WILDLIFE MANAGEMENT BULLETIN

DEPARTMENT OF NORTHERN AFFAIRS
AND NATIONAL RESOURCES
DEVELOPMENT SERVICES BRANCH
CANADIAN WILDLIFE SERVICE

SERIES 1 OTTAWA NUMBER 9

FEBRUARY 1954

CANADA

DEPARTMENT OF NORTHERN AFFAIRS
AND
NATIONAL RESOURCES

NATIONAL PARKS BRANCH

CANADIAN WILDLIFE SERVICE

A PRELIMINARY STUDY OF THE MUSK-OXEN OF FOSHEIM PENINSULA, ELLESMERE ISLAND, N.W.T.

by

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Issued under the authority of
The Minister of Northern Affairs and National Resources

Ottawa

1954

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INTRODUCTION

Much has been written by both popular and scientific writers about the musk-ox (Ovibos moschatus subsp.) of Canada and Greenland; but while the reports contain valuable data, very few investigations have been made to determine and study the many factors influencing the populations of specific areas. These factors are important from an administrative point of view, as they must be known before the herds of musk-oxen throughout the Canadian Arctic can be managed wisely.

With this in mind, the Canadian Wildlife Service, Department of Resources and Development, Ottawa, initiated an investigation of the musk-oxen of Canada. It was decided that aerial surveys of areas where musk-oxen were known to exist, combined with ground studies in regions where they were believed to be abundant, would be made in order to provide the information necessary for management purposes. Reports of a large number of these animals on Fosheim Peninsula, Ellesmere Island, Northwest Territories, led to the choice of that area for study in the spring of 1951. The author was assigned to the project.

Arrangements were made by the Northern Administration Division, Department of Resources and Development, Ottawa, with the Meteorological Service of the Department of Transport, Toronto, and the United States Weather Bureau, Washington, D.C., for the transportation of the author with his equipment from Ottawa to Slidre Fiord, Ellesmere Island, and for partial accommodation and food while there.

The author left Ottawa March 26, 1951, and after stops at Goose Bay, Labrador, Frobisher Bay, Baffin Island, and Resolute Bay, Cornwallis Island, arrived at Slidre Fiord on April 19.

Field investigations began immediately and continued except for interruptions caused by bad weather until August 20, when word was received that it would be necessary to return on an icebreaker. The ship left Slidre Fiord on August 24 and reached Boston on September 4.

HISTORY AND RANGE OF MUSK-OXEN

Perhaps no animal is of greater interest in mammalian ecology and systematics than the musk-ox. Existing under harsh environmental conditions, it has characteristics of both the genera Ovis and Bos, but belongs to neither.

The droppings, hairy muzzle and shorter left sac of the reticulum of the musk-ox are similar to those of the sheep, while characteristics such as the absence of the midfissure of the lip, an unusually large number of cotyledons in the placenta, and the presence of four mammary glands, indicate a relationship to cattle (Lonnberg (32)). The closest living relative is considered by Osgood (37), Allen (2) and Seton (46) to be the bison.

During Pleistocene times, ancestors of existing musk-oxen ranged over northern Europe, northern Asia, and North America from Alaska south to Iowa, Indiana, Pennsylvania, and Kansas (Allen (2), Hone (23)). As the ice retreated during the passing of the last ice age, musk-oxen moved northward in order to stay in the environment to which they were successfully adapted. Certain contemporary animals, such as the mammoth and woolly rhinoceros were unable to survive in changing climatic conditions and became extinct, but lemmings, ptarmigan and others were able to move north with the musk-oxen and still coexist with them.

Musk-oxen became extinct in Europe and Asia in prehistoric times. Hone (23) considers that the northern extension of land in the Western Hemisphere, creating conditions favourable for musk-oxen, is the principal reason for their existence in North America and Greenland today.

The first account of musk-oxen observed in North America was published in 1720 by Nicolas Jérémie, a French officer in charge of Fort Bourbon on the west coast of Hudson Bay from 1697 to 1714 (Allen (2)). In his time musk-oxen probably existed from Hudson Bay to Alaska, north of the tree-line to the Arctic Ocean, as well as on many of the islands of the Arctic Archipelago.

Evidence obtained by Allen (1) and Hornaday (25) indicates that musk-oxen died out in Alaska about the middle of the 19th century. On the Canadian mainland and on certain Arctic islands the numbers and range of musk-oxen have been seriously reduced because of indiscriminate killing by natives equipped with modern weapons and by whalers and early explorers who killed great numbers for food and bedding. Preble (42) has given an account of their range during the period of their reduction. The present range is confined to part of the Arctic mainland of Canada, certain Arctic islands, and northern Greenland. On the Canadian mainland herds are known to exist in the Bathurst Inlet area, the Thelon Game Sanctuary, and the region between Wager Inlet and Boothia Peninsula. The principal Canadian Arctic islands known to support herds are Prince Patrick, Melville, Bathurst, Axel Heiberg, and Ellesmere. The distribution and status of herds in Greenland have been well recorded by Hone (23).

PREVIOUS INVESTIGATIONS IN STUDY AREA

The musk-oxen (Ovibus moschatus wardi) of Fosheim Peninsula have had certain aspects of their vital statistics recorded by previous investigators, who were in the area for a period of 24 hours or less. Kelsall (30) reported the number of calves he observed in 1948 during a helicopter flight over part of the range. Lawrie (31) recorded the results of an extensive flight in 1950 over most of the summer range.

GEOGRAPHY AND CLIMATE

Geography

Fosheim Peninsula lies on the west coast of Ellesmere Island, Northwest Territories. It is bordered on the north by Greely Fiord and on the west and south by Eureka Sound, and contains an area of about 2,000 square miles. Slidre Fiord penetrates the peninsula from the west and lies close to the intersection of latitude 80° N. with longitude 86° 36' W. Figure 1 is a map of the fiord and surrounding district. An area of 450 square miles was covered during the investigation.

Slidre Fiord is 16 miles long and averages 2½ miles in width. At the mouth of the fiord on the north side and parallelling Eureka Sound is a low, narrow coast range of hills. A broad, deeply transected plain extends east of the range to a 3,000-foot escarpment of intrusive rocks of dolerite overlapping

sandstone, known as Black Top Ridge. The plain continues north to Greely Fiord, but is penetrated on the west by hills continuous with the coast range. Eastwind Lake lies in a depression between Black Top Ridge and the hills to the west.

Two streams having extensive drainage flow from the plain and empty into Slidre Fiord. They have cut deep, wide valleys and several of their lateral tributaries have also cut deeply into the plain. The western stream is known as Station Creek and the stream paralleling Black Top Ridge has been named Black Top Creek. The slope rising from the fiord is rock, greatly eroded and weathered.

The relief of the plain is that of level-bedded sedimentary rocks which appear to have a relatively thin cover. Much of the surface is clay partly covered with small, stone, surface erratics. Bedrock outcrops of sandstone occur here and there and are greatly eroded. Marine shells of several genera are present at elevations from sea level to over 300 feet, suggesting that the entire plain was under water during early times. Lateral terracing on slopes near the eastern end of Slidre Fiord in also evidence of this.

From the south shore of the fiord a plain rises to 250 feet. It is bounded on the east by a mesa-type formation of sandstone rising to 750 feet, and on the south by Eureka Sound.

From the eastern end of Slidre Fiord a broad plain extends to a mountain range 30 miles inland. The plain extends northeast of Black Top Ridge towards Greely Fiord and southerly towards Eureka Sound. Extensive sand flats at the eastern end of the fiord are intersected by the deep channel of Slidre River and its braided mouth. This is the only river in the district known to run all summer. The other rivers dry up toward the end of July. Romulus Lake lies to the southwest of the mouth of Slidre River. It has a rock bottom, is deep, and has no emergent or aquatic vegetation. Salt flats extend on each side of the stream that runs from the lake into Slidre Fiord.

The action of permafrost has created polygons of varying sizes and depths throughout the peninsula. The larger ones are up to 50 feet in diameter and smaller ones 10 to 15 feet in diameter are relatively frequent. Hummocks are common and give a very rough surface to much of the plain. As a rule they are covered with vegetation.

The extremes of high and low tide in Slidre Fiord are not more than 18 inches apart. The tidal action, however, is sufficient to cause shore leads late in June by breaking up the ice along the shore. The fiord water was found to have a salt content of 3.5 per cent and an average surface temperature in July of 35° F.

Climate

The climate of Fosheim Peninsula is influenced by the Ellesmere Island icecap to the north and east and by the Arctic Ocean to the northwest. The effects of the latter are modified by the land mass of Axel Heiberg Island, which lies between the ocean and the peninsula.

Winter at Fosheim Peninsula begins in September and most of the snow of the season falls in early winter. After November the weather is usually calm, clear and cold, but blizzards occur occasionally. Prevailing northwest

winds usually clear much of the snow from slopes and hilltops, filling gullies and hollows. Until late in May the windblown snow is very hard and will support animals and vehicles.

The period of constant darkness begins October 22 and lasts until February 20. Ice on the fiord reaches a depth of eight feet by the end of April.

There is sunlight for 24 hours a day from April 15 to the end of August. In May increasing warmth and the tidal action cause cracks to appear in the ice, often running transversely right across the fiord. Late in that month snow begins to melt on slopes with southern exposure. By the middle of June the temperature may reach 50° F. and run-off is at a maximum, filling streams to overflowing. Shore leads in the fiord open at this time and by the end of June are wide enough to permit canoe travel. The ice at the eastern end of the fiord breaks up early in July and the whole fiord is clear by the first of August. Temperatures in July and early August may range from 33° F. to 66° F.

