Polarforschung 58 (1): 1—12, 1988

Distribution and Abundance of Muskoxen (Ovibos moschatus) in the North East Greenland National Park. Results of Surveys Carried out between 72° and 74° North

By Benoît Sittler*

Summary: Muskoxen populations were surveyed in the course of 3 expeditions to North East Greenland to provide data on present status and habitat requirements in the region between 72° and 74° latitude North. The distribution is primarily affected by the snow cover pattern and shows densities from less than 0,1 ind/km² to 1,5 ind/km². Ranges unutilized by muskoxen prior to 1940 now support high densities. The snow cover influences also the population dynamics, as shown by the strong correlation between the calf crop and the amount of snow. The total population is estimated to be about 1000 to 1500 individuals for the whole region.

Zusammenfassung: Moschusochsenpopulationen wurden im Rahmen von 3 Expeditionen nach Nordost-Grönland erfaßt, um neuere Daten über deren Status und Lebensraumansprüche im Gebiet zwischen 72° und 74° Nord zu gewinnen. Die Verbreitung ist vor allem durch die Schneeverhältnisse beeinflußt, wobei die Dichten von weniger als 0,1 Tiere/km² bis zu 1,5 Tiere/km² reichen. Gebiete, in denen vor 1940 keine Moschusochsen beobachtet wurden, zeichnen sich heute durch hohe Dichten aus. Die Schneedecke beeinflußt ebenfalls die Populationsdynamik, wie aus der starken Korrelation zwischen Kälberanteil und mittlerer Schneehöhe zu entnehmen ist. Die Gesamtpopulation für das Untersuchungsgebiet wird auf zwischen 1000 und 1500 Tiere geschätzt.

INTRODUCTION

The distribution and present status of muskoxen within its North East Greenland range is only partly documented. Although synoptic appraisals are available by PEDERSEN (1936, 1942), JENNOV (1945), VIBE (1958), THING et al. (1984), detailed data exist only for a few restricted areas such as Jameson Land which is the southern part of the muskox range in Greenland (HALL 1964, FERNS 1977, LASSEN 1984a, PATTERSON 1984).

The region stretching from Kong Oscars Fjord to Nordfjord (72°—74° N) was mostly depleted of muskoxen prior to 1940 (DEGERBØL 1935, PEDERSEN 1942) but THING et al. (1984) recently estimated 2000 muskoxen. The Groupe de Recherches en Ecologie Arctique implemented studies to update information on the distribution and status of the muskoxen population in this area as well as to describe activity patterns which have been reported by SITTLER & KEMPF (1984).

THE STUDY AREAS

The region covered by the surveys was the southern district of the North East Greenland National Park extending from 72° N to 74° N (Fig. 1). Fjords cut deep into the mountains which rise steeply to altitudes between 1500 and 2500 meters. Toward the coast, islands and peninsulas display a less accentuated topography and alternate with broad valleys or lowlands. Basaltic outcrops forming locally steep cliffs are often connected by these lowlands or terraces.

Within this region, investigations were first focused on two selected study areas described in detail else-

* Dr. Benoît Sittler, Groupe de Recherches en Ecologie Arctique, Prérébois, F-68660 Rombach.

where (KEMPF et al., unpubl. data). The two areas were the Karupelv Valley on central Traill Ø which was investigated in 1979 from June 28 to August 6 and Southern Geographical Society Ø which was intensively surveyed in summer 1982 (June 26 to July 28) as well as in summer 1984 (May 31 to July 25). In addition, the whole region was surveyed (Fig. 1) in 1982 and 1984 by boat trips (July 28 to August 26 1982; July 25 to August 31 1984) as well as by ski journeys (May 31 to June 20 1984).

MATERIALS AND METHODS

The observers (4 in 1979, 7 in 1982 and 8 in 1984) systematically recorded sightings of muskoxen during

