminant livestock.* – Commonwealth Agricultural Bureaux. – The Gresham Press, Surrey. 351 pp.

**Ferguson, M. A. D.** 1987. Status of Peary Caribou and Muskox populations on Bathurst Island, N.W.T., August 1981. – *Arctic* 40: 131–137.

**Hofmann, R. R.** 1988. Morphophysiological evolutionary adaptations of the ruminant digestive system. – In: Dobson, A. and Dobson, M. J. (Eds.). Aspects of digestive physiology in ruminants. *Proc. Satellite Symp. 30th Int. Congr. Intern. Union Physiol. Science. Cornell University, Ithaca, New York July 21–23,* 1986: Comtock Publishing Associates, Ithaca and London, pp. 1–20.

**Holand, Ø.** and **Staaland, H.** 1992. Nutritional strategies and winter survival of European roe deer in Norway. – In: Brown, R. D. (Ed.). *The biology of deer.* Springer-Verlag. New York, pp. 432–428.

**Klein, D. R.** and **Schønheyder, F.** 1970. Variation in ruminal nitrogen levels among some cervidae. Can. J. Zool. 48: 1437–1442.

**Klein, D. R.** and **Staaland, H.** 1984. Extinction of Svalbard muskoxen through competitive exclusion: An hypothesis. – In: Klein, D. R., White, R. G. and Keller, S. (Eds.). Proc. First Intl. Muskox Symp. *Biol. Papers Univ. Alaska Special Rep.* 4: 26–31.

**Olesen, C. R.** 1990. Bestandsutvikling og økologi for moskusokser i Angujaartorfiup Nunaa, Vest-Grønland. – Grønlands Hjemmestyre, Miljø- og Naturforvaltning. *Teknisk rap. nr. 16* – April 1990 85 pp. Mimeographed.

**Olesen, C. R.** 1991a. Rapid population increase in an introduced muskox population; West Greenland. – *Rangifer.* Submitted.

**Olesen, C. R.** 1991b. Feeding ecology and competition of muskox and caribou in West Greenland. – *Rangifer.* Submitted.

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

**Staaland, H.** and **White, R. G.** 1991. Influence of foraging ecology on alimentary tract size and function of Svalbard reindeer. – *Can. J. Zool.* 69: 1326–1334.

**Staaland, H., Scheie, J. O., Grøndahl, F. A., Persen, E., Leifseth, A. B.** and **Holand, Ø.** 1991. Reindeer dining out on Brøggerhalvøya, Svalbard? – *Rangifer.* Submitted.

**Staaland, H., Jacobsen, E.** and **White, R. G.** 1979. Comparison of the digestive tract in Svalbard and Norwegian reindeer. – *Arctic and Alpine Res.* 11: 457–466.

**Thing, H., Klein, D. R., Jingfors, K.** and **Holt, S.** 1987. Ecology of muskoxen in Jameson Land, northeast Greenland. – *Holarctic Ecol.* 10: 95–103.

**Thing, H.** 1984. Feeding ecology of the West Greenland Caribou *(Rangifer tarandus groenlandicus)* in the Sisimiut-Kangerlussuaq Region. – *Danish Rew. Game Biol.* 12 (3): 1–53.

**Thomas, D. C.** and **Edmonds, J. E.** 1984. Competition between caribou and muskoxen; Melville Island, NWT, Canada. – In: Klein, D. R., White, R. G. and Keller, S. (Eds.). Proc First Intl. Muskox Symp. *Biol. Papers Univ. Alaska. Special Rep.* 4: 93–100.

**Tilley, J. M. A.** and **Terry, R. A.** 1963. A two-stage technique for the *in vitro* digestion of forage crops. – *J. Br. Grassland Soc.* 18: 104–111.

**Trudell, J., White, R. G., Jacobsen, E., Staaland, H., Ekern, K., Kildemo, K.** and **Gaare, E.** 1980. Comparison of some factors affecting the *in vitro* digestibility estimate of reindeer forage. – In: Reimers, E., Gaare, E. and Skjenneberg, S. (Eds.). *Proc. Second Int. Reindeer/Caribou Symp. 17.–21. Sept. 1979.* Direktoratet for Vilt og Ferskvannsfisk, Trondheim. 262–273.

**Van Soest, P. J.** 1982. *Nutritional ecology of the ruminant.* – O. & B. Books, Inc. Durham and Downey, Inc. Portland Oregon. 374 pp.

**Vincent, D.** and **Gunn, A.** 1981. Population increase of muskoxen on Banks island and implications for competition with Peary Caribou. – *Arctic* 34: 175–179.

**Wilkinson, P. F., Shank, C. C.** and **Penner, D. F.** 1976. Muskox-caribou summer range relations on Banks island, N.W.T. – *J. Wld. Manage.* 40: 151–162.

*Manuscript accepted 7 February, 1992*