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A STUDY ON THE ARCTIC FOX IN GREENLAND

IMMIGRATIONS, FLUCTUATIONS IN NUMBERS

BASED MAINLY ON TRADING STATISTICS

BY

F. W. BRAESTRUP

WITH 6 FIGURES IN THE TEXT
AND 1 PLATE

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
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INTRODUCTION

This is intended as the first of a series of papers based on Greenland trading statistics.

After seeing how much valuable biological information has been derived from the account books and reports of the Hudson's Bay Company it became evident to the present writer that a similar treatment of the Greenland accounts would be worth while.

It was realized from the beginning that the biological basis of the fluctuations in numbers of foxes in West Greenland is far more complicated than e. g. in Canada, and that anything like a complete elucidation of the more important factors would be impossible without extensive field work. On the other hand some curious features in the variations from year to year of the winter white variety in comparison with the "blue" in northern West Greenland soon convinced me that there must be considerable periodic invasions into this region of white foxes from neighbouring regions inhabited by lemmings. This question, therefore, was made a main point of the investigation, and it is hoped that these invasions will be generally accepted as proved beyond resonable doubt, the more so as I am able to quote direct observations of foxes having arrived by drift ice.

In dealing with the questions which arose it became necessary to compile as far as possible the scattered literature on most aspects of the animal's biology. Some readers should perhaps prefer to have this compilation presented as a whole, with subsequent discussion of the information and problems contained in the report and figures. This was found impracticable, however, but it is hoped that the matter is arranged in a sufficiently clear fashion as to allow a reader who seeks information on a special point to find what he wants.

Chapter I is wholly compilatory, containing a summary of literature on fluctuations in numbers of lemmings and foxes in regions where these rodents are found. The breeding rate of such foxes ("lemming foxes") is compared with that found in foxes with no access to lemmings ("coast foxes"). For a discussion of other food items than lemmings the reader is referred to Chapter IV (p. 63). Instances of the extent of migrations

of foxes at times of lemming scarcity are given in the beginning of Ch. II, which also contains a discussion of the sources, direct or indirect, of our knowledge of the exact years of fox maxima in Canada, and finally on p. 32 a discussion of the means of subsistence of foxes on drift ice.

Unpublished sources.

1. "Koloniernes Regnskaber" (account books of the districts in Greenland) 1793—1882. These books contain information of the numbers of blue and white fox skins traded during each trading year (until 1865 reckoned from $^{1}/_{7}$ to $^{30}/_{6}$, after that year from $^{1}/_{4}$ to $^{31}/_{3}$). There is a gap in the record about 1813—15 owing to the English war. The figures in table V, which are presented graphically on the plate, are taken from these account books. For the period after 1882 the figures published annually in "Beretninger og Kundgørelser fra Grønlands Styrelse" were used. It was not deemed necessary to publish here more than the total numbers of skins and the percentages of these which belonged to the white variety. Complete typewritten sets containing all four figures (blue, white, total number, and percentage) are, however, available. They may be had on loan by application to the Zoologisk Museum, København, and later a set will be handed over to the Bureau of Animal Population, Oxford. These M. S. tables also contain the separate figures for the small districts Christianshaab, Jakobshavn, Ritenbenk, and Godhavn which are here merged into one under the heading of "Disko Bay Districts".

During the first 30—40 years a few skins are sometimes classed as "utidige" (not prime) without being sorted according to blue or white. In such cases the percentages are calculated without regard to the "not prime" skins, assuming that the proportion between the varieties is the same in these. This, of course, introduces a small source of error, and figures including such skins are designated by an asterisk in the table. A few missing percentages in the beginning of the table are due to the circumstance that the two varieties are not held clearly apart in the book.

2. "Fangelister" (hunting records). At each small dwelling place lists are kept, stating the numbers of seals, foxes etc. caught by each man during each week or (in South Greenland) ten days. Unfortunately this valuable material is retained in Greenland archives, but some were sent home at my request. Table II (p. 32) contains a compilation based on the North Greenland lists of 1922—1937.

A brief summary of the contents of the hunting lists is published annually in Greenland, stating the catch at each small dwelling place, but without information as to season.

3. "Indberetninger om Tilstanden og Begivenhederne i Grønland" (reports from the districts in Greenland), 1883—1939, contain detailed information of the weather, ice conditions, success of the hunting and fishing, etc. A general report mainly based on these is printed annually in "Beretninger og Kundgørelser". For the period 1870—82 brief annual reports are available which do not, however, contain much of biological interest. They are printed in "Ministerialtidende" for 1871—1883.

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I am indebted to many persons for help in one way or other. First and foremost to officials of the Greenland Government: the late director Mr. Daugaard-Jensen, and the present director Mr. Oldendow who have both taken much interest in the work and helped me in many ways, the former chief administrator of North Greenland, Mr. Rosendahl who has been untiring in procuring information which proved of the highest interest, the chief of the trading department, Mr. Lyngbæk, the chief trader at Thule, Mr. Hans Nielsen, and many others. Much useful information concerning conditions in Greenland was given me by Mr. Paul Hansen, M. Sc., who for many years has been carrying out fishery investigations there.

To the following Zoologists I owe thanks for advice, information, loan of otherwise inaccessible books etc.: Dr. M. Degerbøl, Dr. C. Elton, Mr. Heding, Professor A. S. Jensen, Dr. P. Brandt Rehberg, and Professor R. Spärck. Mr. G. Seidenfaden, graduate at economics, kindly allowed me to quote some information on the production of Arctic Fox'skins which he has collected from various sources.

I also thank Miss Ingeborg Frederiksen who made the graphs and Mrs. Lena Kieler who translated some Russian literature. Mrs. Ebba With Bræstrup has assisted me with secretarial work whenever possible.

Last but not least I wish to thank Mrs. Volsøe, who during the preparation of the manuscript gave much linguistic advice, and Dr. Crossland who with his usual readiness read the final M. S.

I

LEMMING FOXES AND COAST FOXES

The Arctic Fox is regarded by mammalogists as representing a separate genus *Alopex* Kaup, which may perhaps also include the Corsac Fox. It would be out of place here to discuss in detail its morphology or express any opinion of its systematic position within the *Canidae*, a question which is closely connected with that of the value of HUXLEY's (1880) Alopecoids and Thooids. It is interesting to note, however, that various authors (HILZHEIMER, 1908, 23; MILLER, 1912, 318) have pointed out characters in the skull and teeth by which *Alopex* may be said—from a purely morphologically standpoint at least—to form a transition between the jackals and the foxes, remembering that v. MIDDENDORFF (1875, 942) justly applied to the Arctic Fox the nickname of "der Schakal des Nordens", thus paying credit to a prominent feature in its biology.

Alopex lagopus is highly characteristic of the Arctic Region. The southern limit of the territories in which it breeds corresponds very closely to the timber line. During its periodical migrations (see p. 18) it may indeed penetrate far into the forested regions, but it has never been known to breed there.—Apparently only one instance has been recorded of this species having been found living permanently above the timber line in mountains far to the southwards (Dzungarian Ala-tau; BÜCHNER, 1897). While it is quite probable that this is to be regarded as a survival from the glacial period, it must be remembered that the very extensive migrations undertaken make it possible that the region in question has been reached later. No land seems too northern to support these animals, and tracks of several individuals were found by NANSEN (1897, II, 69—73) on the polar ice at 85° north.

We may be sure, I think, that there is only one species or "race circle" of arctic fox. Rather considerable differences as to size, cranial characters etc. are observable between specimens, and several races and "species" have been described (BARETT-HAMILTON and BONHOTE, 1898; MERRIAM, 1900, 1902). In some regions the racial characters are rather uniform, while in others, including West Greenland, an astonishing individual variation is found, which makes it difficult to separate races.