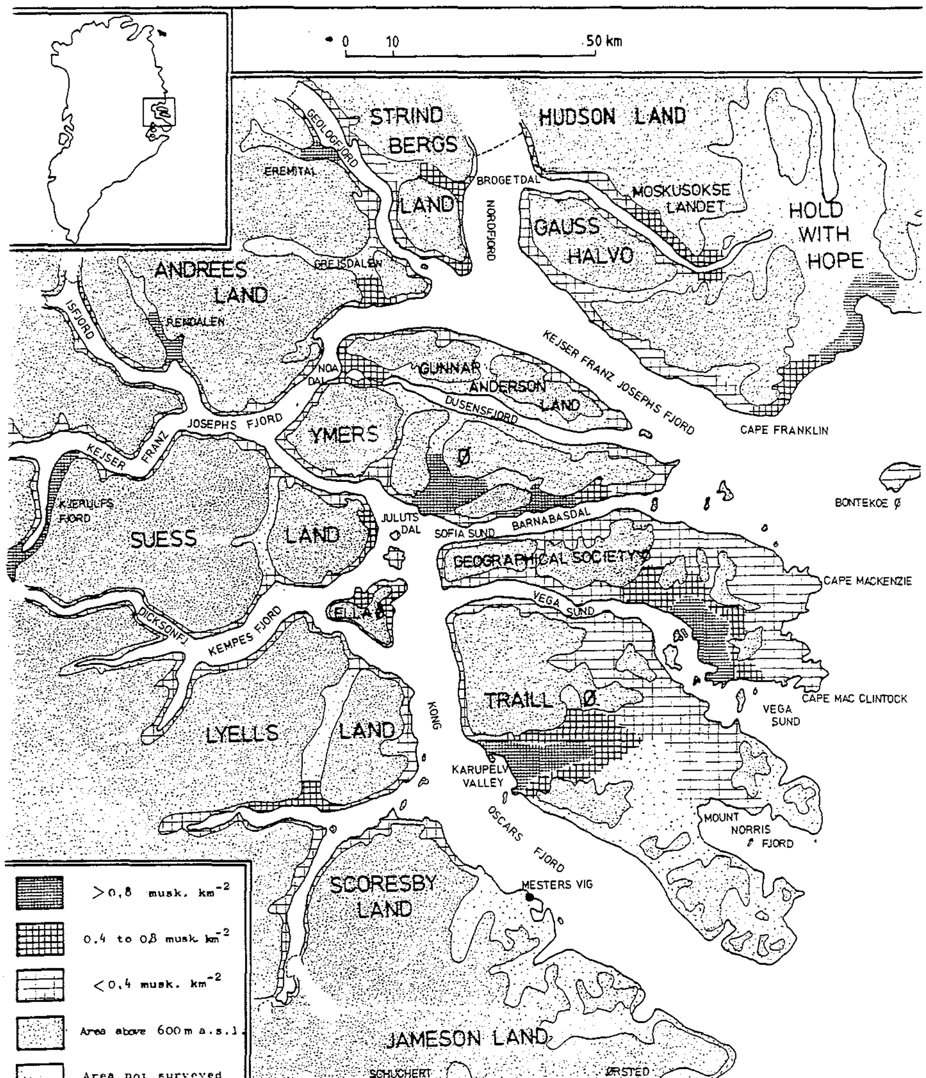

Fig. 1: Distribution and density of observed muskoxen.

Abb. 1: Verbreitung und Dichte der beobachteten Moschusochsen.

transects across the area as well as from vantage points, using 10 x 50 binoculars or 15 x 60 spotting scopes. The distance of observation was kept between 0,2 and 3 kilometers. Recording the time and location of the sightings prevented duplication of herds counted.

Whenever possible, the size and composition of herds was recorded. Because of the difficulties in assessing the exact herd composition at long distance observations (> 2 km), only calves but not yearlings were positively identified from their size.

The boat surveys (with 3 rubber boats) in 1982 and 1984 consisted of a census of all animals observed within the coastal zone when moving along the shore as well as of countings carried out in the main valleys (Fig. 1). The lowland between Vega Sund and Mount Norris Fjord (NE of Traill Ø) was surveyed in 1984 only from the air, when flown over by Bell 212 helicopter (June 1, June 19, June 30).

The pattern of snow melt and snow fall was mapped from satellite photographs of the study area (Landsat 4 and 5) by a dot grid method (HAEFNER & MURI 1978). The technique counts the points overlay-

Location	Size (km^2) of area surveyed	1979	1982	1984
HOLD WITH HOPE	75		n. d.	105 (24)
MOSKUSOKSELANDET / GAUSS HALVÖ	380		28 (3)	n. d.
STRINDBERGS LAND				
— Broget Dal	40		23 (4)	19 (4)
— Kap Ovibos	30		15 (4)	n. d.
— Other	110		2 (0)	5 (1)
ANDREES LAND				
— Eremit Dal	20		n. d.	15 (4)
— Grejsdalen	40		17 (3)	n. d.
— Rendalen	45		53 (12)	45 (8)
— Other	205		7 (0)	9 (2)
YMERS Ø				
— Gunnar Anderssons Land	120		4 (0)	3 (0)
— Noa Dal	35		17 (4)	n. d.
— Juluts Dal	40		22 (4)	33 (6)
— Barnabas Dal	35		40 (7)	29 (5)
— Other	230		16 (1)	13 (1)
SUESS LAND				
— Kjerulfs Fjord	45		48 (7)	n. d.
— Other	225		4 (0)	14 (3)
GEOGRAPHICAL SOCIETY Ø				
— Vega Sund (study area)	70		61 (9)	65 (12)
— Vega Sund (adjacent areas)	120		n. d.	71 (14)
— Eastern part	520		n. d.	0
— Other	480		23 (3)	17 (2)
ELLA Ø	80		22 (3)	n. d.
LYELLS LAND	200		18 (1)	n. d.
TRAILL Ø				
— Karupelv Valley	80	59 (13)	n. d.	n. d.
— Vega Sund Coast	250	n. d.	23 (3)	18 (3)
— Mount Norris Fjord	300	n. d.	n. d.	1 (0)
— Other	420	8 (2)	0	4 (0)
SCORESBY LAND	190	7 (1)	13 (3)	n. d.
		74 (16)	456 (71)	464 (88)

n. d. = not determined

Tab. 1: Muskoxen observed in the different geographical units (see Fig. 1) including proportion of calves in ( ).

Tab. 1: Anzahl der in den verschiedenen Gebieten beobachteten Moschusochsen (siehe Abb. 1). Jeweilige Anzahl der Kälber in Klammern.

ing snow versus points on snow free terrain.

RESULTS AND DISCUSSION

Distribution: The data for the restricted areas (Karupelv Valley, Vega Sund) represent the highest recorded number of muskoxen during an investigation period lasting several weeks (Tab. 1). All other observations were made during a single day, either in the course of boat journeys consisting of a survey of the coastal area or by transects through the main lowlands or valley systems, such as for Rendalen or the north coast of Traill Ø.

The highest density (Tab. 1) was recorded at Hold with Hope in June 1984 (1,5 ind/km²) while Rendalen (1,35) and Barnabas Dal (1,25) were other high density areas. Densities close to 1 ind/km² were further observed in the restricted study areas (Karupelv Valley, Vega Sund) as well as in the Juluts Dal and Kjerulfs Fjord. While below the peak densities reported by LASSEN (1984a) in Schuchert Dal (up to 1,71) our figures for these areas are similar to those found by FERNS (1977) in Ørsted Dal (1,0) or such reported from favourable habitats in the Canadian Arctic (0,87 ind/km² at Truelove Lowland: HUBERT 1977; estimation of 0,6 to 1,0 ind/km² at Bailey Point: THOMAS et al. 1981).