By late August the temperature again begins to drop below freezing and new ice forms along the shore. The fiord is frozen completely across by the middle of September.

Temperatures recorded at Slidre Fiord from January, 1948 to July, 1951, are listed in Table 1.

Precipitation on the peninsula is light, an average of 1 7 inches per year having been recorded for the four years previous to 1951. Summer storms yield little rain and most of the precipitation is in the form of snow in early winter. Records of abnormally wet years may be the result of unusually severe storms or series of such storms.

STATEMENT OF PROBLEM

There is available little objective information about the behaviour of any population of large ungulates living under Arctic conditions. The musk-ox is a unique animal, well adapted to Arctic conditions and inhabiting a range extending north and south for 1,200 miles. Even in the relatively uniform climate of the Arctic regions, life circumstances can be expected to vary considerably over so great a latitudinal range.

It is well known that the productivity of a species varies from region to region with the environmental resistance to the animal. At the same time, beyond the critical level of environmental tolerance, the influences tending to stabilize any population vary directly with the density of that population.

This study was conducted on one of the world's most northerly land masses and was concerned with the most northerly population of large ungulates except that of Greenland. For this reason it was believed that it offered unique research opportunities. Studies of vital statistics, environmental resistance in terms of food production, predators, parasites and diseases, accidents, and climatic influences all promised to yield information of the greatest theoretical interest, and of paramount importance in the management of the musk-ox population.

Observations of the proportions of sex and age classes in herds, along with observations of calving and mating behaviour, were required to determine the present status of the population of musk-oxen on Fosheim Peninsula, and to attempt to educe the principles governing apparent low rates of increase in musk-oxen generally. The ratios of calves, yearlings, and immatures to adult cows would indicate the birth rate and effective reproduction, and hence the trend in numbers of the musk-ox population.

The ratio of adult bulls to cows was considered to be significant in relation to the successful breeding of cows. Reasons for an unbalanced sex ratio in adult mammals may vary for different species and for different populations of the same species. An unbalanced sex ratio at birth, greater mortality of one sex during life, or deferred maturity of one sex, may create such an unbalance. Information on this ratio throughout the study period, therefore, was needed.

Feeding habits and range requirements of musk-oxen were known imperfectly since past investigators had not made statistical treatment of the composition and density of the common plants growing on summer ranges. Data obtained by analysis of such statistics, correlated with quantitative determination of food choice by observation and by stomach examinations, were needed to to indicate the food requirements and range preference of musk-oxen on Fosheim Peninsula.

Winter and summer ranges of most ungulates may be different geographic areas, and these may often have different food species. It was desirable, therefore, to note and record the characteristics of the range and movements of the animals from winter to summer range.

Determination of the factors resulting in mortality of musk-oxen is of particular significance since their rate of population increase is so low. In particular, the effects of wolf predation and mortality of bulls fighting for cows needed study.

In summary, the lack of factual information on certain phases of the life history of musk-oxen left a hiatus in knowledge that had to be filled before plans for their careful management could be formulated. This report is a record of the attempt to provide some of the necessary information.

PROCEDURES, METHODS, MATERIALS

Equipment

Equipment for the investigation included camping gear, clothing, and food appropriate to Arctic conditions. Scientific equipment included a pair of 10 x 35 binoculars, three cameras, dissecting kit, alcohol and formaldehyde, vials and bottles of several sizes, plant press with paper, tape measures, 64-ounce and 100-pound scales, and paper bags of one, two, and five pound sizes, as well as equipment necessary for other wildlife investigations conducted concurrently with the musk-ox study.

Facilities in the laboratory of the Canadian Wildlife Service at Ottawa were used for examinations of the scats of foxes and wolves.

Herd Observations

Many observations of musk-oxen were made on short field trips from the station from April 19 to August 20, but most of the data were gathered while working out from field camps.

On several occasions the author was accompanied by dogs when herds were studied. The musk-oxen would form a characteristic defence group upon sighting the dogs, and would retain it until approached to within 50 feet or even less. This made it possible to distinguish the sex and age of most of them.

In most cases dogs were not present and the musk-oxen would often run if approached nearer than 100 yards. Binoculars were then used to clarify necessary details.

Sex identification of adults was based in all cases upon horn structure, as stated in Allen (2). The method of urinating confirmed identification in many cases. The horns in adults of both sexes sweep down, out, and up; but those of the male are thicker and longer than those of the female. According to Allen (2) and Pike (41), they nearly unite on the forehead in the sixth year to form a massive basal expansion used in fighting for mates, and in defense of the individual or herd. Horns of adult females are shorter and more slender, and do not unite over the forehead but are separated by hide and hair.

The sex of immature animals is difficult to determine. Confusion exists in regard to animals up to three years of age, although in the second year the horns of bulls are whiter and project more nearly straight from the head than those of females. This characteristic was used in some cases by the writer, but he did not feel justified in using it in most cases because of elements of doubt regarding relative horn sizes.

The ages of sexual maturity of cow and bull musk-oxen have not been definitely established. Hoel (21) and Pedersen (40) concluded from their observations of adults raised from calves in captivity, that both sexes matured at three or four years of age; but Jennov (26) believed that the males were not mature until six years of age, or when the massive horn development over the forehead is complete.

During the present study all bulls observed contending for mates, in possession of herds, or mating with cows had fully developed horns. It was not known whether the younger bulls were not participating in mating activities because of immature development of sex organs, or because they were unable to contend successfully with fully developed bulls who had greater experience in fighting.

In view of the fact that all the bulls active in mating had complete horn growth, this characteristic was diagnostic in classifying the male adults.

Determination of the age of female musk-oxen at sexual maturity is more uncertain. Young (52) states that a female musk-ox does not breed until four years of age. Cows with calves observed during the present study all had horns characteristic of Allen's group of females in their fourth year and older. Like the bulls, older females were greyer in general colour and darker in horn

colour than young females. For purposes of the study, females were considered to be adults if the basal depression of their horns had reached the maximum, almost touching the jaw, and if the apical portions of the horns were curved upward and out. This occurs during the fourth year of life.

Immature animals were distinguished by incomplete horn development and smallness of body size. Yearlings of both sexes have small straight horn projections; in the males the length of the horn sheath is probably about 100 mm. and in the females about 60 mm., as Allen (2) found that at 18 months, males had horn sheaths about 165 mm. in length, and females had sheaths about 110 mm. in length.

The identification of calves presented no difficulty.

Card records were kept of each herd seen. Where possible, using the criteria explained above, musk-oxen were recorded in four age groups; adults, immatures, yearlings, and calves. Adults included bulls six years and older and cows four years and older; immatures were two-, three-, four-, and five-year-old bulls and two- and three-year-old cows; yearlings were one-year-old animals of both sexes; and calves were animals of both sexes born in 1951.

Animals not classified for age and sex were recorded either as adults or as immatures and adults. Herd movements and composition; calving data; feeding habits of adults and calves in late winter, spring, and summer; defensive action of bulls and cows against wolves, dogs, and man; fighting between bulls; actions of herds during rut; post-rutting activity; and other observations were recorded on the cards or in field note-books.

On August 24, a brief survey of herds in the Eastwind Lake region was made by helicopter. One hour was spent in covering 150 square miles of musk-ox range, in order to obtain data comparable to those obtained in 1950 by Lawrie (31), and in order to make a final check on the study population.

Pathological Studies

One musk-ox, a two-year-old male, was collected under permit July 29, for pathological examination and for record purposes of the National Museum of Canada. Examination for external parasites was made, and stomach and intestines were searched for internal parasites. Labelled vials and jars containing a 10 per cent solution of formaldehyde were used to preserve the parasites, which were sent for identification to Dr. L.P.E. Choquette, Institute of Parasitology, MacDonald College, Quebec.

Mortality Studies

Records of musk-oxen found dead on the range were kept and the lower mandibles of most skulls were retained for tooth measurements to be made later in the laboratory. Foxes and wolves had fed on all the dead animals found and this excluded the possibility of obtaining much useful information from the carcasses. Some facts were obtained concerning location, approximate

age, sex, possible cause of death, and length of time since death. Many of the animals had been dead several years, and the slow rate of decomposition of organic matter in high latitudes made determination of the year of death very uncertain in such cases.

Wolf scats were picked up on the winter and summer ranges of the musk-oxen and were later analysed for their contents. Three wolves were collected and the contents of their stomachs were examined. One observation of wolves attacking a herd of musk-oxen was recorded.

Range Studies

Determinations of composition, frequency of occurrence, and density of plants growing on spring and summer ranges of musk-oxen were made on the plain north of Slidre Fiord from July 19 to 27.

Plants were collected throughout the study area, but special attention was paid to the spring and summer range. The plant material was pressed, dried and labelled. The collection of 114 specimens of 64 species was submitted to A.E. Porsild, Chief Botanist, National Museum of Canada, who identified the specimens and deposited the collection in the National Herbarium.

In most instances, vegetation was so sparse that visual estimation of percentage occurrence, or of area covered by any given plant, was considered to be too inaccurate. The Clarke Point Sample Method (8) was used to determine the frequency of occurrence of vegetation growing on the musk-ox range which extended over the valleys of Black Top Creek and Station Creek, and the plain between the two valleys. Ten thousand points in 1,000 quadrats were taken 50 yards apart on parallel transects running transversely across the river valleys. The positions of the transects, which were 500 yards apart, are indicated in Figure 1. The transect area involved two square miles of range, representing types of habitat varying from dry hills and plains to moist river beds and slopes.