These taxonomic questions do not concern us here, but the great variations of characters in Greenland are interesting as a probable result of immigrations, and will be briefly dealt with later.

The food supply is the dominant factor in the ecology of the arctic fox within its breeding range, and in this respect we have to make a sharp distinction between areas inhabited by murine rodents of the subfamily *Microtinae*, and such countries from which these animals are absent. The largest areas void of *Muridae* are to be found in Greenland, viz. all of West Greenland up to Hall Land (81° north) and the eastern coast south of Scoresby Sound. In Spitsbergen too no mice are to be found[1]) and in Iceland the family is represented in the open by long tailed field mice (*Apodemus*) only. These are quantitatively of less importance and do not play a prominent part in the diet of the foxes; it is not even definitely known, apparently, whether they are taken at all. (See SÆMUNDSSON, 1932, 116.)

In all the rest of the Arctic, except a few small islands, one or two species of lemmings are found. Some of the more southern parts may even be inhabited by other members of the *Microtinae*, which may be quantitatively dominating in some years, e. g. *Microtus ratticeps* in Norway, and these are of equal importance to the foxes. Lemmings, as well as ordinary field-mice, are rapid transformers of vegetables into flesh, and moreover they are easily procured by the foxes even in winter when their feeding grounds are covered by a deep layer of snow. Vivid descriptions of foxes tracing lemmings under the snow by smell or—more probably—by hearing (c. f. PAYNE, 1888, 116; STEFANSSON, 1923, 26) and then rapidly digging down for them, have been given from personal experience by MANNICHE (1910, 47; East Greenland), FREUCHEN (1935, 125; Arctic North America), and DUBROVSKY (1937, 12; Nowaya Zemlya).

As early as 1760 GMELIN emphasized the value of lemmings to the foxes as a food item which could be procured all the year round and pointed out the close agreement between the highly varying number of lemmings at a place and that of foxes. He even mentions a certain regularity in this disappearance and reappearance of lemmings and foxes: "Quam regionem deserverunt, eam post tres quatorque annos repetunt" (GMELIN, 1760, 371).

Gmelin's remarkably correct account of the Arctic Fox was based on conversation with intelligent native hunters in Siberia. His statements on the principal dependence of foxes on *Muridae* have been unanimously

[1]) It seems to be quite certain that some race of *Dicrostonyx* has at certain times been found in Spitsbergen, probably brought by drift ice (HEUGLIN, 1874, 8; Petermann's Mitth. 1872, 217), but curiously enough the species has not been able to get a permanent foothold there.

confirmed by subsequent authors (e. g. SCHRENK, 1854, 400—01; COLLETT, 1895, 46, and 1912, 275; HØST, 1935) for countries where mice and lemmings are found—with one or two remarkable exceptions which refer to islands (pp. 8, 12). Allusions to something like a periodicity in the occurrence of foxes are also contained independently in other writings from the 18th and 19th centuries. PENANT (1784, 43) states on the authority of a certain Mr. Graham that arctic foxes "are only migratory in Hudson's Bay once in four or five years". WRANGEL (1839, 209), who wintered in Nishni Kolymsk 1820—23, writes that, according to the natives, the foxes are especially numerous in the tundra once in every three years, and the same thing is related for the Jana District by BUNGE (1887, 99) who adds that, according to the natives, this is caused by a permanent wandering of foxes all round the pole, which make them appear first at Jenisei, Chalanga, and Anabara, then at Lena and Jana etc. Finally we may quote v. MIDDENDORFF (1875, 944): "In unbestimmbaren Zeiträumen bald nach zwei, drei bis sechs Jahren stellen sie sich in grösserer Menge ein".

All these statements evidently refer to the now well established "four year cycle" in the numbers of Arctic Foxes; they are incomplete, however, in so far as these fluctuations in the numbers of lemmings and foxes were generally belived to be caused by migrations only. The lemmings in times of scarcity were thought to be elsewhere, a belief which is easily explained by the fact that these animals really do undertake wanderings in "lemming years" and by their secret mode of living in ordinary years.

Collett in his papers on the Norwegian Lemming (e. g. COLLETT 1895) gave convincing evidence that epidemic diseases, which attack the wandering swarms as well as those which remain on the breeding grounds, are the real cause of the sudden decline in numbers after lemming years.—The existence of such die-off's in the wandering lemmings was, indeed, recorded in print as early as 1532 in an otherwise fantastic account by JACOB ZIELER (cited in COLLETT, 1895, 6).—Collett also pointed out that prolific years commonly occur simultaneously in several species, an abnormal increase likewise being observed in other mice in lemming years. He further thinks that an assemblage of predators from neighbouring regions is not the sole reason for their great numbers in such years but "they too are influenced by the fruitfulness of the year" (COLLETT, 1895, 21).

Further progress in the knowledge of fluctuations in numbers of fur bearers and their prey has been largely due to trading statistics, especially to the fur returns of the Hudson's Bay Company, an important part of which was published by POLAND (1892), without comment, however, of the periodicity so clearly shown by the figures. MACFARLANE

(1905) refers to a 10 year periodicity in the numbers of various mammals in the forested parts of Canada, mentioning also epidemic diseases in the "American Rabbit" (*Lepus americanus*), but in the case of marten and lynx he still adheres to the migration theory. SETON (1912) presented some of the fur returns in a graphical form, pointing out that they showed marked periodic fluctuations even in the predators, thus indicating a real ebb and flow in the numbers of these animals throughout northern Canada. He further supported this by field notes. HEWITT (1921, 213—234) also presented graphs which for the first time include one illustrating the numbers of skins of Arctic Foxes sold annually in London by the Hudson's Bay Company. He gave a very clear criticism of the still prevailing migration theory. After admitting that migrations do occur he goes on to say (p. 227): "But it is important that this migratory tendency should not be confused with the phenomenon of the periodic fluctuation. Migration is one of the earliest and most popular explanations of the disappearance of a species of animals, but like many popular ideas it is not founded on fact. That migration is not a cause of the periodic fluctuation is proved by a study of the total fur returns for the whole territory covered by the Hudson's Bay Company."..... In the Arctic Fox the cycle was found to be much shorter than in the more southern species, the maxima following each others with an interval of four years in most cases. (Sometimes the interval was found to be 3 or 5 years, exceptionally 6 years.) Hewitt gives no reason for this difference, but a few years afterwards ELTON (1924) directed attention to the Norwegian records of lemming migrations, which are an index of overpopulation, and follow usually at the same short intervals as the maxima of Arctic Foxes in Canada. This affords a reasonable explanation of the cycle in numbers of its dependant the Arctic Fox, an explanation which has gained further support from JOHNSEN's (1929) work on fluctuations in Norwegian wild life based on the amount of premiums paid annually for the destruction of various beasts of prey. JOHNSEN's graphs also fill out a few gaps in the recorded maxima of mice and lemmings. The predators do show peaks in numbers at the predicted times, indicating increase of their prey even in those instances at which this increase has escaped direct observation.