Some areas apparently with favourable topography had only a few muskoxen. This applies especially to the East of Geographical Society Ø, between Cape Mackenzie and Cape Mac Clintock, where only few tracks suggested that the occurence of muskoxen was sporadic. Similarly, muskoxen are also rare on the north coast of Traill Ø, where an area of more than 250 km² supported less than 25 animals. Islets scattered along the fjords or off the coast usually had no muskoxen at that time of the year, i. e. when no longer connected with the mainland by the fjord ice. Exceptions were in 1982 Ruth Ø where a solitary bull was observed and Kista Ø with 2 males. The occurence of droppings as well as the discovery of carcasses (N = 5) however account for regular visits of islands in winter.

Individuals or tracks have been recorded in all fjord systems, for example the groups recorded in 1982 in Kjerulfs Fjord (48 ind.) where gently sloping sides offer quite favourable habitats compared with all other inland fjords. The six muskoxen observed in 1982 and five in 1984 at the head of Isfjord confined on a narrow landstrip between the fjord and steep mountains (more than 2000 m) apparently had no possibility to leave this habitat (about 10 km² steep slopes) until the autumnal freezing of the fjord. A similar observation was made in Dickson Fjord where in 1984 a group of 11 muskoxen was held "captive" on a very steep slope (50%).

Within a region, topography partially mediates local distribution patterns. Areas supporting the highest densities are such exposed to the south and protected to some extent from northerly winds by mountain ridges. Depending on slope and snow accumulation pattern, those habitats are the first to clear during the snow melt and provide therefore better foraging opportunities. Such a situation is best exemplified by differences recorded between 1982 and 1984 in the snow melt pattern around Vega Sund area (Tab. 2). The preference for such site conditions has been documented by PEDERSEN (1936), JINGFORS (1980) as well as by surveys carried out on Jameson Land by LASSEN (1984b) and THING (1984). Predominan-

Location	Exposition	Slope (%)	1982				1984				
			06. 28	07. 04	07. 11	07. 18	06. 21	06. 28	07. 04	07. 11	07. 18
Delta Adam af Bremen Dal	S-SW	5	55	25	10	2	80	50	20	5	1
Upper Adam af Bremen Dal	W	15	75	55	30	10	95	80	60	35	10
Basalsø	E	20	75	50	20	5	95	75	45	15	5
North Coast of Traill Ø	NE	5	80	55	25	5	95	80	60	30	5

Tab. 2: Snow melt pattern around Vega Sund area. Proportion of ground covered by snow estimated from ground surveys (in %).

Tab. 2: Phänologie der Schneeschmelze im Vega Sund-Gebiet. Prozentualer Anteil der schneebedeckten Flächen geschätzt aufgrund von Geländebeobachtungen.

	Daneborg (20° 10′ W, 74° 20′ N)	Mesters Vig (24° W, 72° 15′ N)	Kap Tobin (23° W, 70° 28′ N)
1970	189,7	239,6	628,3
1971	251,1	292,3	523,4
1972	304,6	463,1	674,5
1973	229,1	233,9	522,8
1974	267,7	476,6	741,9

The figures are a total of liquid precipitation (rain) and water equivalents of solid precipitation (snow).
Die Daten umfassen die Gesamtmenge der flüssigen Niederschläge (Regen) sowie die Wasserequivalente für Schnee.

Tab. 3: Total amount of precipitation (mm) recorded by the stations of Daneborg, Mesters Vig and Kap Tobin (data only available for the period 1970—74).

Tab. 3: Jährliche Niederschlagshöhen (in mm) der Stationen Daneborg, Mesters Vig und Kap Tobin (Daten liegen lediglich für die Zeit 1970—74 vor).

ce of such habitats with favourable topography within most of the areas partially accounts for the high abundance of muskoxen.

On a regional basis, we have no direct measurements of snow depths in different areas. Data from the meteorological stations (Daneborg, Mesters Vig, Kap Tobin) (Tab. 3) show that precipitation is highest at the outer coast (Kap Tobin) and increases towards the south. During the period 1970—74, there was an average difference in winter precipitation of 179% between Mesters Vig and Kap Tobin and 242% between Daneborg and Kap Tobin. The climatic differences between the inland fjords and the outer coast, i. e. in relation to the distance from the open sea have also been illustrated by SOERENSEN's (1941) phenological investigations in this region. Summarizing his observations, it can be stated that as a rule there is an increasing continentality towards the inland, expressed in form of longer periods with temperatures above 0° C (up to 4 months, versus less than 10 weeks at the outer coast, including temperature deviations of up to 4° C in July and August. As to the precipitation, it was reported that snow cover was "noticeably" thicker at the outer coast than inland.

Accurate snow depths measurements are only available for Mesters Vig station (DANSK METEOROLOGICAL INSTITUTE, unpubl. data). Within the last 15 years, average snow depth exceeded 1,20 m during at least 3 months a year; in 1972 and 1976 snow depths even exceeded 2 meters. While these data are only representative locally, Central Traill Ø and Geographical Society Ø probably has a comparable snow regime (SØRENSEN 1941, PETERSEN 1938).

Examination of satellite photographs taken in spring as well as in autumn confirm the above characteristics of the snow cover in the region (Tab. 4). Inland areas are the first to clear in late spring (difference of

	1980	1981	1983		1984			
Location	06. 16	06. 20	06. 11	07. 11	06. 10	06. 19	07. 05	09. 25
Wollaston Forland	—	—	40	10	—	—	—	—
Holp with Hope	—	—	20	10	55	25	15	—
Rendalen	20	—	0	0	10	0	0	—
Brogetdal	20	—	0	0	25	0	0	—
Kjerulfs Fjord	10	—	—	0	10	0	0	—
Juluts Dal	30	0	20	0	30	15	0	—
Vega Sund	50	20	90	40	85	60	25	35
East of Geogr. Soc. Ø	80	60	100	80	100	90	70	100
Mount Norris Fjord	70	60	100	90	100	85	60	100
Karuplev Valley	40	10	90	20	75	60	15	0
Mesters Vig	80	30	100	60	95	75	35	75
Schuchert Dal	0	0	10	0	20	5	0	0

(— = data not available)

Tab. 4: Proportion of ground covered by snow in different areas of North East Greenland, according to satellite photographs (expressed in %).