To ascertain the area covered by the more numerous plants, 200 quadrats, each 10 feet square or 100 square feet in area, were laid out and studied in conjunction with the point sample studies. The quadrats were 100 yards apart on Transects 2 and 4 in the Black Top Creek valley, and on Transects 11 and 12 in the Station Creek valley, with 100 in each valley. A one square foot frame, 1 per cent of the quadrat area, was used to determine the area of ground covered by each species. The frame was placed over a plant in the quadrat and the amount of space occupied by the plant could then be expressed as a percentage of the total area studied.

Observation of Feeding Habits

Two methods were used to ascertain what species of plants were eaten by musk-oxen during late winter and early summer months. When possible a record of the number of minutes an animal fed on each plant species was kept. These minute counts were made with difficulty because of the scarcity of food plants and even more so by the musk-ox habit of nibbling here and there as they walk.

The second method of determining food species was the examination of the stomach contents of a two-year-old male collected July 28, on the summer range where quadrat studies were conducted.

RESULTS OF INVESTIGATION

Composition of Herds Throughout Study Period

During April and May, 1951, herds of musk-oxen were scattered usually five to 10 miles apart, over their winter range on the south shore of Slidre Fiord and north of Eastwind Lake to Greely Fiord. Once a favourable feeding area had been found, the herds generally remained there for several days, and this facilitated observation of them. Some herds were too distant for the author to do more than obtain a total count and determine whether calves were present. For example, on April 21, 18 miles were walked in temperatures from -27° to -10° F. to examine a herd at close range and obtain data upon it. On that day four other herds were seen, but all from five to eight miles away, too far off to determine their composition. A census of two of these herds was taken on April 25, but in the other two only the number of calves was determined.

During April and May, most herds contained two or more adult bulls. A herd composed solely of bulls was noted only once in this period. From June 1 to August 15, five of 16 herds had two or more bulls and, 11 herds had only one. Twenty-six additional bulls were observed in the area at the same time: 14 were solitary animals and the remainder were in three groups of two, four, and six, respectively. In some cases the solitary bulls were five to 10 miles from the nearest musk-oxen but in most instances they were within two miles. The solitary bulls were restless feeders, and ate only small amounts of vegetation while walking across the range. Only two herds in which no bulls were present were noted during the summer.

It is believed that before June 23 no animals in any herd were recorded more than once. Until that date all herds examined were observed carefully for movement and possible change in number. The data obtained could, therefore, be compiled for analysis since they were unlikely to contain duplications. These data are included in Table 2 which refers to herds in which the sex and age of all or nearly all the animals were identified.

Adults

For the period April 19 to 25, the sex ratio of adults was 1:2.1, or seven bulls to 15 cows; for May 17, 18, and 26 the ratio was 1:2.1, or eight bulls to 17 cows; and for June 20 it was 1:4, or eight bulls to 32 cows. The sex ratio of all adults recorded from April 19 to June 23, inclusive, was about 1:2.2, or 36 bulls six years of age and older to 78 cows four years of age and older. This ratio includes solitary bulls as well as animals in herds.

Immatures

As it was not possible to age with accuracy immature musk-oxen other than yearlings and calves, they were classed in one age group - the immatures. This group probably was composed of two- and three-year-old females and two- to five-year-old males. Ten of 17 herds noted between April 21 and June 23 contained one or more immatures, a total of 26 in all. The ratio of immatures to adult cows during this period was 26:78, or 1:3.

Yearlings

Only three yearlings were recorded during the course of the summer. These were observed on June 20 in the valley of Black Top Creek, and were in three herds, two of which contained no calves.

The significance of, and possible reasons for, the proportions of the age and sex classes determined for the herds observed throughout the study period are considered in the section Discussion of Results.

Proportion of Calves in Herds

The ratio of calves to cows in herds where all or nearly all the animals were sexed and aged is included in Table 2. Table 3 summarizes the data regarding the number of calves observed by Kelsall (30) in 1948, by Lawrie (31) in 1950, and during the study period in 1951, having regard only to those groups in which all or a random sample were sexed and aged.

Although the samples were small, the ratio of calves to cows obtained throughout the summer was fairly constant. An exception was noted during the height of the calving season in May, when a high proportion of calves was found. During late June and August the calf to cow ratio was nearly the same: about two calves to nine cows.

In considering the percentage of calves in the total population, the period June 3 to June 23 is the only one considered to be significant, as earlier observations were made during the calving season. The percentage of calves for that period, 10.7 per cent of the total number of animals in the herds, or 19.6 per cent of the number of adult cows, is believed to be an accurate indication of the productivity of musk-oxen on Fosheim Peninsula at the end of the calving season. The lower percentage found in the aerial count two months later may have been partly the result of calf mortality during the intervening period and partly of the difficulty in counting calves accurately from the air.

Two counts made from a helicopter were large enough to be comparable. The survey conducted by Lawrie (31) on August 25, 1950, showed that 32, or 7.7 per cent, of 413 animals counted on about 300 square miles of range, were calves. A smaller survey made on August 24, 1951, by the author, showed that nine, or 6.9 per cent, of 131 animals counted on 150 square miles of the same range were calves. Both aerial counts included the Eastwind Lake area, a preferred musk-ox range.

The implications of the calf ratios are examined in the section Discussion of Results.

Observations of Calving

Calving by musk-oxen on Fosheim Peninsula during 1951 occurred between April 15 and June 15. Most calves appeared to have been born between the last week in April and the end of May.

Temperatures in the months of April, May, and June are included in Table 1. From April 19 to 25 the temperature ranged from -27° to 10° F. Clear skies and light winds prevailed during that week, and the first 25 days of the next month. At the end of this period - May 25 - temperatures had risen to the

freezing point and by June 15, the end of the calving season, they had been as high as 45° F. It is apparent that early calves are subjected to more rigorous conditions than those born in the last month of the calving season.

Calving had commenced shortly before the writer arrived in the area on April 19, as two calves estimated to be less than 48 hours old were observed on that day in a herd of 14 adults and immatures on the south shore of Slidre Fiord.

On April 25 a newly born calf was found with a small herd of three cows and one mature bull. This herd was two miles inland from the south shore of the fiord, on a slope from which the wind had removed much of the snow and exposed grasses, willows and other vegetation. The calf was very unsteady on its feet, but was able to walk short distances to follow the grazing cow. Upon one occasion, the calf nuzzled the cow in the region of the udders but it did not feed. Throughout the period of observation the calf remained close to the cow whose hindquarters were partially covered with frozen blood.

Three other herds of five, eight, and 18 individuals, respectively, were noted the same day. The last herd contained one young calf, the other two herds, none.

In two herds at the end of the fiord the five calves present on May 17 were estimated to be two to three weeks old. The calves nibbled dried grasses and ran about actively.

There were no calves present in two herds sighted five miles north of Eastwind Lake on May 5. Calves were first noted on the north shore of the fiord on June 3. On June 14, 20, and 23, there were calves in nine herds grazing in the valley of Black Top Creek. Nine of these calves were well developed and were probably four to six weeks old, but one calf recorded June 20 was estimated to be no more than one to two weeks of age. This calf was in a herd which also included six cows, one bull, one yearling and another calf about six weeks old. No other late-born calves were noted.

It was not possible to sex calves because of the herd protection given them, but observations of the method of urinating showed that both sexes were present.

There was no evidence to suggest that cows seek a solitary spot to bring forth calves. All cows observed during the calving months of April, May, and early June were in herds. None was alone or with only other cows or immature animals. The protection given by the herd would be of value to a cow and her calf during the critical period of birth.

Cows that had given birth to calves shed their hair later than other adults. At the end of June the inner wool of most of these cows was just beginning to shed, patches of loose hair clinging to their humps. The generally sleek appearance of these animals was in marked contrast to the patchy appearance of other adults whose shedding was well advanced.

Calves appeared to begin feeding on vegetation a few weeks after birth. Five calves noted eating dried grasses on the south shore of the fiord on May 17, were believed to be two to three weeks of age. In

June calves fed extensively on plants, but were also obtaining milk from cows. This also appeared to be the case in July and August, during the mating season.

During the summer months, calves romped frequently, running and whirling in circles, stiff-legged and with head flung up. Even when playing, however, they stayed near the herd, and particularly close to their mothers.

Mating Activities

The gestation period of the musk-ox cow is thought to be about eight months, about the same as that of the buffalo cow. A calving date in late April, in May, and possibly in early June would place the date of conception in July or August. Observations of mating in early August support this conclusion. On August 5, a bull was seen to mate with a cow in a small herd near Eastwind Lake. There were two other cows, two calves, and four immature musk-oxen in the herd, but no yearlings. On August 12, in a herd of 14 in the same vicinity, a bull served a cow.

Fighting between bulls for the possession of one or more cows occurred chiefly during the summer months of June, July, and August, but was observed twice in May. On May 17, three adult bulls were in a group about a mile from a herd of 14 animals on the south shore of the fiord. When first observed the bulls were lying down, but upon sighting the author, they immediately rose to their feet and ran off a short distance. Detecting no movement, two bulls ran a short distance farther, parallel to each other and about 25 feet apart, and, suddenly turning towards each other, met with a crash that was heard half a mile away. They repeated the action twice and then commenced grazing. The same bull appeared to be the aggressor in both cases. On May 26 a young, nearly matured, bull clashed once with an old bull. Both belonged to a herd of 14 animals.

Sporadic conflicts occurring well before the commencement of the mating season, such as those just described, are not considered to be significant in respect of dominance in the herd. There may be some desire on the part of a bull to dominate, but such fighting may be principally a response to certain stimuli in a behaviour pattern essentially related to the mating season.