It will be seen from the above that these results are to some extent mere confirmations of statements made from time to time in literature from 1760 onwards. The credit for full understanding of the phenemenon of fluctuations in numbers is due, however, to scientists of this century. Collett, Seton and Hewitt led the way by proving that migrations are only secondary phenomena, and ELTON (1924, cf. also 1931 a) published the first comprehensive account, which in spite of the fact that his theories have been liable to modification on some points, has outstanding merits

as a starting point for subsequent discussion and research. A considerable part of later work on fluctuations is also due to Elton and his collaborators at the Oxford "Bureau of Animal Population" of which he is a director. Here, we need only mention those papers directly applying to the Arctic Fox. "The Arctic Wild Life Enquiry" has, up to 1940, resulted in three publications covering the years 1935/36 to 1937/38, (CHITTY and ELTON, 1937; CHITTY, 1938, 1939) on numbers of lemmings, Arctic Foxes, and Snowy Owls based on reports from many localities in the Canadian Arctic for the years mentioned. A paper by ELTON (1931 b) on epidemics in foxes and sledge dogs in Canada, also contains informations on the Arctic Fox cycle together with some corrections to his former statements on its exact average length. We shall have occasion to refer later to the exact dates of peaks in numbers of Arctic Foxes in Canada so far as they are known, and also to discuss in some detail the migrations which result from the sudden drop in food supply after each maximum.

As was to be expected this short and violent cycle in numbers is not apparent among those populations of Arctic Foxes inhabiting regions where no lemmings are found. ELTON (1934, 64), who has briefly referred to this fact, points out that it is confirmative of the belief that the "four year cycle" of foxes is caused by the corresponding cycle in lemmings and not by some factor acting simultanously on lemmings and foxes (such an oppinion was apparently held by COLLETT (1895, 22)). It is obvious that there must be a pronounced difference as to conditions of life between those foxes which have access to lemmings and those which have not. It will be shown later that the vast majority of the latter group is dependent to a very large extent on products of the sea, at least in winter which is always the critical season. We may, therefore, designate them as "coast foxes" as opposed to "lemming foxes".

The lemming foxes are almost invariably white in winter, the "blue" variety being rare among them. MIDDENDORFF (1875, 942) estimated 3—4 per cent blue foxes in northern Siberia, and in continental arctic America they are even rarer. In the years 1853 to 1877 the Hudson's Bay Company sold in London a total of 125.200 skins of Arctic Fox, only 1.100 of which were blue (less than one per cent) (MACFARLANE, 1905, 706).—On the other hand, in West Greenland, Jan Mayen, Pribilof Islands, and Komandorski Islands the blue phase is dominant, and in Spitsbergen this was the case in former times (LITKE, 1835, 114), in the course of the last century they have been reduced to only about 10 per cent. The preponderance of white foxes in certain districts of West Greenland is also a comparatively novel phenomenon (cf. p. 45). In Iceland the blue and the white variety are found in nearly equal proportions, the blue being slightly the rarer (SÆMUNDSSON, 1939, 4).

An interesting instance of differences as to instincts between coast foxes and lemming foxes is found in St. George Island (Pribilof Group) which harbours an endemic form of lemmings, unknown in the other island, St. Paul. The case is stated as follows by OSGOOD, PREBLE, and PARKER (1915, 109): "Although lemmings are abundant on St. George, and it has always been assumed that they are devoured by the foxes whenever possible, there seems to be no positive evidence to this effect. Among the contents of large numbers of fox stomachs examined during past years no remains of lemmings seem to have been found. During the autumn of 1913, at a time when lemmings were unusually abundant, no evidence was found that any were eaten. At the same time the stronger foxes were eating their own kind. It seems scarcely credible that lemmings should never be eaten, but it is plain that they cannot form an important element in the food supply."—There are two other islands where the "coast foxes" have access to mice. From notes by BARABASH-NIKIFOROV (1938, 425) one gets the impression that while the Arctic Foxes on Bering Island do feed on the red backed mice (*Chleithrionomys rutilus*) introduced about 1875 (STEJNEGER, 1884, 85), he is of the opinion that they do not count for much in the food supply of the foxes. In Iceland, as previously mentioned, there is apparently no positive evidence that the foxes feed on the indigenious long-tailed field mice (*Apodemus*).—Conditions in Iceland are somewhat peculiar in other respects, because the foxes do much damage to sheep, and a rather large proportion of them may on that account remain inland throughout the year.

According to ALWIN PEDERSEN (1930, 379) the foxes inhabiting the Liverpool Coast and along the entrance to Scoresby Sound, where there are rich bird cliffs, are smaller on an average than the lemming foxes found further inland. In the bird cliff population the blue and the white phases are represented in about equal proportions, while those from farther inland are mostly white (PEDERSEN, 1934b, 63; 1926, 169). It is not to be understood either that the comparatively few blue foxes in the continents of Asia and America are evenly distributed among the white ones. Here too we find a greater proportion of blue animals on the coast. MIDDENDORFF (1875, 943) pointed out that this is the case in Siberia, and in arctic America the same thing is clearly seen from the data given by MACFARLANE (1905, 706) and PREBLE 1908, 218) for the Mackenzie Region. While, according to Preble, usually about 100 skins are traded during a season at Fort Norman (65° north), the blue phase is unknown there, at Fort Good Hope further north the blue phase is sometimes obtained, and at Fort McPherson (67°30′ north) nearest the coast, where many skins are traded from the Eskimos, there are probably up to 10 per cent blue. Fort Anderson a little farther from the coast (68°30′ north, 128° west) during the season 1861/62

traded 350 white and 10 blue skins and the next year 320 + 10 (PREBLE, 1908, 220). MACFARLANE (1905, 707) tells us that the few blue skins obtained at Fort Good Hope as mentioned above, resulted from Indian trade with the Eskimos of the Anderson region after the Fort was abandoned in 1866. It is further apparent, as pointed out by MacFarlane, that the blue phase is "a very rare inland visitor", which again indicates differences as to mode of living, between the white foxes and those with a high percentage of blue: the latter do not or very seldom partake in the periodical wanderings to the south so characteristic of the lemming foxes.

Remembering that the lemming foxes once in about four years have to go through a whole cycle from a high flow of numbers to scarcity, and up again to a new maximum, we must expect their breeding capacity to be very high, and since the coast foxes are not usually subject to such violent fluctuations in food supply from year to year, it is natural to suspect profound differences in this respect between the two biological groups. A survey of the literature does, in fact, fulfil these expectations.

To begin with lemming foxes, GMELIN (1760, 367), well informed as usual, said: "In this den they also give birth to the young in a number of six, seven, eight, even up to twenty-five, according to whether the year is favourable to fertility (prouti anni fertilitas favet)". MIDDENDORFF (1875, 943) also speaking of the Arctic Fox in Siberia, relates that sometimes more than 20, up to 23 or 24 young are said to be taken from the same den. He attempts to explain this by suggesting that these may have been borne by more than one mother, or by assuming that there are several litters during a summer. The last assumption, at least, cannot be true. Middendorff's embarrassment is apparently due to statements in the literature that not more than eight young are born at a time; Gmelin's account is ignored, but as an afterthought in a footnote he quotes a Russian author Figurin to the effect that the number of young in a litter may range from 7 to 17. Middendorff finally admits the possibility that the number of young may vary with the years. COLLETT (1912, 278) in his book on Norwegian Mammals states: "The number of young is most often 6 to 8, more seldom 9—12; several times 14 young have been found, and in one case 16. Eighteen young are recorded as found in the mountains at Eastern Slidre, but these probably belonged to two females". It is not clear why 16 is acceptable while 18 is not. As a matter of fact HØST (1935, 137) is able to quote an instance from a farm in Sogn, Norway, of 21 young having been born alive by one female blue fox in the spring of 1930. Fifteen of these were successfully raised. Høst therefore finds nothing improbable in the statements of old foxhunters on the Hardangervidda, who have found up to twenty young Arctic Foxes in the same litter. SCHAANING (1916, 187,

190) found 16 embryos in an Arctic Fox in Novaya Zemlya in 1903, a year rich in lemmings there. During the summer he found 13 grown up cubs in one den.