Tab. 4: Anteil der schneebedeckten Flächen in verschiedenen Gebieten Nordost-Grönlands, ermittelt durch Auswertung von Satelliten-Aufnahmen (ausgedrückt in %).

3 to 4 weeks between the head of the fjords and the eastern part of Geographical Society Ø); and inland areas are also the last to become covered with snow in September, indicating that the total amount of snow is greater at the outer coast than far inland, a fact already reported by VIBE (1958). Noteworthy is the fact that Schuchert Dal where LASSEN (1984) found the highest densities is cleared very early; this applies to a lesser extent to Stordalen (between Hudson Land and Hold with Hope) equally known to support high muskox densities (HENRICHSEN 1982, THING 1984, O. SOERENSEN, pers. comm.). Regarding the snow conditions in this latter area, PETERSEN (1938) stated that the very sparse precipitation probably ascribes to local conditions prevailing there.

Compared with snow depths encountered in other parts of the muskox range, the gradient observed within the region suggests that mean annual snow thickness in the inland valleys is probably similar to that known for Canadian habitats, i. e. less than 60 cm (TENER 1965), while the herds on Geographical Society Ø and on Traill Ø have to cope with a mean snow cover of more than 1 meter.

The influence of snow cover has been quoted by PEDERSEN (1936) as governing distribution of muskoxen in winter by inducing migrations from snow filled valleys to less snowy wintering quaters on windswept plateaus or mountains. The lack of such wintering grounds has even been regarded by PEDERSEN as accounting for the absence of muskoxen in the Keyser Franz Joseph Fjord area as well as on Geographical Society Ø and Traill Ø. Similarly, SPENCER & LENSIK (1970) attribute the success of muskoxen on Nunivak Island where average snow depth is 130 cm to ''the fortuitous exposure of forage in dunes and at the edge of marine escarpments''. In contrast, muskoxen have, however, been reported as cratering through snow a meter in depth (VIBE in WHITE et al. 1981).

Physical characteristics of the snow layer is also important as a factor in muskox ecology as suggested by high winter mortality reported by VIBE (1958) and PARKER et al. (1975), subsequent to formation of ice crusts. While rare in North East Greenland (less than once every ten years during this century), such icing affects primarily coastal areas, i. e. areas with increased oceanic influence favouring the onset of mild weather periods including rainy days leading to the appearance of a surface crust on the snow layer. It is obvious that by causing crashes of populations, such phenomena affect first the population dynamics. Further, as described by MILLER et al. (1975), by inducing local and regional movements, it also governs the distribution patterns.

Snow cover also indirectly influences muskox ecology by modulating the length of the growing season which is correlated with the primary production of the tundra (SØERENSEN 1941, WEBBER 1974). Although there are no quantitative data available for this area, the productivity of areas with a late melting snow cover (with more than 40% still covered with snow mid July) is markedly lower than those cleared as early as mid June. However, when snow cover is shallow and thaw sets in early in the season as in the inland areas, a water deficit for plants may occur during the growing season; this is also a factor reducing primary production. These aspects all limit the carrying capacity of such habitats.

Population estimate: From the figures sampled during the surveys and the densities recorded, population size can be tentatively estimated for the region between Mesters Vig and Nordfjord. While the muskoxen were primarily censused in the lowlands and on the coastal zone within a distance of 3 km, the survey does not include the remote mountainous areas, meaning that almost all observations apply to lower altitudes, as a rule below 600 m a. s. l. Herds roaming in higher altitudes could in fact only be ascertained on Geographical Society Ø on a plateau ranging between 500 and 800 m connecting upper Tvoerdal to Lysdal.

In 1982, 456 muskoxen were counted and 464 in 1984. These figures correspond to a mean density of about 0,15 ind. per km^2, which is half that reported by LASSEN (1984) for ranges in Southern Jameson Land. In 1984, nearly 55% i. e. 3305 km^2 out of 6100 km^2 of the area below 600 m a. s. l. were surveyed.

When assuming that the remaining 45% support similar densities, then the population estimate for all ranges below 600 m would amount to about 850 individuals.

The population of the remote mountainous areas above 600 m is difficult to estimate. The surface area of the mountains is more than 3 times that of the lower ranges. VIBE (1958, 1967) has reported inland observations of muskoxen retiring in ranges between 800 an 1200 m or on nunatakker, mainly following winters with extremely adverse snow conditions. Similar observations were also made by THING (pers. comm.) on Jameson Land. The presence of tracks far inland indicate that probably some muskox herds use the higher ranges of the area between Mesters Vig and Nordfjord. Their total number probably does not reach or exceed that of the lower ranges. A population size ranging from 1000 to 1500 individuals is a reasonable estimate for the whole area.

Population dynamics: The present survey confirms a spatial as well as numerical expansion of the muskoxen population since the observations reported by DERGERBØL (1935) and PEDERSEN (1936, 1942), examplified by the apperance of muskoxen in areas like Geographical Society Ø and Traill Ø. The lack of reliable quantitative data preclude accurate assessment of the increase. PEDERSEN (1936), on the basis of winter counts, estimated the total population as being about 500 individuals, mainly concentrated on Strindberg Land, Andrees Land and Ymers Ø.

The expansion of the muskoxen population in areas where it was absent prior 1940 is best illustrated by data available for the Karupelv Valley (Traill Ø), and discussed by FERNS (1977). Counts performed there yielded a maximal daily total of 8 individuals in 1962 (HALL 1964) and an enumerated total of 20 individuals in 1974 (FERNS 1979). Even a population estimate of 25 animals in 1974 is less than half of our estimate in 1979 (58 ind.) which would correspond to a total increase of 132% within 5 years. Such a figure suggests an increase similar to that known for introduced ungulate populations (CAUGHLEY 1976). It is however difficult to evaluate to what extent this increment is the result of the intrinsic rate of increase or immigration or possible inaccuracy of former counts (the rugged topography of the upper valley making overlooking of herds likely).