In late spring and early summer bulls unsuccessful in obtaining mates generally left herds in which they had been tolerated during the winter months. Occasionally they herded together, but more frequently they roamed singly over the summer ranges. Late in June, as the breeding season approached, such bulls became aggressive and attacked bulls in possession of herds of cows. In nearly every case the dominant bull in a herd was old, and probably well experienced in fighting. At this time he was content to defend himself if attacked and to keep himself between an aggressive bull and the herd. When the breeding season was in progress, however, the slightest approach to a herd by an outside bull would result in conflict between the outside bull and the herd bull.

Typical examples of such behaviour were noted on several occasions.

On June 26 the actions of two herds in the valley of Black Top Creek were under observation for several hours. One herd of four adult bulls grazed past a herd consisting of one bull, six cows, two calves, and one yearling. One of the four adult bulls left the first herd and started grazing near the second herd. The defending bull placed itself between the intruder and his herd. For three hours all of the animals grazed quietly until the two bulls suddenly, as if at a given signal, met head on with a crash. The outside bull, being the aggressor, came to a position about 15 paces in front of the herd bull, and shaking his head once or twice, he twice charged the other, who stood still. The aggressor halted the first charge about two feet away from his antagonist, but he completed the second one. After the second charge, the two animals remained as they were for a moment, then turned slowly away to feed. The herd bull, after a short pause, turned suddenly on the herd and harried it for a distance, scattering the cows and calves. The intruding bull remained near the herd another hour and 20 minutes and then walked away toward Eastwind Lake.

The second type of behaviour, that of a bull defending his herd at the slightest provocation, was noted near Eastwind Lake on August 5. In this case the author and the geographer, P. Gadbois, were intruders. Upon the approach of the two men, the bull advanced for a short distance from the herd of 10 animals. He stopped, snorted, bellowed, extended his tongue, pawed the earth with his front hooves, and rubbed his nose on his forelegs and on the edge of the hole he had scooped in the ground. He then strode through the herd several times, occasionally snorting.

On August 11, a four-hour battle between two old bulls was fought near a herd of 17 animals in the valley of Black Top Creek. No wounds resulted from the conflict and the bull previously in possession of the herd was the victor.

Movements from Winter to Summer Ranges

The principal requirement of suitable musk-ox winter range is an area such as a slope, or the top of a ridge, or a plain, where prevailing winds keep snow depths at a minimum, and where grasses and other foods are sufficient. A secondary requirement is a refuge, such as a gully, for use during blizzards and periods of sub-zero winds. Fresh water and green vegetation appear to be the chief requirements of the summer range.

On the study area, winter and summer ranges of musk-oxen were 15 to 20 miles apart for some herds, and between five and 10 miles apart for others. In many cases the movement from winter to summer range was from high to low ground - from a windswept slope or plain to a wide valley below. In other cases the movement was horizontal, from a windswept plain where the supply of grasses, which had been adequate for winter forage, was reduced in quantity because of grazing, to areas where winter snow had protected vegetation from utilization, and where there was moisture enough for denser, more succulent growth.

During April and May musk-oxen were found on the slopes and plains of the south shore of Slidre Fiord, on the ridges at the eastern end of the fiord, and on the plains rising from the south shore of Greely Fiord.

These three areas satisfied the requirements for an adequate winter range. Where the animals were feeding, snow varied in depth from nil to 10 inches. Food in the form of dried grasses (Poa sp., Agropyron latiglume, Arctogrostis latifolia and Festuca brachyphylla), dryas (Dryas integrifolia), saxifrage (Saxifrage sp.) and other, less preferred, species were present in quantities large enough to enable the musk-oxen to remain in those areas for at least two months. Numerous gullies provided ample protection during inclement weather.

Individual herds travelled slowly during the movement from winter to summer range. Early in June, as snow was melting from the steep slopes, herds were noted leaving the plains on the south shore and at the end of the fiord, for the valley of Black Top Creek 15 miles away. Herds from Greely Fiord moved into the Eastwind Lake area at the same time.

On June 20, 55 animals in seven herds were grazing along a seven-mile length of Black Top Creek. They remained in the same neighbourhood until early in July and then moved toward Eastwind Lake. At that time streams were drying up and vegetation along the creek was not as dense or succulent as in the vicinity of Eastwind Lake and the ponds near it. On August 24, 131 animals, many in large herds, were counted by helicopter within a five-mile radius of the lake. The mating season was nearly finished and the formation of large herds was in accordance with the observations of other investigators.

The investigation of musk-oxen terminated on August 24, but it is believed that the herds moved to their winter ranges in September and October, as the snow of those months would cover all vegetation growing in the lake area to a depth of a foot or more. This snow depth, combined with exposure to blizzards and depletion of the range through grazing during July and August, would induce the herds to seek a more favourable habitat.

The evidence seems to show that the musk-oxen of Fosheim Peninsula are in no sense of the word migratory. It indicates that they are nomadic, grazing seasonally where conditions for the obtaining of food and shelter are most favourable.

Range Studies

Station Creek and Black Top Creek drain the plain extending from Slidre Fiord to Eastwind Lake. Soil formation and composition are similar, and vegetation was found to be uniform in the valleys of the two creeks. Grazing musk-oxen moved freely over the two valleys and the plain between them. Because of this uniformity in vegetation and utilization, the range has been considered as one unit in the analysis of the plant studies.

The most outstanding characteristic of this range is the very large proportion of non-vegetated ground. Gravel, rock, silt and clay together constitute 85.5 per cent of the area, and only 14.5 per cent of the area has vegetative cover.

Stream beds and small rock outcrops accounted for part of the unproductive area, and clay hillsides and hill tops, dry and eroding, were frequently barren. On the whole, however, the percentage of

vegetative cover was low because of scattered growth of plants in unfavourable climatic and soil conditions, not because of large barren areas.

Table 4 shows the per cent frequency of occurrence of the recorded plant species, and the per cent of the area covered by each of the species that had a frequency of occurrence greater than 1 per cent. It will be noted that Agropyron latiglume a preferred musk-ox food, occurred in only 0.72 per cent of the points examined. Of particular significance are the percentages of willow and grasses available for musk-ox food. As all grass species were eaten, their availability is considered to be a prime factor controlling the abundance of musk-oxen on Fosheim Peninsula.

Plants of greatest frequency of occurrence were not necessarily those covering the largest area. Those species of small basal area, the grasses and sedges, were less dense than willow and dryas. Nourishment provided by these latter species, per pound of plant, does not appear to be as much as that given by grasses, since the twigs and stems of the willow and the roots of the dryas occupy a large part of the total surface area covered by the plant.

Feeding Habits

The results of the timed counts of feeding musk-oxen are shown in Table 5. As previously mentioned, scarcity of food plants and the habit musk-oxen have of walking as they graze, made it virtually impossible to record the number of minutes an animal grazed on each plant species. For this reason four species of grasses, Poa sp., Agropyron latiglume, Puccinellia angustata, and Festuca brachyphylla that were found to have been grazed by musk-oxen, have been grouped in the table under one heading as grasses.

Consumption of dryas, willow, and saxifrage was not observed in April and May, but these species were utilized in summer months to some extent. Sedges growing on the borders of ponds and streams were usually grazed heavily when available. Grasses were the principal foods in April, May, and June. Although quantitative data were not obtained in July and August, observations of grazing during these months indicated similar utilization.

The conclusions reached from minute counts and other observations were substantiated by the examination of the stomach contents of a two-year-old bull musk-ox collected July 28, two miles north of Slidre Fiord, near Transect 1. Grasses made up the greater part of the contents, and willow and dryas, with a few plants of other species, such as Melandrium triflorum, made up the remainder.

In April and May, before the snow had melted, musk-oxen were feeding on slopes and hill tops where snow depth did not exceed 10 inches. By breaking the crust with their front hoofs, which are larger than their hind hoofs, and by pawing away the snow, and frequently pushing it away with their noses, the musk-oxen were able to obtain dried grasses and other plants.

In summer musk-oxen graze over a relatively wide area, partly because of the scarcity of suitable food. Grasses and willow grow in clumps often several feet apart. Much of the constant walking however, was due to other unknown causes, as many grass clumps were left untouched.

Herds often were seen to rest, before grazing, on an area with a good view of the surrounding country, usually an elevated slope or a hill. Musk-oxen that were lying down would get up occasionally, stretch, and then lie down again, often facing in a different direction. It seemed a general practice for the bull to rest 20 or 30 yards from the remainder of the herd. The bulls and cows sleep on their sides, occasionally with their heads stretched out in front of them and resting on their chins, but more often with their heads turned back to rest on their sides. While chewing their cuds the animals lie down in a normal position, with their chins low to the ground.

When grazing undisturbed, a herd usually spread out over an area of several hundred square yards; frequently individuals were 300 to 400 yards apart, but the entire herd would be moving in the same general direction. Upon several occasions individual cows or immature animals that had strayed farther from the herd than was customary, were seen to run to the herd immediately upon noticing their unusual situation.

Two types of droppings, shown in Figures 6 and 7, were found on the range. Round, hard caribou-like dung, was determined to be winter dung. The dry, coarse diet is believed to produce this type. Summer dung is softer and shaped like the dung of the domestic cow, and is a product of green, often succulent, vegetation. Examples of this type of dung were first noted on June 9. A herd of nine musk-oxen had been grazing on green grass shoots and on dried grasses of the previous summer in the valley of Station Creek. As two types of food were being eaten, the droppings were only partially of summer consistency.

Ponds and streams satisfied water requirements of musk-oxen from early June to the end of August. In winter, snow was eaten, a fact that has been recorded by MacFarlane (33), Richardson (44), and Bell (5). Several observations of snow being eaten were made in April and May, but the quantity consumed daily was not determined.