Thus, Gmelin's statement that up to over twenty may be born is confirmed by several independent observations. His second statement that the fertility of the animal is dependent on conditions, i. e. the number of lemmings, is also confirmed by recent observations. ALWIN PEDERSEN, who is apparently the only author who has referred to a difference in fertility between what is here called lemming foxes and coast foxes, states (1931, 380) that in the region of Scoresby Sound, N. E. Greenland, the foxes living in the bird cliffs breed successfully every year, while those further inland living principally on lemmings do not breed, or only a few of them, in years of lemming scarcity; as a set off the number of young in lemming year is comparatively high. More recently in a popular book on East Greenland animals PEDERSEN (1934b, 65) relates that the young are said to be devoured by the parents when conditions are unfavourable. DEVOLD (1940, 8) states that in *Alopex*, as in Snowy Owls, the young eat each other when there is not food enough. According to HØST (1935, 379) there were not a few adult Arctic Foxes at their dens on the Hardangervidda, Norway, in 1935, "but either they have not been breeding this year, or they have eaten the young;" in 1935 mice and lemmings were very scarce at the locality in question, in 1934 they were numerous, and the foxes bred successfully. It will appear from these records that, while certainly very few or no young are raised in unfavourable years, it is far from clear how this result is usually brought about. BOITSOV (1937, 26) states that in the year 1934 on the Kola Peninsula practically all females had copulated, but only 70 per cent bore cubs; further there was a high percentage of still born or not viable young. Unfortunately, neither the food conditions nor the number of cases examined are stated. BOITSOV (1937, 28) also writes that the death rate in young Arctic Foxes may sometimes be 100 per cent.

Now, turning to coast foxes we find that the most exact statements on the number of young pertain to the Komandorski Islands. "The number of pups in a litter, as the old records show, did not exceed a maximum of 12 pups. Out of 17 litters counted on Copper Island in the period 1931—33, five litters consisted of 6 pups, six of 7, three of 5, one of 10, one of 8, and one of 4, the average being 6,4 to a litter." (Barabash-Nikiforov, 1938, 425). In the Pribilof Islands JUDGE examined 22 litters of which the smallest numbered 5 and the largest 11 cubs (OSGOOD and others, 1915, 111).[1])

[1]) According to the natives, however, litters have been found containing as many as twelve or thirteen young ones (LEMKEY and LUCAS, 1902, 217).

In West Greenland the size of the litter is apparently much the same. FABRICIUS (1788, 439) states that from 3 to 7 pups are born, and R. MÜLLER (1906, 304) says that, to judge from the number seen at a time outside the burrows, there are seldom more than 6 to 8 pups. He has never seen more than 6 foetuses in a bitch fox, but some Greenlanders told him that the number may amount to 10.

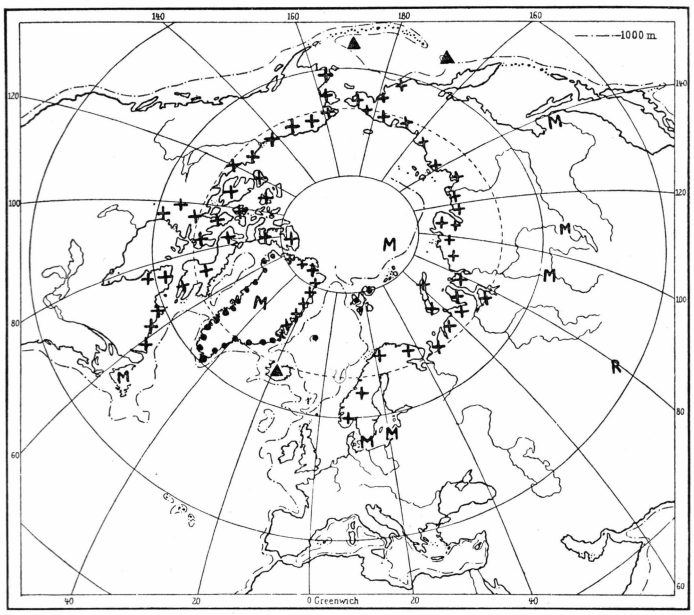

Fig. 1. The breeding range of the Arctic Fox, and some extreme instances of migrations (M). Areas inhabited by lemming foxes are marked by crosses, dots indicate coast foxes, and triangles the islands where Muridae are found without being of any importance to the foxes (also coast foxes). R indicates the only known occurrence of the species as a survivor.

Thus it appears absolutely certain that there is a pronounced difference in the breeding rate, between coast foxes on the one hand and lemming foxes on the other, in accordance with the much greater need for fertility of the latter at certain times. It is true that we should like more investigations on the breeding rate in different years and in different populations, which could enable us to compare average, since in comparing maximum numbers there is a large source of error. But when we find that in one group the maximum number of cubs, recorded several times, is double that found in the other in spite of extensive reseach, we have a right to conclude that a considerable difference exists. It is true that until records have been procured of the breeding rate of captive animals from different sources under standard conditions we cannot be

absolutely sure that this difference is not merely a phenotypical phenomenon. This is improbable, however, and on the whole it may be said that the known facts strongly suggest that there are physiological differences between the two groups, in addition to the difference in outward appearance which consists in a much higher percentage of the blue variety in coast foxes.

This case of ecological differentiation is not unique among mammals. As an interesting parallel may be mentioned the old world red squirrel (*Sciurus vulgaris*). SEREBRENNIKOV (1931, 493) states that in Middle Siberia three color types of this species may sometimes occur together, but are mostly, to a certain degree, ecologically isolated according to the composition of the forest. In Danmark a population of very dark squirrels evolved during the several thousand years when the Danish forests were composed exclusively of deciduous trees. After the planting of fir and spruce the indigenous population was not able to profit to any large extent by the improved feeding conditions (c. f. the unability of the coast foxes on St. George to profit by lemmings). The great augmentation in numbers of squirrels in this country in the last decades is due in the main to introduced squirrels of the red variety (SPÄRCK, 1936).

II

PERIODIC INVASIONS OF ARCTIC FOXES INTO WEST GREENLAND

It appears from statements by GMELIN (1760, 371) and subsequent writers that the periodical migrations of those Arctic Foxes which depend principally on lemmings, occur mostly or always in winter or early spring. This may not necessarily mean that the sudden decline in the numbers of lemmings always happens in these seasons, though this is probably most often the case.[1]) The reason is no doubt that during the summer there is always plenty of other food, especially migratory birds, their eggs and young (v. BAER, 1841, 103). Ptarmigan, it is true, are as a rule found throughout the year, and probably they form an important food item even in winter. If these birds are numerous at the time, the severity of the situation may thus be somewhat mitigated, but, owing to the great number of foxes after years of plenty acute food scarcity must necessarily follow the die-off of lemmings, either at once, or—if the die-off occurs in late spring or summer—in the following autumn. It is natural that many of the starving foxes will then attempt to seek food elsewhere. We have seen above that the resulting migration has attracted attention for centuries, and that it was erronously thought to be the cause of the fluctuations; it was believed that the lemmings went elsewhere, the foxes followed, and after a few years both returned. We know now, firstly, that when the lemmings seem to disappear it is because most of them die, and secondly, trading statistics for large areas show that the foxes fluctuate in numbers tolerably simultaneously over large areas. This, as pointed out by ELTON (1914, 132; 1934, 63) indicates some controlling agent (e. g. a climatic pulsation) being at work, otherwise the ups and downs at the various localities in a large area would tend to cancel out. It is true that there are usually some

[1]) According to ZIEGLER (1532) the migrating lemmings "die when they taste the new herbs" in spring. This belief which has been prevalent among Scandinavian peasants up to our times (NILSSON, 1847, 380, COLLETT, 1895, 37, 52) may contain a biologically significant truth.

regional differences. As a striking instance may be mentioned that in the winter of 1921/22 there was a maximum catch of foxes in about half of eastern arctic Canada with a subsequent minimum the following winter simultanously with a maximum catch in the other half of the area (ELTON 1931 b, 686). Here, of course, some of the migrating starving foxes in the first year would have a chance of reaching those regions where lemmings were still plentiful, but next year they and their progeny would have to face starvation again.