We cannot compare the population change between 1982 and 1984 as not all areas referred to were surveyed. For the restricted study area at Vega Sund, the maximum number of muskoxen recorded in the 2 years was an increase of 4 animals in 1984 (65 versus 61) which would correspond to a yearly increase of about 3%.

The role of reproduction as a factor in the population dynamics was approached through the assessment of the number of calves within the total population (Tab. 1). The overall calf crops were 21,6% in 1979, 15,5% in 1982, 19% in 1984. THING (1984) has summarized calf crops previously recorded in Greenland. Our data, while below the highest figures such as those shown by the herds introduced in West Greenland (> 25%), lie over the mean value. It is interesting to note that in 1979, the GREA survey ascertained a calf crop of 21,6% on Traill Ø, while in the same period, ESKRINE (in THING 1984) reported a proportion of 25,3% in Scoresby Land. Similarly in 1982, LASSEN recorded a calf crop of 21,8% on Jameson Land, while the GREA survey yielded only figures of 15,5% in the survey area north of Mesters Vig.

The breeding success of muskoxen has often been acknowledged as affected by the prevailing snow conditions, a fact well demonstrated by population crashes reported from Greenland and Arctic Canada (VIBE 1958, GRAY 1973, FERNS 1977). This influence becomes particularly evident when comparing the calf production with the average snow depths during the breeding and calving season (Tab. 5). The snow depths referred to are either those given by the authors (VIBE 1958, HALL 1964) or compiled from records of Mesters Vig station (BOEN HANSEN, Statens Luftfahrtvaesen, pers. comm.). The average snow depth during the breeding season until the end of the calving season, i. e. from December to May, is highly correlated with percentage calf crop ($r = 0,915$). When assuming there is a individual threshold snow depth for every cow in the population, below which there is no influence on calving and above which calving is affected, then we obtain for the calf crop of the population — provided the threshold snow depth is normally distributed in the population — following function:

$$Y(s) = C\left[1 - F(s)\right]$$

where

$$F(s) = \frac{1}{\sqrt{2\pi}\,\sigma}\int_{-\infty}^{s} e^{-\frac{(s-\mu)^2}{2\sigma^2}}\,ds$$

is an integral of normal distribution

A non-linear square fit for the parameter gives: $C = 24{,}8$, $\sigma = 25$, $\mu = 114$. The linear regression: $Y(s) = -0.169.s + 32.1$ as well as this curvilinear regression as a Gauss integral describing the relationship between snow depth and calf crop can be taken from Fig. 2.

This curvilinear relationship indicates that snow depths around 115 cm (as an average for the period December to May at Mesters Vig) are a threshold value. Provided there is no other influence occuring, such as human interference, and in view of the calf crop of 10,5% quoted by FREEMANN (1971) as required for maintaining the population at equilibrum, then we could conclude from the available snow data series that there was an overall increase since 1978 (with favourable snow conditions in 6 out of 7 years: 1978, 79, 81, 82, 83, 84), while the period before was featured by at least 4 years with adverse snow conditions (1972, 73, 74, 76).

A shortcoming of the data which necessitates a cautious interpretation of the correlation between snow depth and calf production is that we do not know to what extent the snow depths derived from measurements at Mesters Vig are representative for the whole area, on account of the local and regional differences already ascertained in the snow melt pattern. Although of questionable use as absolute figures, those snow records, however, do reflect the differences in snow cover between the years. Additionally, this correlation does not include possible differences in snow characteristics such as the formation of ice crusts which, in the present series of data, only occured in association with the heaviest snow cover in 1954.

The influence of the amount of snow on the breeding success is such that a thick snow layer lasting a long period imposes such high energy costs of foraging that pregnant females are in poor physical condition at the calving time. Cows that do not directly succumb to starvation, either bear their calves too early or the calves die soon after birth, being unable to obtain sufficient food from their starving mother.

Another shortcoming is in this respect that the calf percentages referred to were taken at one to a few months after calving, whereas we cannot separate the effects of inter-uterine and neonatal mortality in-

References	Year	Area	Sample size	% calves	Monthly snow depths (in cm) D	J	F	M	A	M	Mean snow Depth
VIBE 1958	1954	72°—73°	323	1,5	170	190	210	220	240	220	208
HALL 1964	1961	71°—72°	267	23,6	45	67	90	102	95	35	72
HALL 1964	1962	71°—72°	78	5,6	115	150	180	140	125	80	132
FERNS 1977	1974	71°—72°	233	3,0	45	175	175	170	160	120	141
GREA	1979	72°—73°	74	21,6	30	55	50	80	50	20	47
ESKRINE in THING 1984	1979	72°	71	25,3	30	55	50	80	50	20	47
HIGGS in THING 1984	1980	74°	200	6,5	118	155	125	150	180	110	140
GREA	1982	72°—73°30	456	15,5	40	45	80	135	110	100	85
LASSEN 1984	1982	71°—72°	1168	21,8	40	45	80	135	110	100	85
GREA	1984	72°—73°30	464	19,0	40	70	110	140	120	110	98

Tab. 5: Data on calf crop and snow cover from different surveys implemented in North East Greenland (between 71° and 74° latitude North).