The mineral requirements of the ungulates under study are unknown. Some information was obtained from observations, and a collection was made on July 8 of the white soil on each bank of the stream flowing from Romulus Lake to Slidre Fiord. Results of the analysis of a sample of this soil, by the Department of Agriculture, Ottawa, are given below.

Calcium sulphate ($CaSO_4$)	0.374%
Magnesium sulphate ($MgSO_4$)	0.546%
Sodium sulphate (Na_2SO_4)	9.880%
Sodium chloride (NaCl)	5.590%
Organic matter (loss on ignition)	0.270%
Total	16.660%

Traces were present of Na_2CO_3 and a potassium salt.

Musk-ox tracks, and shallow, scooped-out pits were scattered over the surface of the patches of white soil, possibly indicating that musk-oxen ate the soil to satisfy their mineral requirement. Dung found in the vicinity of the stream was greyish and friable.

Cowan and Brink (9) have reported on the utilization by ungulates of salt licks in the Mountain National Parks of Canada. They found that the Artiodactyla of those parks used the licks during summer months and that this seasonal use, was, in part, based upon factors other than availability. Musk-oxen may utilize the lick under consideration in the same way, as, although much of the area was free of snow when visited May 17, there were no recent musk-ox tracks on or around the lick. It is probable that the soil was eaten in June by the herds that moved from winter grazing on the south shore of the fiord to summer grazing near Eastwind Lake.

Parasites

Careful examination of the two-year-old bull collected July 28 resulted in finding only one species of parasite, a tapeworm (Monezia sp.) in the small intestine. Five individuals of this species were present. No external parasites were found.

Mosquitoes were the only insects observed that may have bothered musk-oxen. Mosquitoes were observed only during a period of about 10 days to two weeks, in July, and may have been active in that period only on days that were warm and humid.

Mortality Factors

Wolf Predation. - Adult musk-oxen are particularly well adapted for defense against wolves, the only predator of these animals on Fosheim Peninsula. Sharp, heavy horns, nimble feet, powerful bodies, and the herd defence formation enable them to withstand most attacks.

The population of wolves (Canis lupus arctos) on the peninsula in past years is unknown. Verbal statements of their numbers and activities in the vicinity of Slidre Fiord had been received prior to this study from observers who had visited the area in 1950. These reports placed the wolf population at a high level, but observations in the field over a period of four months in 1951 led to the conclusion that if previous reports of a large wolf population were substantially correct the population had under gone a considerable reduction in numbers during the past year. No figures on past population sizes exists, but records of the numbers of wolves killed near the weather station since 1947 have been kept. Six were shot in the winter of 1947-48, about a dozen in the winter of 1948-49, six in the autumn of 1949, at least 12 during the summer of 1950, four during the winter of 1950-51, and three during the summer of 1951, a total of 43 wolves. The dogs at the station attract wolves to it.

Eleven observations of a total of 27 wolves were made during a four-month period in 1951. At least 15 wolves were involved. Most observations were of single or paired animals, but on August 20 a pack of three adults and nine young invaded the station area, nearly killing one of the dogs.

The data indicate that the population of adult wolves in the vicinity of Slidre Fiord during the summer of 1951 was not large, probably not exceeding 10 animals. Tracks were uncommon and, except in one case, were seen after a wolf had been sighted.

The analysis of 85 wolf scats picked up on the summer and winter ranges of musk-oxen disclosed that 70, or 83.3 per cent, contained

remains of Arctic hare (Lepus arcticus monstrabilis) and 15, or 16.7 per cent, contained remains of musk-oxen. Three wolf stomachs were examined: one collected June 29 was empty, one collected June 2 contained remains of Arctic hare, and one collected June 8 was partially filled with musk-ox hair and bones.

Further evidence of wolves eating musk-oxen was observed by Charles Handley in 1948. Kelsall (30) reported that Handley saw a pack of four adult and three young wolves attack an adult bull musk-ox August 29, 1948, near Eastwind Lake. One of the wolves was shot and an examination of its stomach contents revealed that the animal had been eating musk-oxen.

An observation of wolves attacking a herd of musk-oxen was recorded by the author on June 20, 1951. A herd of 14 musk-oxen that had been feeding undisturbed for several hours on the western slope of Black Top Ridge were seen to form a defensive group. Two wolves, one white and one grey were then noted lying down together 50 yards from the herd. Occasionally one of the wolves circled the herd and then returned to lie down. Eventually 10 of the musk-oxen lay down, while four remained standing facing the wolves. The calf in the herd kept close to the cows, grazing near the resting adults until the white wolf suddenly dashed around the four standing adults and toward the calf that was now outside the group of animals lying down. The calf immediately ran to the centre of the herd and all the musk-oxen rose to their feet. The one adult bull charged the wolf in an attempt to gore it but the wolf nimbly turned aside and trotted off to its mate. Both wolves left the vicinity about half an hour later, heading towards the eastern end of the fiord.

The remains of 28 musk-oxen were found in different locations during the study. Scats of wolves and foxes (Alopex lagopus groenlandicus) were found near each. Twenty-three were adults, of which 14 were bulls, seven cows, and two of undetermined sex. Five were skeletons of immature musk-oxen. The probable ages of 26 of the musk-oxen, determined by using criteria described by Allen (2), are listed in Table 6.

The causes of deaths of these musk-oxen can only be inferred. The skeletal remains had been scattered and often partially destroyed. Wild animals rarely die of old age and considering the relatively high wolf population on Fosheim Peninsula during the previous three years, it was concluded that many of the dead animals, including the five immature animals, were killed by wolves. The lone wandering of bulls increases their vulnerability to predation, and it is probable that if a pack of wolves encountered a lone bull, wounded or old, they would be able to kill it.

Mortality Through Fighting.—It is known that musk-ox bulls have killed or seriously wounded their opponents during the mating season. Hearne (19), Pike (41), Jensen (27), and others have discussed battles observed by them. Most of these battles occur in July and August but some have been reported by Jennov (26) to have occurred in February. Evidence of the violence of the fighting was found in 1951. Three skulls with broken horns, and one carcass that appeared to have cracked cervical vertebrae, were discovered. One skull was found with the horn on the left forehead broken through to the skull. This was the animal that had the cracked vertebrae.

No wounded bulls were recorded on the range examined during the study, but one old animal was noted to have lost his left horn from the level of the eye.

DISCUSSION OF RESULTS

The analyses of the composition of the herds throughout Fosheim Peninsula in 1951 bear out many of the observations of earlier investigators of musk-oxen in other regions.

Adult Sex Ratio

The observation of Hearne (19) on the Arctic mainland, that very few mature bulls were present in musk-ox herds, has been verified by all serious investigators since his time, and was further verified in 1951 for herds on Fosheim Peninsula.

The percentage of bulls in 118 adults (33.9 per cent) recorded from April 19 to June 23, is mid-way between the findings of MacMillan (34) (40 per cent) and Howard (24) (27 per cent) on the Arctic Islands. While precise reasons for the variation cannot be given, it is probable that it is due to differences in predation pressure, types of terrain under observation, movements of bulls, and degrees of thoroughness of observation.

The significant fact is that in all cases the proportion of males is low. During the present study three factors may have caused this low proportion.

First, it is probable that some bulls were not counted. Solitary bulls were often found miles from the nearest herd and they preferred ridges and alpine meadows and gorges where they could easily remain hidden.

Secondly, fighting and predation may result in greater mortality of bulls than of cows. The fact that 14 of 21 dead adult animals found on the range were bulls, seems to indicate that bulls may suffer greater mortality than cows, in proportion to their numbers. If this were true, however, the average age of the bulls found dead might be expected to be less than that of the cows, while the contrary was found to be the case.

Thirdly, the low proportion of adult bulls may be partly due to their deferred maturity. As bulls are reported to mature two to three years later than cows, any counts of sexes in adults in herds would omit four- and five-year-old bulls, which would materially affect the sex ratio. Evidence obtained from studies of 26 immature animals suggests that nine were four- and five-year-old males. If these nine are added to the 40 adult males, the ratio is 49 bulls to 78 cows or 1:1.6, and the percentage of bulls is 38.6 per cent.

In all cases observed in the present study, bulls in possession of herds were fully mature. Solitary bulls, on the other hand, ranged from mature young animals to very old ones. A combination of experience and strength is probably necessary for success in conflicts for cows. Immature bulls are tolerated in a herd until they reach sexual maturity. Experience in actual conflict, therefore, would not be gained until after the fifth or sixth year of age. Bulls probably do not succeed in winning a fight for a herd until the seventh or eighth year of age and this would account for the rather limited age class of successful bulls.

Annual Increment

The ratio of calves to cows is considered to be more significant in determining yearly productivity than the ratio of calves to all other animals, which, if the samples are small, is influenced by variables such as the number of immature animals, and particularly the number of bulls, beyond the point of significance. Over a period of years, however, the percentages of calves in total populations should give a reliable indication of productivity.

The ratio of immature animals to cows observed during the period April 19 to June 23, 1951, was found to be 26 to 78. The calf to cow ratio for the same period was 19 to 78. A percentage survival was calculated as follows:

If, as in 1951, the 78 cows produced 19 calves in each of the years 1946 to 1950 inclusive, a total of 95 calves was produced in those years. From this total 19 was subtracted in consideration of females born in 1946 and 1947 that would be definitely mature in 1951. This left a maximum possible survival of 76. The actual survival was 26 immature animals and three yearlings, a total of 29 or 38.1 per cent.

This figure is based on several assumptions but may serve as a mathematical expression of survival for future reference and comparison.