The net result of the lemming die-off is that most of the foxes die also. It is probable that nowadays the major part end as furs, since in the starving condition they willingly enter the numerous traps; some succumb to various diseases, and some are eaten by wolves or their own kind. It is thought that those Arctic Foxes which in such years migrate far to the southwards never return to the North (ANDERSON, 1930, 98).

Before presenting the evidence for immigrations of lemming foxes into West Greenland we may give some instances illustrating the length of such migrations as recorded in literature.

At the river Yenisei the Arctic Fox does not breed south of Dudinsh (MIDDENDORFF, 1853, 73), but migrating individuals have been caught as far south as Yeniseisk (GMELIN, 1760, 364) after a journey of 1300 km or more. Two individuals which were shot at Kirensk (River Lena) must have travelled even further. Journeys of similar magnitude are proved by individuals killed at the Amur estuary (NORDMANN, 1861, 321), on the coast of Latvia c. 56° north (v. BAER, 1844, 47), not far from Leningrad (v. BAER, 1841, 89) and in extreme southern Scania (southern Sweden) (NILSSON, 1847, 264). NILSSON (l. c.) writes that in 1832 a southward migration occurred through the whole of the middle and southern parts of Scandinavia. In Scania they began arriving in March, and, in spite of a rather large number being killed, some were seen during the entire summer and autumn and in the following winter. An accumulation of individuals was noted at the extreme southern point of Scania, indicating that they would have gone even farther if they had not been stopped by the sea. There was not the slightest indication that they attempted to breed. In southern Finland too it is known that these animals have sometimes arrived not as single stragglers, but in rather considerable numbers (v. BAER, 1841).

In Canada according to ELTON (1931, 689) "after a year of abundance in the North it is common for a "run" of Arctic Foxes to be met with in the posts further south, in the margin of the forest zone, and actually also right down into the heart of this region. The extent and duration of these migrations south varies considerably".—At the coasts movements of the drift ice are known to be an important factor determining the extent of these wanderings (ELTON, 1934, 62). The Arctic Foxes

which, according to AUDUBON and BACHMAN (1854, 96), have been observed in northern Newfoundland were no doubt brought there by the ice, and it is well known that white foxes occasionally reach the Pribilof Islands from the north on the pack ice (OSGOOD, PREBLE and PARKER, 1915, 105).

It is not to be understood, of course, that the migrations of Arctic Foxes are always towards the south.—As a proof of movements towards the north may be mentioned that NANSEN (1897, II, 69—73) found the tracks of four foxes not far from the Pole at about 85° north and 75° west. The tracks led nearly in the same direction, towards the north-east.—We have to remember that individuals caught far down in the forest zone are easily recognized as stragglers, while movements in other directions may escape notice because the animals when caught, are thought to belong to the native population. If, however, the immigrants belong to a population in which the proportion between the blue and the white phases is markedly different from that found in the resident population, then, of course, the arrival of migrants may make itself felt in the catch as an alteration of the normal blue to white ratio. We shall attempt to show that this happens repeatedly in West Greenland.

The big variations found in the blue to white ratio in West Greenland have been refered to by R. MÜLLER (1906, 301) and by A. S. JENSEN (1928, 39) without any attempt being made to explain this fact. Müller mentions the winter 1887—88 as remarkable for the exceptionally large surplus of white foxes which was caught.

At Thule, in extreme northern West Greenland, FREUCHEN (1935, 124) "observed that whereas in some years four to seven per cent of the foxes caught were white, their number would at times grow to over sixty per cent for no apparent reason, falling the next year to about six per cent". Freuchen would not entirely reject the assertion of the Eskimos that this is due to climatic influences, having ascertained that during the summer before the catch of many white foxes the weather had been exceptionally cold. He thinks it more probable, however, "that the preponderance of westerly winds had driven the ice, and with it wandering foxes, from Ellesmere Land and North Devon to Greenland", but "on the other hand", he says, "one does not see so many foxes on drift ice that it would mean such a pronounced increase as was the case here (three or four hundred foxes)". According to private information (quoted below p. 23) from Mr. Hans Nielsen, the present chief trader (Kolonibestyrer) at Thule, the prevailing opinion up there now is that the white foxes arrive when there is lemming scarcity in Ellesmere Land.

There is absolutely no foundation for the assumption mentioned first by Freuchen that a climatic influence may alter the blue to white

ratio of a population. The dimorphism in the Arctic Fox is known to be dependent on genetic differences. Thousands of blue foxes are kept nowadays in a domesticated or semi-domesticated state, and yet no case has ever been recorded of an alteration towards the white variety. The absence or extreme scarcity of individuals showing transitional characters, also is against such an assumption.

Fluctuations in the numbers of blue and white foxes in the Upernavik District during the last twenty years (see plate at end of paper) are especially suggestive of invasions. Here we find a very distinct four-year cycle in total numbers, as well as in the numbers of white as percentages of the totals (dotted line). As previously mentioned such a four-year cycle (the actual length may vary somewhat) is peculiar to lemming fox populations and is not normally found in coast foxes. Even a superficial examination of the plate shows that in the northern districts an exceptionally high percentage of whites tends to appear at intervals of about four years. In analysing this phenomenon further we need to know the years of Arctic Fox maxima and lemming maxima in Canada in the past, and we may discuss, therefore, as a beginning, the sources of this information.

Firstly, we have the graph illustrating fluctuations in the Hudson's Bay Company's fur returns (1850—1914). As originally published by HEWITT (1921, 221) it represents the numbers sold in London in the years indicated. ELTON (1924) used these figures for deducing the lemming maxima, but, as pointed out by MACLULICH (1937, 8), he was in error in assuming that the skins sold in London during any particular year were caught in the winter ending the same year. As a matter of fact, the auctions were held in spring, and the figures represent mostly the catch of the season ending the previous year. They may even include some skins taken two years previously, owing to delay of shipments by ice (POLAND, 1892, XX). Thus, for instance, a peak on the curve in 1869 means maximum catch in Canada in the winter of 1867/68 and probably a lemming maximum in the summer of 1867 with subsequent die-off.

Secondly, we have a list of fox maxima at Fort Chimo, Labrador, published by ELTON (1931 b, 686) as a result of studies of account books.

Thirdly, the list of Snowy Owl invasions into southern Canada and U. S. A., published by GROSS (1931, 1935) offers an important index of lemming scarcity in the North (GROSS, 1931). The years of Snowy Owl invasions coincide well with the years of maximum abundance of foxes (GROSS, 1931). The owls, like the foxes, are principally dependent on lemmings, increasing and decreasing with the same rhythm as lemmings and foxes. It appears from an observation by STEFANSSON (1923, 26) that there is even a more direct link between owl and fox. One day in

the autumn of 1914, in southern Banksland, Stefansson observed several foxes digging up lemmings from under the snow. Here and there on the top of a small hill an owl sat watching the foxes. When a fox had traced a lemming and was about to plunge through the snow cover for it, an owl would silently approach, and the moment the fox had caught the lemming, the owl would violently attack the fox with the obvious intention of scaring it into dropping its prey. In the cases observed by Stefansson (he does not state how many) the owl was not successful, but Eskimos assured him that they had seen the fox drop his prey, which was then secured by the owl.