Tab. 5: Angaben über Kälberanteil und Schneehöhen aus verschiedenen Untersuchnungen in Nordost-Grönland (Gebiet zwischen 71° und 74° nördl. Breite).

duced by adverse snow conditions from the influence of low pregancy rate. The latter, i. e. the proportion of cows pregnant, is known to be a sensitive indicator of foraging availability during the foraging season (GUNN 1984) which affects both the onset of ovulation for cows as well as the entering of bulls into rutting condition. Information is however lacking in order to appreciate to which extent the foraging availabilty in summer, which incidentally is also influenced by the snow cover pattern (effect on length of growing season), is affecting the pregnancy rate of the populations surveyed. According to PEDERSEN (1936), cows in good condition may produce a calf every year and occasionally twins, while TENER (1965) stated that the short season of high quality summer forage characteristic of the high arctic may allow only alternate breeding of cows.

Similar negative effects of snow cover on calf crops are known from other ungulate populations. BARRETT (1982) has reported a high percentage of fetal mummification and dessication (i. e. only 14 "viable" fetuses out of a total of 82) among mature pronghorn does after a winter with prolonged heavy snowfall in Alberta. Unusual adverse snow conditions resulted also in noticeably reduced calf crops in reindeer populations on Svalbard (REIMERS 1982), while similar significant relationships have been ascertained by MECH et al. (1987) between the snow accumulation during previous winters and calf rates among white tailed deer (Odocoileus virginianus) and moose (Alces alces) populations.

Accurate assessments of mortality rates are in fact poorly documented in the literature (PARKER et al. 1975, ALENDAL 1976, HUBERT 1977, GRAUVOGEL 1984, GUNN et al. 1984, KLEIN & STAALAND 1984, REYNOLDS & ROSS 1984, THING 1984), and apart from the population introduced on Nunivak Island in Alaska (SPENCER & LENSIK 1970, SMITH 1984), there is no other muskoxen population which was thoroughly monitored with regard to mortality causes. In the present study, carcasses and skulls found in the area were systematically recorded, but the determination of causes and years of death proved to be difficult. The only reliable data comes from comparing the records made in the restricted study area in 1982 with those gathered in 1984, giving the mortality within 2 years for a known

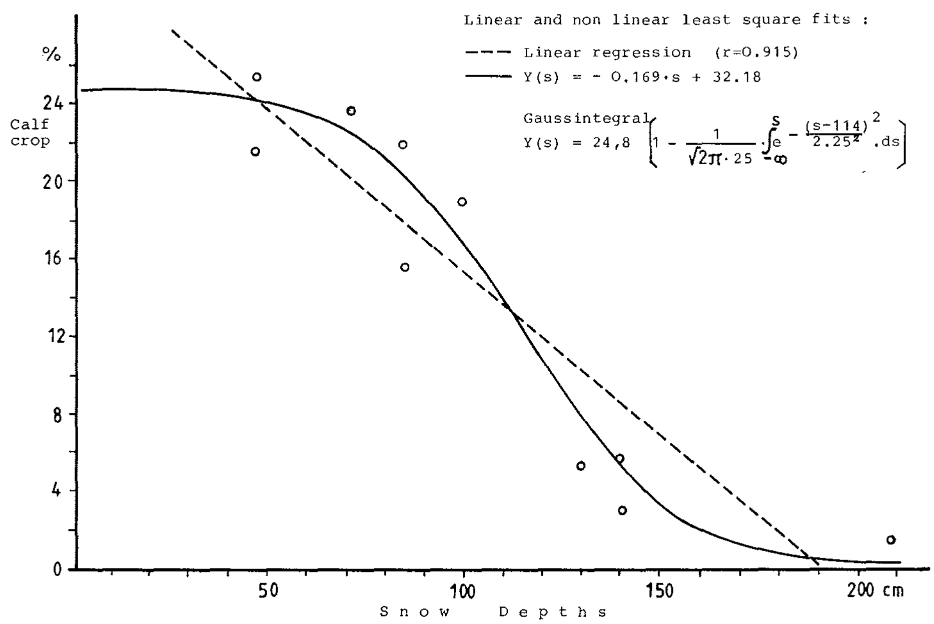

Fig. 2: Relation between calf recruitment and average snow cover (data referred to are listed in Tab. 5).

Abb. 2: Beziehung zwischen Kälberproduktion und durchschnittlicher Schneehöhe (die zugrunde gelegten Daten sind aus Tab. 5 zu entnehmen).

population. Six carcasses not recorded earlier were found in the restricted study area at Vega Sund. They belong to muskoxen succumbed between autumn 1982 and spring 1984: adult bulls = 3; adult females = 1; subadult = 1; undetermined = 1. No accurate statement can be made as to the cause of their death. When considering this figure of 6 individuals out of a population of 61 animals, we can deduce a minimal mortality rate of 5% a year, which suggests at least that no severe conditions occured within these 2 years, confirming observation of calf recruitment in 1984 and snow conditions in 1983 and 1984.

The only cases where death causes are clearly documented refer to a human interference, as far as in 1982, the carcasses of 2 herds with respectively 7 and 9 individuals (including 2 pregnant females) were found in the study area, 2 other cases of muskoxen killed by men having been reported in the same year from adjacent areas (Sverreborg hut). In 1984, ascertained muskoxen killing amounted to 3 individuals. This 1982 figure of at least 18 individuals (+ 2 unborn calves) represents more than 10% of the total population ascertained for Geographical Society Ø, balancing out nearly the natural increase of the population in year with good climatic conditions.

Predation as an additional cause of mortality has been reported by THING (1984) as being of minor importance in this part of Greenland, although the increased occurence of wolves reported by ELANDER (1987) and confirmed by our own observations of tracks could affect the population to a greater extent in the future.