Assuming that the immature group includes females two and three years old and males two, three, four, and five years old, then the 26 animals surviving consisted of one-third or 8.6 females and two-thirds or 17.4 males, an average increment of the herds under study of just over four of each sex per year.

Calf Production

The percentage of calves tallied from the air was about the same in 1950 as in 1951. As both samples were large enough to be significant statistically, some support is given to the assumption that the calf crop for 1951 was normal.

Seventy-five per cent of 78 cows observed from April 19 to June 23, 1951, did not have calves. For June 20 the figure was 78 per cent and for the period June 3 to 23 it was 80 per cent. These figures clearly demonstrate the low reproductive rate of musk-oxen. Similar low production has been reported in the writings of Jensen (27), Manniche (35), Nathorst (36) and Pedersen (40), who found a low percentage of calves in herds in Greenland; and in the writings of Hoare (22), and Clarke (7) regarding herds in the Thelon Game Sanctuary in Canada.

How frequently adult female musk-oxen breed has never been determined fully. An explanation of their low reproductive rate has been put forward by Jensen (27), Freuchen (15), Hennessy (20), Johansen (29), Critchell-Bullock (10), and others, who believed that musk-ox cows calve in alternate years. The low percentage of calves found in herds of Fosheim Peninsula in 1950 and 1951, and the fact that only 20 to 25 per cent of adult cows had calves in 1951, would support the theory of breeding in alternate years.

It is interesting to note that three cows, each closely associated with a yearling, observed in three different herds on June 20, were without calves. These observations, along with that of August 5, in which a cow without a calf, in a herd including two other cows with calves, was seen to mate with a bull, may suggest that as long as a calf is with a cow, the cow will not mate. Freuchen (15) also was of this opinion. The failure to mate, in a cow in which parturition has occurred, and which is nursing a calf, is probably the result of the absence of the oestrus cycle during the breeding season.

The importance of environmental factors on calf mortality and production is unknown. Storkersen (49) believed that adverse weather in April accounts for the death of some calves born during that month. The utilization of food consumed in winter for the maintenance of body heat and life functions reduces the amount of nourishment available for embryos, and under extreme conditions, may cause resorption or abortion. Such conditions have been reported in deer, elk, and other animals and may affect significantly calf production of musk-oxen. Much information on this subject is required, however, before definite conclusions may be drawn.

The significance of predation upon calf survival is discussed below.

Calving Date

Dates of calving in musk-oxen of Fosheim Peninsula agree with those reported by Greely (16) Sverdrup (51) and Ekblaw (11) for latitude 80° N. on Ellesmere Island, and are similar to those found on Melville Island by Storkerson (49) and in the Thelon Game Sanctuary by Clarke (7). An interesting point is, that, although Fosheim Peninsula is more than 1,100 miles north of the Thelon River and has a shorter summer period, the calving dates are similar, and if anything are perhaps earlier than those of Thelon musk-oxen. It might be expected that the contrary would be true.

Variation in the length of the daily period of light is responsible for the onset of breeding in certain large ungulates of temperate regions. Hart (18) has given evidence of this in his studies with sheep. The analysis of breeding dates in musk-oxen suggests a similar causal mechanism. In the Thelon Game Sanctuary, latitude 63° N., maximum sunlight is of 21 hours duration on June 21. By July 31 sunlight lasts 18 hours a day and decreases steadily until December 21. On August 31, at the end of the breeding season, 14 hours of daily sunlight are experienced. On Fosheim Peninsula, latitude 80° N., 24-hour daylight commences about April 14 and lasts until August 31, the end of the musk-ox breeding season there. Thus periods of sunlight grow shorter before musk-oxen commence to breed in the Thelon Game Sanctuary, but the sunlight on Fosheim Peninsula is of 24 hours a day duration throughout the mating period.

It is postulated that a trigger mechanism of alternating light intensities initiates the onset of the oestrus cycle in musk-oxen and acts on them before the period of 24-hour daylight, or before the period of maximum daylight, whichever the case may be. It is suggested that this causal mechanism may be associated with the vernal equinox, March 21, since the increments of increasing light before and after the equinox differ markedly over 17 degrees of latitude of musk-ox distribution. If a relatively wide latitude of duration of the alternating periods of increasing light and decreasing darkness will initiate the oestrus cycle, then the date of onset would vary considerably. If a rather critical range of alternating intensities is required, for

example 12 hours of light, 12 of dark plus or minus one hour, then the commencement of the oestrus cycle and resulting births of musk-oxen in the two areas under consideration - the northern and southern limits of the range - would be approximately uniform. More information on precise dates of calving in the Thelon region is required before definite conclusions may be educed.

Parasites

Musk-oxen of Fosheim Peninsula are more fortunate than most of the Artiodactyla as external parasites appear to be absent, or at least negligible, in their effect on the health or activity of the animals. Internal parasites may exert some influence on general well-being, particularly during winter months, but there is no evidence, as yet, to support this. The two-year-old male collected July 28 was in excellent condition, with an abundance of fat, although five large tapeworms were present.

The life history of the genus Monezia on Fosheim Peninsula is not known, except that the adult stage of the tapeworm is reached in the intestine of the musk-ox. It is possible that an intermediate stage of the cestode may be spent in an aquatic invertebrate, many individuals of which exist in shallow ponds scattered over the summer range. However, it has been demonstrated by Stunkard (50) that an intermediate host of the Monezia was a mite, Galumna sp., and, although no mites were found during the present study, intensive search may prove their existence on the peninsula and their capacity as hosts for Monezia.

Two instances of parasitic infestation in musk-oxen have been recorded in the literature. Fielden (12) stated that two species of parasites he found in musk-oxen in east Greenland were Taenia sp. and Filaria sp.

Jensen (27) mentions finding "a tapeworm in the bladder phase" in the liver of a bull musk-ox shot August 7, 1899, at Hurry Inlet, Greenland. There does not appear to be any reference in the literature to parasites of musk-oxen inhabiting Canadian territory.

Wolf Predation

One of the most interesting behaviour actions of musk-oxen is the method of defense employed upon the approach of danger. In a herd that is approached by wolves, dogs, or man, the animals form a closely-knit group, with adults and immatures facing outwards and calves hiding between adults or occasionally, when very young, underneath the long hair of the cows. Single animals seek high ground or a cliff where some measure of security can be obtained. The herd defense system is practically impregnable against wolf attacks, but cases of solitary animals being killed by wolves are relatively numerous.

The assessment of wolf predation on the musk-oxen under study could only be directly inferred from observation of musk-oxen remains, and these, except in three cases clearly due to predation, were in such a condition that causes of death could not be determined.

Indirect evidence of the killing of musk-oxen by wolves may lie in the observations, by Handley and the author (see page 18) of wolves attacking the ungulates, and in the ratios of adult bulls to cows in skeletal remains. While the wolves were not observed to be successful in

obtaining prey, possibly because of man's interference, the fact that musk-ox remains were found in stomachs of wolves by both observers is a possible indication of such success. The ratio of two bulls to each cow in 21 adult remains suggests that selective influences create a greater mortality among bulls. These influences may include the solitary habit of bulls unsuccessful in obtaining mates, and the wounding of bulls during conflicts to obtain females. In either case, but particularly in the latter, the bulls must be vulnerable to wolf predation, as protection through herd defence is absent.

The numerous instances of lone bulls being killed by wolves, that have been enumerated by Fielden, (12), Sverdrup (51), Ekblaw (11), Rasmussen (93), Jennov (26) and others, support the view that many of the bulls found dead during the present study were killed by wolves.

The killing of adult bulls by wolves and its effect on the rates of increase of musk-oxen is not considered to be significant. The ratio of one adult bull to two cows, and the fact that 26 unmated bulls were observed, would suggest that in a polygamous species such as musk-oxen the removal of the unmated bulls would not decrease the opportunity for successful breeding of available cows. It is significant that 12 of the 14 bulls found dead were determined to be 10 or more years of age. This suggests that the tendency for solitary wandering, with consequent increased vulnerability to predation, occurs with advancing age when bulls are no longer successful in contending for mates.

The fact that only seven dead females were found on the range can be attributed to their habit of remaining in a herd, even though it is a small one, with resulting increased protection. In two cases, however, a female and an immature musk-ox had been killed together, suggesting that in certain circumstances even this protection is not sufficient against a determined attack. Although the data are insufficient for valid analysis, the ages of the cow remains may indicate that mortality is spread through various ages as would be expected in a normal population.

Three $2\frac{1}{2}$-year-old, one yearling, and one 6-months-old musk-oxen found dead were probably wolf kills. Immature animals do not as a rule leave the herds, nor do they become involved in fights for cows. Accidents may have caused the deaths of many of the animals discovered, but it is not likely that all deaths can be attributed to this cause. Unfavourable winter range conditions also may cause some mortality, but this is not generally so, for Stefansson (47) found the animals fatter in January than in July on Melville Island.

The killing of cows and immature animals, including calves, by wolves may exert a significant check on population growth and maintenance. Lawrie (31) reported seeing in August, 1950, 32 calves in a total of 413 musk-oxen - a ratio of calves to other age classes of 32 to 381, or 1:11.9. From April 19 to June 23, 1951, only three yearlings were observed in a total of 162 animals which included 19 calves. An exceptionally heavy calf loss must have taken place during the intervening winter. Although only one calf, probably killed and certainly eaten by wolves, was found, it could not safely be said that most of the loss was due to causes other than predation. It is unlikely that adverse weather conditions caused much abnormal loss, as an examination of the climatic records does not reveal unusual conditions during that winter and spring. Wolves are able to destroy most of the carcasses of calves killed by them, and many calves may have been killed by wolves and not found.