This interesting observation apparently has been overlooked by biologists, buried as it is in a book of travel (not mentioned in BENT, 1938). It explains how the owls, in spite of their inability to get at lemmings under snow, may subsist in great numbers in the North in winter, when there are plenty of these rodents. After the decline of lemmings the owls go south in large numbers.

The Northern Shrike (*Lanius b. borealis*), which breeds immediately south of the timber line, also shows a well marked four-year cycle in abundance during its southward migration in winter, and the years of maximum abundance coincide with those of Snowy Owls and Arctic Foxes (DAVIS, 1937). The shrike also depends chiefly on mice.

As a supplement to the above mentioned reports we have SPEIERS' (1939) account of fluctuations in numbers of birds in the Toronto region. He points out that, besides Snowy Owls and shrike, the numbers of wintering Rough-legged Buzzard also show a corresponding three to five year cycle, but he is of opinion that the large numbers of Snowy Owls, Rough-legged Buzzards and Northern Shrikes in the South in certain winters are not due to a simultaneous lack of food in the North. As an alternative hypothesis it is suggested that these birds migrate every year, usually in small numbers, but after a successful breeding year they are common enough to attract general attention. This is true as far as shrike and buzzard are concerned (with the reservation that they probably migrate owing to lack of accessible food[1]), but in the case of the Snowy Owl Speiers is apparently not right. This owl will occasionally remain in the north in winter, nearly or quite as far as the northern limit of its breeding range (Lincoln in BENT, 1938, 371). GROSS (1931, 504) writes that according to Sutton there were few nesting pairs of Snowy Owls on Southampton Island in the summer of 1929, but during the following winter the birds became extremely abundant,

[1]) According to Townsend (in BENT, 1937, 269, 279) the migrations of the Rough-legged Buzzard are dependent on the snow cover which prevents the birds from getting at the mice. The earlier the snow fall comes, the earlier the birds go south.

no doubt owing to the great abundance of lemmings. Speiers says that in the winters of 1905/06 and 1926/27 these birds occured in the South "when according to DAVIS (1937) Microtus in the north was at its peak of abundance." This statement must be due to a misunderstanding of Davis. As to 1926/27 he stated, on the contrary, that the die-off began late in the summer of 1926. It is true that CABOT (1920, 294) from whom the record of the other maximum is taken, stated that in 1906 "the mice disappeared with the snow". Apart from the possibility that the decline in Labrador really began earlier this may well have been the case further north.

The result of this necessary digression is that while the maxima in numbers of Rough-legged Hawks and Northern Shrikes generally coincide with the years of Snowy Owl invasions the latter are the more reliable indices of fluctuations in the numbers of lemmings and other mice. The owls may remain in the north in winter during lemming maxima owing to their ability to hunt in the dark and their parasitic habit of robbing the foxes.

Scattered in books of travel, reports of expeditions etc. are to be found some indications as to fluctuations in the numbers of lemmings and foxes. Some compilatory work of this kind has been undertaken by the author without any claim to completeness, and a few statements are cited below, when they are thought to shed light on the present problem. In this respect statements on the more or less successful breeding of Snowy Owls and Long-tailed Skuas are also important as indirect evidence of lemming numbers, since these species do not breed in bad lemming years (c. f. LØPPENTHIN, 1932, 96; BERTRAM, LACK, and ROBERTS, 1934).

We may begin the discussion of the evidence of immigrations of foreign foxes into West Greenland by considering the last twenty years, because the most complete information is available for this period permitting a somewhat closer analysis of the phenomenon. By consulting the table[1]) at the close of this paper or the graphic representation of the figures on the plate, it will be seen that, in the most northern district, Upernavik, the figures representing the total catch of foxes form very distinct peaks during the winters of 1923, 1927, 1931, and 1935. The published "hunting records" ("Sammendrag af Fangelister") show that a large part of the skins procured during the peak years originate from the extreme northern part of the district, where the catch is very

[1]) In this table, as elsewhere in the present paper, percentages of white foxes are always given with one decimal. This may seem absurd when the numbers are small, but it has the convenience that it may be seen at a glance whether a certain figure means a number of skins or a percentage, and furthermore the percentages are always accompanied by the figures on which they are based.

small during ordinary years. It may be seen that the curve illustrating the percentage of white foxes in the catch varies with that of the total catch, there are peaks strictly corresponding to the maximum catches. These peaks in the percentages reappear in the curves pertaining to districts further south (where the curve of the total catch does not show such peaks), but as we proceed southwards they gradually disappear. It is interesting in this connection to know something about conditions further north, in the Thule District, where, until a few years ago when it was taken over by the government, trading was carried out by a private company.

Mr. Hans Nielsen, the chief trader, has kindly answered my questions concerning the biology of the Arctic Fox at Thule, especially as to possible evidence of migrations, his letter of August 1st, 1938, containing the following statements: "It is well known here in this district that the blue foxes breed along the coast from Melville to Etah at bird cliffs, especially at cliffs inhabited by Little Auks, and these foxes are known to migrate towards the south during the autumn and winter. North of Etah they are mostly white foxes (which is also the case in Ellesmere Land). The white foxes also go south, but as a rule not until the end of January and during February. The migrating white foxes seem to drive out the blue ones. For instance when there is good hunting of blue foxes at a dwelling place, the catch of these often becomes very small after the arrival of the white fox.

Traces of foxes are very often met with far out at sea, especially in places where there are bears. During the years 1923, 1927, 1931, and 1935 white foxes were comparatively numerous. People here think that these years coincide with the periods—every four years—when there are few lemmings in Ellesmere Land."

Later I had the good fortune to be able to discuss the matter with Mr. Nielsen personally, who also informed me that artificial feeding is practised in the Thule district. The foxes, therefore keep to the feeding places and if they disappear from a place or if others arrive, this is easily observed. During late years some polar Eskimos have been living permanently at Cape Melville in the extreme south-eastern part of the district at the Melville Bay.—Here a headland reaches far out into the bay. It consists of several mountains with short valleys in between, through which many foxes migrate, so providing very good fox hunting.

Through the courtesy of Mr. Rudolf Sand and Mr. Rosendahl I have obtained a list of the numbers of skins received from the Thule District during various years, and also some lists stating the numbers traded monthly in some years, which will be referred to later. It is important to note, however, that these figures do not represent the whole catch, because in this district some 2—300 skins are used yearly

by the inhabitants themselves, and unfortunately the proportion between blue and white skins among those which are retained varies according to catch and fashion. It may be seen from figure 2 that the maxima in the total catch and the percentages of the white variety