CONCLUSION

Muskox populations in this part of Greenland are exposed to various range conditions induced by topographical as well as climatical differences prevailing within the whole area. Climatic factors, i. e. mainly the snow cover pattern are the principal influence on the population's distribution and population dynamics. The evidence for the importance of snow depth is first of all the scarcity of muskoxen on the outer areas of Geographical Society Ø and Traill Ø, where the snow thickness reachs its maximum within the whole area, secondly, the high correlation ascertained between the amount of snow in winter time and the calf crop. The primary plant production which is known to regulate ungulate populations (BOBEK 1977) should be regarded as currently secondary in importance for the muskoxen productivity in this survey area, setting possible population limits only in extreme conditions, such as in the innermost valleys and fjords where the plant standing crop may be limited by a deficient water supply, or at the outer coast where the late thaw and adverse temperature conditions reduces, growing season to a minimum. Between these extremes, the habitats have a relative high primary productivity, as confirmed by other surveys on primary consumers (KEMPF, pers. comm.). Those areas (Karupelv valley, Central Geographical Society Ø, Ymers Ø) were only colonized by muskoxen within the last decade, suggesting that these favourable foraging conditions are now able to counterbalance the adverse winter snow conditions still prevailing here, with snow depths which are by far maximum compared to those reported for other habitats within the natural range of this species (more than 100 cm as a rule in wintertime versus less than 60 cm in other habitats). From information available, it is however difficult to know whether this expansion in these new habitats may be attributed to a population pressure in the adjacent inland ranges where primary production could be limiting, or if it is due to a general and long-term improving of the snow conditions since the population low reported in the thirties.

A population eruption similar to that quoted by CAUGHLEY (1976) for ungulates colonizing habitats which had not been utilized for a long time could not occur here due to these limitations induced by this specific snow cover pattern. While considering this, it becomes also evident that caribou, once common in the area according to the amount of antlers, and which disappeared from NE Greenland at the turn of the century, could not thrive under present snow conditions, depths exceeding 60 cm being often reported as limiting for this species (FORMOZOV 1964, PRUITT 1959, LA PERRIERE & LENT 1977, SKOGLAND 1978). Their removal was attributed to a long-term worsening of snow conditions (VIBE 1967), which must have affected muskoxen to a lesser extent, i. e. favouring possibly its own dispersal and expansion.

Further, the snow cover characteristics and the parcelling out of the range in small units separated by deep fjords precludes in another respect from the effective existence of so-called refugias as described by THOMAS et al. (1981). In providing best conditions to muskoxen, especially with regard to snow cover, these refugias are places where populations from marginal ranges use to retire to in extreme winters. With densities generally much higher than elsewhere (1,5 animals/km²), the refugias constitute cores of local populations as such ascertained on the basis of the occurence of dental anomalies by HENRICHSEN (1982) in Central Hold with Hope and Schuchert Dal, i. e. outside the present survey area.

While providing evidence of the overall effects of the snow on the present muskoxen population, this survey, which actually was restricted to summer observations, can make no statement on the seasonal variation in habitat requirements, lacking direct observations in wintertime, both regarding the utilized range as well as concerning regional and local snow cover gradients, including physical data on snow characteristics, such as the hardness. Little is also known about the movement patterns, especially whether and to what extent exchanges between the population units are liable to occur. Further investigations should in this respect primarily include a large-scale monitoring of snow cover pattern throughout the area as well as observations on range selection and herd movements in wintertime.

ACKNOWLEDGMENTS

The studies reported here were part of the GREA Expeditions to NE-Greenland initiated in 1979, 1982 and 1984 under the leadership of C. Kempf. The successful completion of this work involved the support of the Ministry for Greenland which deserves special thanks for kindly granting the required authorizations and allowing access to the study area. Generous assistance was received from the manager and staff of Mesters Vig station. The author wishes to express his gratitude to the many GREA members whose observations have been fundamental to this paper. The help received from Owe Soerensen (Sirius Patrols) for transmitting winter observations and from Boen Hansen (Statens Luftfartvaesen) whose kindly compiled meteorological data is also gratefully acknowledged. Constructive criticism and improving suggestions in preparing this paper were received from H. Thing and the late R. Gessain, while valuable advice regarding the statitical treatment of data was obtained from N. Börsken.

References

Alendal, E. (1976): The muskox population (Ovibos moschatus) in Svalbard. — Norsk Polarinstitutt Årbok 1974: 159—174.

Barrett, M. W. (1982): Distribution, behavior and mortality of pronghorns during a severe winter in Alberta. — J. Wildl. Mgmt. 46 (4): 991—1002.

Bobek, B. (1977): Summer food as the factor limiting roe deer population size. — Nature 268: 42—49.

Caughley, G. (1976): Plant herbivore systems. — In: R. M. May, ed., Theoretical ecology: Principles and management, 91—113, Oxford.

Degerbøl, M. (1935): Animal bones from King Oscar Fjord region in East Greenland. — Medd. Grønland 102 (2): 93—97.

Elander, M. (1987): The Wolf (Canis lupus) in Greenland. A historical review and present status. — Arctic (in press).

Ferns, P. N. (1977): Muskox abundance in the southern part of the range in East Greenland. — Arctic 30 (1): 52—60.

Formozov, A. N. (1964): Snow cover as an integral factor of the environment and its importance in the ecology of mammals and birds. — Boreal Institute Occ. Publ., Univ. of Alberta, Edmonton.

Freemann, M. M. (1971): Population characteristics of muskoxen in the Jones Sound Region of the North West Territories. — J. Wildl. Mgmt. 35 (1): 103—108.

Grauvogel, C. A. (1984): Muskoxen of northwestern Alaska: Transplant success, dispersal, and current status. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 57—62, Fairbanks.

Gray, D. R. (1973): Social organization and behaviour of muskoxen. — Unpubl. Ph. D. thesis, Univ. of Alberta, Edmonton.

Gunn, A. (1984): Aspects of management of muskoxen in the North West Territories. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 33—40, Fairbanks.

Gunn, A., Decker, R. & T. W. Barry (1984): Possible causes and consequences of an expanding muskox population, Queen Maud Gulf Area, North West Territories. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 41—46, Fairbanks.

Haeffner, H. & R. Muri (1978): Methodology of snow mapping from satellites. — Proceedings of Int. Symp. on Remote Sensing for Observation and Inventory of Earth Resources and the Endangered Environment 3: 2357—2371.