If, as reported, there was a high wolf population on Fosheim Peninsual in 1950, and possibly in part of the early months of 1951, it would have exerted a maximum predation pressure on the herds. It is true that a plentiful and more easily obtained supply of Arctic hare was available, but still it would appear that much of the reduction of the 1950 calf crop must have been the result of wolf predation.

Migration

The observations concerning the rather sedentary habits of musk-oxen under study support those of Greely (16), MacMillan (34), Hanbury (17), Bernier (6), Clarke (7) and others who believed that musk-oxen are not migratory, but make seasonal movements to areas where food and shelter requirements are most favourable, and differ from the statement of Sabine (45) that extensive migrations take place. Their habit of seasonal movement can be compared with that of other wild ruminants such as sheep and goats that, at the approach of winter, leave their summer ranges for areas where food is available and shelter can be obtained.

Certain secondary effects of the non-migratory custom and of the low rates of increase are probable. The re-occupying of depleted musk-ox ranges and the invasion of new territory would be a gradual process. Fielden (12) reached similar conclusions from his observations in Greenland.

Condition of the Range

No evidence of overgrazing on either summer or winter ranges was found during the present study. It would appear that population checks on musk-oxen of Fosheim Peninsula have prevented their numbers from reaching the point where overgrazed range exists.

Botanical Composition of the Range

It has been pointed out by Clarke, et al (8), that the number of samples required to determine the botanical composition of the vegetation of a range apparently depends on the density of the grass cover. Their analyses have shown that in an area where the plant cover is about 4.8 per cent some 3,600 points obtained by the point sample technique should be examined in order to reduce the standard error of the mean to less than 5 per cent. Since 10,000 points were sampled on the summer range of musk-oxen during the present study the standard error of the mean is considered to have been reduced to less than 5 per cent, as the grass cover of Poa species, Alopecurus alpinus and Agropyron latiglume, the more abundant species, totalled 4.81 per cent.

The most abundant plant species on the range, and the one occupying the largest area, was Dryas integrifolia, although collectively the three species of Poa, indicated in Table 1, were more abundant. Salix arctica was in second place.

It is significant that two genera of grasses, Poa and Agropyron that were found in the stomach of a young bull musk-ox and that were recorded along with two other less abundant genera of grasses in the minute counts, should constitute about 3.8 per cent of the points sampled. The grasses, along with willow, which constituted 2.5 per cent of the total points, form a large part of the total food supply available to musk-ox herds.

Food Preference

Food habits determined for the musk-oxen under study did not differ greatly from those reported by Storkerson (49), Johansen (29), Fielden (12), Bay (4), Peary (39), and others. Greely (16) considered that saxifrage and dryas were the principal winter foods of musk-oxen on the east coast of Ellesmere Island, but this may have been the result of scarcity of grasses rather than food preference. Certainly the food value stored in seed heads of grass would be greater than that of the dried leaves of the willow and dryas, and would satisfy nutritional requirements more easily. It is also possible, of course, that musk-oxen have a rather wide range of food habits and are able to survive in several areas which may differ in plant composition and abundance.

Minute counts of grazing musk-oxen showed that grasses were preferred foods during the months of April, May, and June, as 85.9 per cent of 1,240 minutes were spent by 62 musk-oxen in grazing on those plants. Willow was second in preference, occupying 10 per cent of the total time observed. Dryas and saxifrage were less preferred species.

The importance of sedges in the diet of the ungulates is not known. Certainly in spring such plants must form a significant part of the total food supply, and they would probably be eaten in appreciable amounts, when available.

SUMMARY

Musk-ox herds in an area of 450 square miles in the vicinity of Slidre Fiord, Fosheim Peninsula, Ellesmere Island, Northwest Territories, were investigated during the period April 19 to August 24, 1951.

Data on sex and age classes obtained up to June 24 were believed to be free of duplication. After that date some intermingling of herds took place.

Adult cows were found to outnumber adult bulls two to one. In late winter and early spring, herds often contained more than one adult bull, but at the beginning of summer usually all but one adult bull left each herd. Bulls began fighting for possession of cows in the latter part of June. The breeding season was believed to extend from about mid-July to the end of August; mating was observed twice, on August 5 and 12.

Calving occurred from mid-April possibly to early June. In counts made June 3 to 23 the ratio of calves to adult cows was 1:5.1. During this period calves made up 10.7 per cent of all musk-oxen observed.

The small number of immatures of both sexes observed (29 as compared with 78 adult cows) suggests that mortality factors and a low reproductive rate result in a low rate of increase in the herds.

Winter and summer ranges were found to be near each other and movements between ranges appeared to be seasonal, not migratory. The principal requisites of the ranges seemed to be a relatively snow free area with adequate forage and some protection from the weather for the winter range, and green vegetation and fresh water for the summer range. Grasses, the preferred

food, occurred in 4.8 per cent of 10,000 points examined by the Clarke Point Sample Method and occupied 85.9 per cent of 1,240 observed minutes.

Wolves, the only predators co-existing with the musk-oxen, may cause a considerable mortality of calves. The surplus of bulls of breeding age indicated that loss of males by predation would not be likely to prevent the successful breeding of cows.

ACKNOWLEDGMENTS

During the writing of this report Dr. Ian McT. Cowan, Department of Zoology, University of British Columbia, provided valuable criticism and comments. Mr. A.E. Porsild identified the plants collected and Dr. L.P.E. Choquette determined the parasites. Analysis of soil specimens was carried out by the Department of Agriculture, Ottawa. Excellent facilities and transportation were provided by the Department of Transport.

To all of these the author extends his sincere thanks and makes grateful acknowledgment.

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Table 1. Temperatures in Degrees Fahrenheit Recorded at Slidre Fiord, Ellesmere Island, N.W.T., January, 1948 to July, 1951.

Month	1948			1949			1950			1951		
Month	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Jan.	-04.6	-53.1	-56.7	-09.0	-55.4	-39.1	-17.0	-56.9	-40.1	-10.0	-58.1	-38.1
Feb.	-12.3	-60.0	-44.5	-04.0	-55.4	-36.4	-07.0	-59.7	-31.3	-16.9	-56.8	-40.5
Mar.	-07.0	-62.7	-38.7	-00.8	-50.8	-28.9	-07.7	-55.0	-29.3	-01.8	-49.3	-30.6
Apr.	21.0	-45.9	-18.9	06.0	-42.0	-21.1	-04.1	-46.2	-22.6	-21.0	-41.0	-16.6
May	37.1	08.8	16.9	41.6	-14.7	10.9	35.2	-19.0	11.9	36.0	6.5	18.1
June	52.2	28.0	36.8	54.0	30.0	37.8	52.4	21.5	36.1	55.2	10.2	36.9
July	66.1	33.7	41.9	59.0	33.6	42.3	66.8	33.0	43.0	59.8	33.1	42.2
Aug.	53.0	28.7	37.6	53.2	17.0	38.1	49.9	28.0	37.6			
Sept.	38.2	-05.3	24.1	37.7	-05.0	20.1	38.9	-08.6	16.3			
Oct.	20.2	-29.3	-05.3	18.0	-29.7	07.8	12.8	-33.2	-10.4			
Nov.	17.9	-47.1	-20.0	-04.8	-45.7	-23.5	24.0	-40.7	-19.6			
Dec.	13.4	-57.3	-43.5	-06.2	-51.8	-35.7	00.2	-46.1	-27.1			

Table 2. Age and Sex Composition of Animals Identified in Herds Observed, April 21 to June 23, 1951.

	April 19 to 25	May 17,18,26	June 3 to 23	Summary
Herds	3	4	12	19
Adult cows (1)	15	17	46	78
Adult Bulls (2)	7	8	21	36
Ratio (2) to (1)	1:2.1	1:2.1	1:2.2	1:2.2
Calves (3)	3	7	9	19
Ratio (3) to (1)	1:5	1:2.4	1:5.1	1:4.1
Yearlings (4)	0	0	3	3
Immatures (5)	6	12	8	26
Ratio (5) to (1)	1:2.5	1:1.4	1:5.8	1:3

Table 3. Calves in Herds Observed in 1948, 1950, and 1951.

	Calves (1)	Other than Calves (2)	Total (3)	Ratio (1) to (2)	Per Cent (1) of (3)
Aug. 29, 1948	9	43	52	1:4.8	17.3
Aug. 25, 1950	32	381	413	1:11.9	7.7
1951					
April 19 to 25	4	56	60	1:14	6.7
May 17, 18, 26	7	40	47	1:5.7	14.9
June 3 to 23	11	92	103	1:8.4	10.7
Aug. 4 to 6	5	73	78	1:14.6	6.4
Aug. 24	9	122	131	1:13.6	6.9

Table 4. Results of Analyses of Range by Clarke Point Sample Method.

Plant Species	No. Points Recorded, out of 10,000	Per Cent Occurrence	Per Cent of Area Covered
Poa sp.	299	3.0	0.48
Dryas integrifolia	269	2.7	3.5
Salix arctica	248	2.5	2.25
Carex rupestris	181	1.8	0.18
Alopecurus alpinus	108	1.1	1.16
Agropyron latiglume	72	0.72	
Carex stans	39	0.39	
Potentilla pulchella	29	0.29	
Physcia muscigena	26	0.26	
Polygonum viviparum	23	0.23	
Stellaria longipes	18	0.18	
Cochlearia officinalis	18	0.18	
Epilobium latifolium	16	0.16	
Cassiope tetragona	15	0.15	
Moss	15	0.15	
Saxifraga oppositifolia	14	0.14	
Luzula nivalis	14	0.14	
Papavar radicatum	10	0.10	
Taraxacum phymotocarpum	6	0.06	
Dupontia fisheri	5	0.05	
Cerastium alpinum	4	0.04	
Lichens	4	0.04	
Potentilla emarginata	4	0.04	
Melandrium triflorum	3	0.03	
Festuca brachyphylla	3	0.03	
Eriophorum scheuchzeri	3	0.03	
Saxifraga tricuspidata	2	0.02	
Armeria maritima	2	0.02	
Erigeron compositus	1	0.01	
Deschampsia brevifolia	1	0.01	
Total Vegetation	1,452	14.52	

Table 5. Musk-oxen Minute Counts.