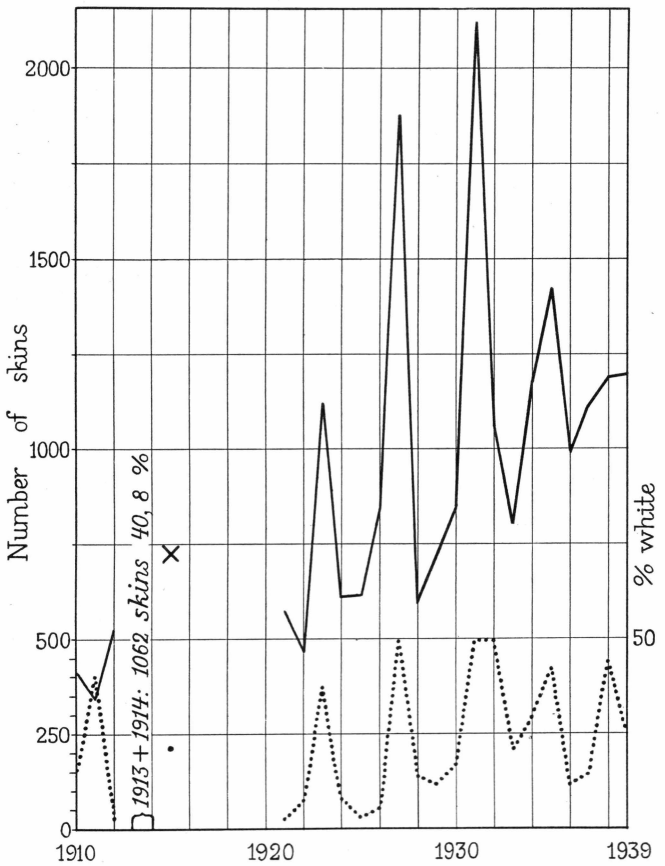

Fig. 2. Numbers of skins of Arctic Foxes received from the Thule District. Dotted lines: percentages of white.

coincide perfectly with those found in Upernavik and further south, as already mentioned above for 1923—35 on the authority of Mr. Nielsen.

In the first three columns of table I are listed the years during which we should expect emigrations of foxes from Arctic Canada. They are based on the sources discussed above. The first column contains the years of maximum catch of foxes traded by the Hudson's Bay Co. Up to 1913 they are deduced from HEWITT (1921, 220), but for the later years the following sources, which agree with each other, are made use of: Statements by Dr. Elton (1931 b, 686, and by letter 1936), and a list of the numbers sold at the H. B. Co.'s auctions in London during

Table I. Table comparing winters with high percentages of white skins in northern West Greenland (column IV) with winters during which emigrations of foxes from neighbouring regions are probable from various sources (column I—III and VI). See the text. The meaning of column V is explained on p. 39. "1852" means winter of 1851/52, etc.

Maximum catch of Arctic Foxes		III	IV	V	VI
I Canada (H. B. Co.)	II Ft. Chimo (Elton)	Snowy Owl invasions	W. Grl. maximum percentages	"Mad foxes" W. Grl.	Fox maximum N. E. Grl.
? 1852	..	..	1852	..	..
1853	..	..	..	..	..
1855	..	..	1856	..	..
1860	..	..	..	..	..
1863	..	..	1864	..	..
? 1865	..	..	..	..	..
1868	..	..	1868	? 1868	..
..	..	..	..	..	1870
1872	1873	..	? 1873	..	..
..	..	..	..	1875	..
1877	..	1877	? 1877	..	..
1883	1883	1883	1884	1884	..
1887	1888	1887	**1888**	..	..
1891	1891	1890	1892	..	1891 or 92
1895	1894	1893	..	? 1894	..
1898	1898	1897	..	..	..
..	..	..	..	..	? 1899
1902	1902	1902	..	?summer 1902	..
1906	1906	1906	(Up. 1906) 1907	summer 1906 1907	1907
1910	1910	..	1910—11	1910, ? 1911	..
?	1914	..	? 1914	..	..
1918—19	1918	1918	1919—20	1919, 1920	..
1922—23	1922	..	1923	..	..
..	..	..	..	..	1925
1927	1927	1927	1927	..	..
..	..	..	..	..	1929
1930—31	..	1931	1931—32	1931—32	..
..	..	..	..	..	1933
1935	..	1935	1935	1935	..
..	..	1938	1938—39	..	1938

the years 1914—39 according to information received from the Company by Mr. Seidenfaden, and kindly placed at my disposal. Assuming that skins sold in the autumn were traded during the season ending the same year, while those sold in spring are from the previous year, the

numbers of white foxes traded during the various trapping seasons are in round numbers as follows:

1915..... 10.000	1923..... 57.000	1931..... 74.000
1916..... 6.000	1924..... 18.000	1932..... 34.000
1917..... 6.000	1925..... 43.000	1933..... 24.000
1918..... 22.000	1926..... 26.000	1934..... 35.000
1919..... 22.000	1927..... 56.000	1935..... 52.000
1920..... 10.000	1928..... 19.000	1936..... 46.000
1921..... 21.000	1929..... 19.000	1937..... 25.000
1922..... 50.000	1930..... 36.000	1938..... 39.000

It is interesting to note that the years 1923, 1927, 1931, and 1935, during which there was an exceptionally big invasion into the Upernavik District, are even exceptionally rich years in Canada. During the years before 1915 the catch only once exceeded 15.000 (1877: 24.000). No doubt the comparatively large catch in Upernavik is, to some extent, due to a growing interest in this industry owing to the rise in prices, and in Canada the trapping has also grown more intensive, but it seems improbable that these circumstances alone could bring about such results.

In a few instances a maximum is stated in the table to cover two years. This means that there are regional differences, a peak has occurred in one part of Canada's Eastern Arctic during one year, and in another part it is not reached until the next (Elton, from study of account books and records from the various posts). The figures cited above make it probable that this was also the case during 1935 and 1936.

The next column contains the years of maximum catch at Fort Chimo, Labrador, according to statements by ELTON (1931 b, 686).

Dr. Elton further informed me (by letter) that in Baffin Island things are sometimes different; at Lake Harbour there seems to have been a maximum during the winter ending 1926 (based on reports, not fur returns, but confirmed by scarcity the following years).

Column III (invasions of Snowy Owls into temperate Canada and U. S. A.) is from GROSS (1931, 1935), except 1938 which is taken from SPEIERS (1939, 413) and refers to the Toronto region only,—and 1887 which has been derived from various sources. GROSS (1931) mentions no invasions between 1883 and 1890, but he says that "it is possible that in the years when there were no Snowy Owl invasions corresponding to the Arctic Fox four years maximum that a migration on a smaller scale occured which did not attract sufficient attention of ornithologists to be put on record as a whole. This assumption is borne out to a certain extent by individual records of Snowy Owls published by newspapers and various ornithological journals in those years."

Since it proved very important in the present connection to know for certain whether 1887 or 1888 was the year of lemming minimum (see below) I have looked up records for these years and find fairly good evidence that a Snowy Owl invasion occurred during the winter ending 1887. According to notes in the periodicals "American Field" and "Forest and Stream" (cited in "Auk", **4**: 341, 1887 and **5**; 315, 1888) several were recorded from Illenois and Michigan. Further one was shot in South Carolina, Dec., 1886 ("Auk", **8**: 55, 1891), and some were seen in Montana during the same winter ("Auk", **12**: 214, 1895).

Column VI contains a list of winters during which emigrations of foxes from East Greenland might be expected to have occurred, according to information brought together in the next chapter. It may be seen that during the period with which we are concerned at present they have been entirely out of step with those for Canada and with the years during which there was an abnormal surplus of white foxes in northern West Greenland, and therefore we may exclude the possibility that these extra, white, foxes have come from that region via the inland ice. That some foxes may arrive by this route—however strange this may seem—is indicated by an observation recorded by I. P. Koch (1913, 237), who during his journey over the "Great Ice" from Dove Bay in North-East Greenland to the Upernavik District on June 13th, 1913, saw the fresh tracks of two foxes, which, coming from the direction of Melville Bay, had been travelling at a steady speed toward the east. There is no reason why such crossings of the inland ice should not occur sometimes in the opposite direction, but there is no evidence that this occurs on a scale sufficient to influence the catch in West Greenland.