Hall, A. B. (1964): Muskoxen in Jameson Land and Scoresby Land. — J. Mammalogy 45: 1—11.

Henrichsen, P. (1982): Population analysis of Muskoxen, Ovibos moschatus based on the occurence of dental anomalies. — Säugetierkunde Mitt. 30: 260—280.

Hubert, B. (1977): Estimated productivity of muskoxen on Truelove Lowland. — In: L. C. Bliss, ed., Truelove Lowland, Devon Island, Canada: A high arctic ecosystems 467—491, Edmonton.

Jennov, J. C. (1945): Moskusoksebestanden i Nordostgrønland og nogle spredte iagttagelser og betragtninger verdrörende dyrlivet i Nordostgrønland. — Nordostgrønlandsk Fangstkompagni Nanok, København, 128 pp.

Jingfors, K. T. (1980): Habitat relationships and activity patterns of a reintroduced Alaskan muskox population. — Unpubl. M. S. Thesis, Univ. of Alaska, Fairbanks.

Kempf, C., Piantanida, A. & B. Sittler (1982): Rapport scientifique de l'expédition 1979 au Groenland (Traill Ø, Côte Nord Est). — Groupe de Recherches en Ecologie Arctique, Rombach, 104 pp.

Klein, D. R. & H. Staaland (1984): Extinction of Svalbard muskoxen through competitive exclusion: An hypothesis. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 26—31, Fairbanks.

La Perriere, A. & P. Lent (1977): Caribou feeding sites in relation to snow characteristics in Northeastern Alaska. — Arctic 30 (2): 101—108.

Lassen, P. (1984a): Muskox distribution and population structure in Jameson Land, Northeast Greenland. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 19—24, Fairbanks.

Lassen, P. (1984b): Aktivitetsstudier in: Moskusokseundersøgelser i Jameson Land 1983. — Grønlands Fiskeri og Miljøundersøgelser — Vildtbiologisk Station, Kalö, 67—91.

Mech, L. D., McRoberts, R. E., Peterson, R. O. & R. E. Page (1987): Relationship of deer and moose populations to previous winters' snow. — J. Animal Ecology 56: 615—627.

Parker, G., D. C. Thomas, D. C. E. Broughton, E. & D. R. Gray (1975): Crashes of muskoxen and Peary caribou populations in 1973—74 on the Parry Islands, Arctic Canada. — CWS Prog. Note 56, 10 pp., Ottawa.

Patterson, E. A. (1984): Sightings of muskoxen in Northern Scoresby Land, Greenland. — Arctic 37 (1): 61—63.

Pedersen, A. (1936): Der grönländische Moschusochse Ovibos Moschatus Wardi Lydekker. — Medd. Grønland 97 (7) 82 pp.

Pedersen, A. (1942): Säugetiere und Vögel. Dansk Nordostgrønlands Expedition 1938—39. — Medd. Grønland 128 (2), 119 pp.

Petersen, H. (1938): Das Klima der Küsten von Grönland. — In: H. Köppen & W. Geiger, eds., Handbuch der Klimatologie. Bd. II, Teil K, Berlin.

Pruitt, W. O. (1959): Snow as a factor in the winter ecology of barren ground caribou. — Arctic 12 (3): 159—179.

Reimers, E. (1982): Winter mortality and population trends of reindeer on Svalbard, Norway. — Arctic & Alpine Res. 14 (4): 295—300.

Reynolds, P. E. & D. E. Ross (1984): Population status of muskoxen in the Arctic National Wildlife Refuge, Alaska. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 63, Fairbanks.

Sittler, B. & C. Kempf (1984): Activity pattern of muskoxen during continuous summer daylight in North East Greenland. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 101—104, Fairbanks.

Skogland, T. (1978): Characteristics of the snow cover and its relationship to wild mountain reindeer (Rangifer tarandus tarandus L.) feeding strategies. — Arctic & Alpine Res. 10 (3): 569—579.

Sørensen, T. (1941): Temperature relations and phenology of the North east Greenland flowering plants. — Medd. Grønland 125 (9). 305 pp.

Spencer, D. L. & C. J. Lensink (1970): The muskox of Nunivak Island, Alaska. — J. Wildl. Mgmt. 34 (1): 1—15.

Smith, T. E. (1984): Population status and management of muskoxen on Nunivak Island, Alaska. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 52—56, Fairbanks.

Tener, J. S. (1965): Muskoxen in Canada. — Can. Wildl. Serv. Monog. 2, Ottawa, 116 pp.

Thing, H., Henrichsen, P. & P. Lassen (1984): Status of the muskox in Greenland. — In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 1—6, Fairbanks.

Thing, H. (1984): Food and habitat selection by muskoxen in Jameson Land, northeast Greenland: A preliminary report. In: D. R. Klein, R. S. White & S. Keller, eds., Proceedings of the first international Muskox Symposium, Biol. Pap. Univ. Alaska. Spec. Rep. 4, 69—74, Fairbanks.

Thomas, D. C., Miller, F. L. Russel, R. H. & G. R. Parker (1981): The Bailey Point region and other muskox refugia in the Canadian Arctic. A short review. — Arctic 34 (1): 34—36.

Vibe, C. (1958): Muskox in East Greenland. — Mammalia 22: 168—174.

Vibe, C. (1967): Arctic animals in relation to climatic fluctuations. — Medd. Grønland 170, 101 pp.

Webber, P. J. (1974): Primary production of tundra. — In D. Ives and R. G. Barry, eds., Arctic and alpine environments, 445—474, Boulder.

White, R. G., Bunnell, F. L., Gaare, E., Skogland, T. & B. Hubert (1981): Ungulates on arctic ranges. In: L. C. Bliss, O. W. Heal and J. J. Moore, eds., Tundra ecosystems: a comparative analysis, 397—483. Edmonton.