	April 25	May 17	May 18	June 20	June 22	June 23	June 26	Total
Grasses	80	140	160	192	135	183	175	1,065
Dryas	-	-	-	21	-	11	-	32
Willow	-	-	-	47	31	20	25	123
Saxifrage	-	-	-	-	14	6	-	20
Total No. Minutes	80	140	160	260	180	220	200	1,240
No. Musk-oxen under Observ.	4	7	8	13	9	11	10	62

Table 6. Ages of 26 Musk-oxen Found Dead on the Range.

	6mo.	1yr.	2½yr.	6yr.	7yr.	8yr.	10yr.	11yr.	12yr.	Total
Immature	1	1	3	0	0	0	0	0	0	5
Male Adults	0	0	0	1	1	0	4	5	3	14
Female Adults	0	0	0	1	1	2	0	0	3	7
Total	1	1	3	2	2	2	4	5	6	26

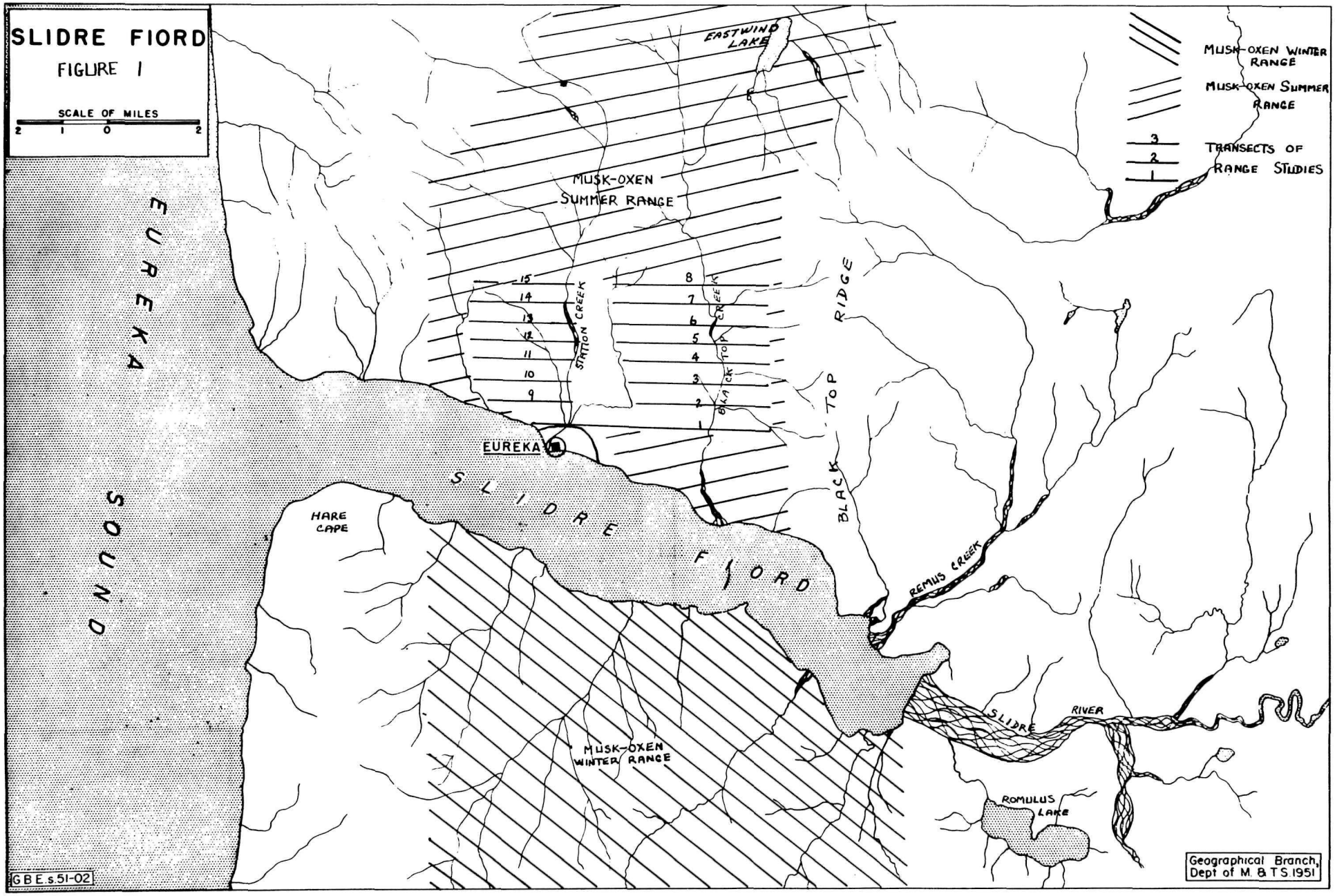
SLIDRE FIORD
FIGURE 1
SCALE OF MILES
2 1 0 2
EUREKA SOUND
EASTWIND LAKE
MUSK-OXEN SUMMER RANGE
MUSK-OXEN WINTER RANGE
MUSK-OXEN SUMMER RANGE
3
2
1
TRANSECTS OF RANGE STUDIES
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
STATION CREEK
BLACK TOP CREEK
RIDGE
BLACK TOP
EUREKA
SLIDRE FIORD
HARE CAPE
REMUS CREEK
SLIDRE RIVER
MUSK-OXEN WINTER RANGE
ROMULUS LAKE
GBE.s.51-02
Geographical Branch, Dept of M. & T.S. 1951

Fig. 2. Herd of 11 musk-oxen including two calves. May 26, 1951.

Fig. 3. Two bulls take up positions to repel dogs. Near mouth of Slidre Fiord, August 16, 1951.

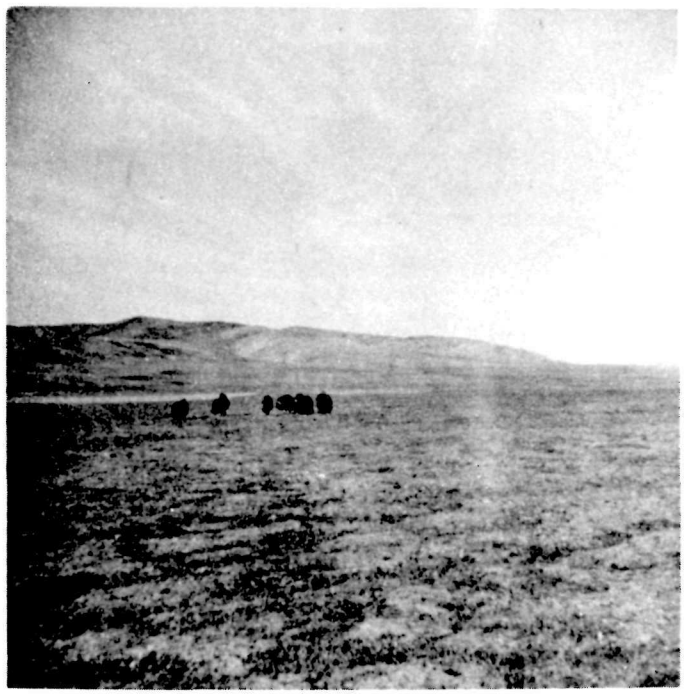

Fig.4. Herd of six adult bulls, in the Eastwind Lake area. August 6, 1951.

Fig. 5. Musk-oxen grazing in the valley of Black Top Creek. June 26, 1951.

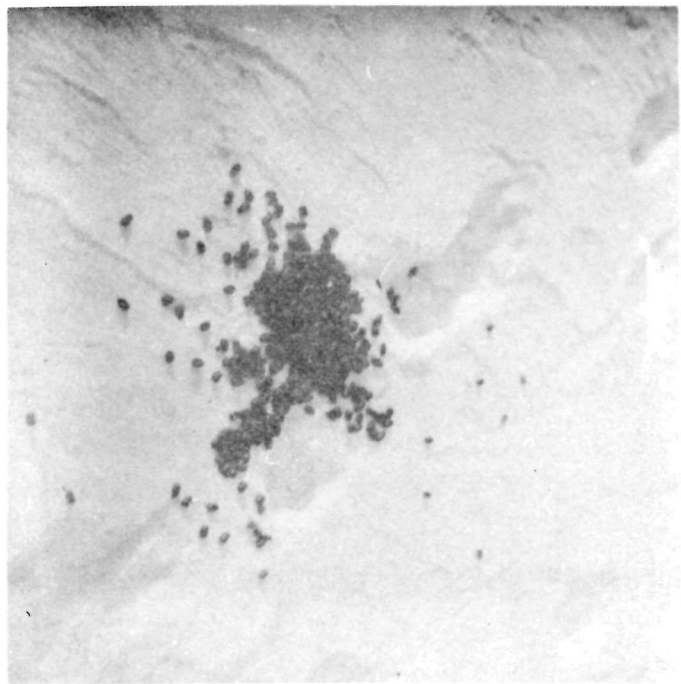

Fig. 6. Winter dung of adult cow musk-ox. South shore of Slidre Fiord, May 26, 1951.

Fig. 7. Summer dung of adult cow musk-ox. In the valley of Black Top Creek, June 26, 1951.