The percentage of the white variety among the foxes which invade northern West Greenland during the years listed in the table must be very high to bring about such changes in the composition of the catch. The Canadian foxes fulfil this requirement. According to information from Dr. Elton the percentage of the white variety in Baffin Island and Ungawa Bay is nearly 99. In N. E. Greenland this percentage is much lower. Even allowing for the fact that the blue variety preponderates among the foxes which live at the bird cliffs, while the percentage of white is comparatively high among the foxes substisting on lemmings, migrants from East Greenland may be expected to contain about ten per cent of blue foxes. This means that there may be invasions from N. E. Greenland without any well marked effect on the catch. In extreme northwestern Greenland, where lemmings are also present the maximum years are probably most often simultaneous with those of Canada. At least there is evidence of fox maxima here during the winters of 1873 and 1877 (cf. Bessels, 1879, 347, and Feilden, 1877), which agree

with Canada, while at the same time maxima in N. E. Greenland were apparently out of step (maximum 1870).

Thus the white foxes invading the districts of Thule and Upernavik during certain years may also originate from the extreme northwestern parts of Greenland itself. Most probably they are partly derived from there and partly from Ellesmere Land.

It may be seen from the main table and graph that in certain years the influence of the invasions make themselves felt far to the southward. In the period with which we are at present concerned, this was the case in 1923. The figures representing the percentages of white foxes show a very distinct maximum in this year as far south as Egedesminde, and even in the district of Holsteinsborg there would seem to have been some extra, white, foxes in the catch from that year.

There are certain facts indicating that the surplus of white foxes during certain years in these parts are not due to a continuance along the coast of the invasions which have reached the more northern districts —or at least not exclusively. On the contrary, certain observations show that foxes may arrive with that stream of drift ice which in Greenland is called the "west ice". The literature contains several records of foxes having been found far out at sea on the drifting pack west and east of Greenland. As to the Baffin Bay ice (called "west ice" in Greenland) there are at least two records of foxes having been encountered far from the nearest land. A blue fox was shot in March, 1858, at the ship "Fox", which was then drifting with the ice off Upernavik, 130 geographical miles from the nearest land (MCCLINTOCK, 1859, 88), and members of Hall's expedition saw a fox while drifting with the pack 150 km off the coast of Labrador on April 4th, 1873 (Petermanns Mitth. **1873**, 387).

Evidence that this ice may bring foxes in considerable numbers is, however, published here for the first time. This evidence is especially important in this connection because there is agreement as to time with the theory, the correctness of which we are endeavouring to prove. Mr. Poul Hansen, M. Sc., who is engaged in fishery investigations in Greenland, told me that he had heard from Mr. Rosendahl, then chief administrator of the province of North Greenland, that during the spring of 1931 many white foxes were caught on the "west ice", and that the Greenlanders remarked that these foxes looked different from the resident foxes. Mr. Rosendahl, with a readiness by which the present investigation has often profited, gave further information (by letter Nov. 1938). On June 16th, 1931, Mr. Rosendahl on official business visited a Norvegian whaler anchored at Hunde Island in Disko Bay. The captain of this boat told him that the previous day he had met two Norvegian sealers, which at that time were lying 120 miles west of Wester Island

(the most western island in the northern part of the Egedesminde district). The crew told him that they had arrived on the first of April at the border of the "west ice" 15 miles off Kangatsiak (an outpost in the Egedesminde district, 45 km south of Wester Island) and since then they had been hunting walrus. On June 1st they were 60 miles off Wester Island, the ice being as usual at that time drifting rapidly toward the west, and on June 14th—15th they were, as previously mentioned, 120 miles out at sea. During all this time while hunting walrus they had been able to shoot ten bears and many white foxes. They had not stated the number, however.

The Greenlanders of the Egedesminde District told Mr. Rosendahl that several times during that summer they found carcasses of walrus left by the Norwegian hunters on the drift ice, and they had also seen some skinned foxes. It was one of these Greenlanders who said that in his opinion the skulls were not quite like that of the foxes usually found in the district.

To the last statement we may remark that Canadian foxes are generally larger, with a broader brain case than the West Greenland foxes.

Especially the fact that the foxes were designated as "white" is against an origin from the nearest land, because in the Egedesminde District about two thirds of the foxes belong to the "blue" variety.

Later Mr. Rosendahl has kindly collected additional information for me on the occurrence of foxes in the "west ice". The Greenlander Martin Larsen, who with four others use to hunt for walrus in this pack, states (by letter, June 1939) that in 1932 he saw two foxes 20 km from the nearest land, and in 1935 he saw three foxes "one blue and two black ones" about ten km out at sea. These observations were probably made during late spring or early summer.

It is not surprising that blue foxes also occur on the drift ice, they may perhaps come from the Thule District where the blue foxes are known to go south in winter, as previously mentioned.

The experienced fox hunter Johs. Filemonsen, who lives at a place called Tunungassok in the southern part of the Egedesminde District, has answered a number of questions on foxes put by Mr. Rosendahl, by letter of June 27th, 1939, from which we may here quote that part which refers to foxes on the "west ice": "During 1918 many foxes were seen out on the west ice, and nearly all of them were probably caught. These foxes are no doubt not Greenland foxes, they are white and larger than our foxes, and the fur is more dense. In 1932 the west ice brought blue foxes, which are also a little different from our blue foxes. The blue foxes of the west ice have bluish teeth. These foxes have probably come from southern or northern Greenland. They are also more tame

than our foxes. That, indeed, is the reason why they were all caught in a short time. One hunter during a single fox hunting caught 42 foxes.

In 1937 foxes of the same kind as those of 1918 arrived. They were all white, and were few in numbers. These foxes landed on the islands, from which they kept away Black-Backed Gulls and other birds. Personally I have only seen three of these foxes caught."

It may be observed that 1918 (like 1931) was a year during which we might expect an emigration of foxes from Canada to have occurred, and during the season 1918/19 more white foxes than usual were in fact caught in the Egedesminde District. During 1937 we should apparently not expect an invasion of foxes into Greenland, and it is expressly stated that there were only a few that year.

In discussing the origin of these "drifting" foxes we need to know something about the Baffin Bay pack ice, its sources movements and extension.

According to SMITH (1931, 43) supply for the Baffin Bay pack comes from "the upper reaches of Smith Sound, from the water arms of the American Archipelago via Jones Sound, Lancaster Sound, and Eclipse Sound, and from the fast ice formed locally around the shores of Baffin Bay. The floes converge as they feed into the narrow neck of Davis Strait, and passing out to the south, relieve the congestion in the upper waters."

The extension of this pack ice varies a good deal. "If large quantities of fast ice break up in Melville Bay, and if the winds drive across additional masses, the navigation that particular spring and summer will be greatly hampered, and the only means of proceeding north-ward in such a year is to hug the Greenland shore to Cape York, hence to steer westward. . . . . If little ice is formed or if the normal amount fails to break out of Melville Bay, Smith Sound and the Arctic Archipelago, the pack will be of small extent and the so-called North Water will enlarge. . . . . In occasional winters pack ice is said to fill Baffin Bay solidly from shore to shore." (SMITH, 1931, 44).

This drift ice is always passing close to the Baffin Land coast, though in summer a narrow lead is formed along the shore. It is the eastern limit which is variable. Commonly the pack lies close to the shore in spring as far south as the Egedesminde District, occasionally this may happen in the Holsteinsborg district, and even—but very seldom—in the district of Sukkertoppen or even Godthaab. During such years nothing prevents foxes from passing directly from Baffin Land to Greenland. It is true that older authors have often described the pack as being split into two separate streams of ice, but SMITH (1931, 43) says that this is not borne out by a careful analysis of conditions as a whole. There are more or less compact portions of the ice, but the agility of

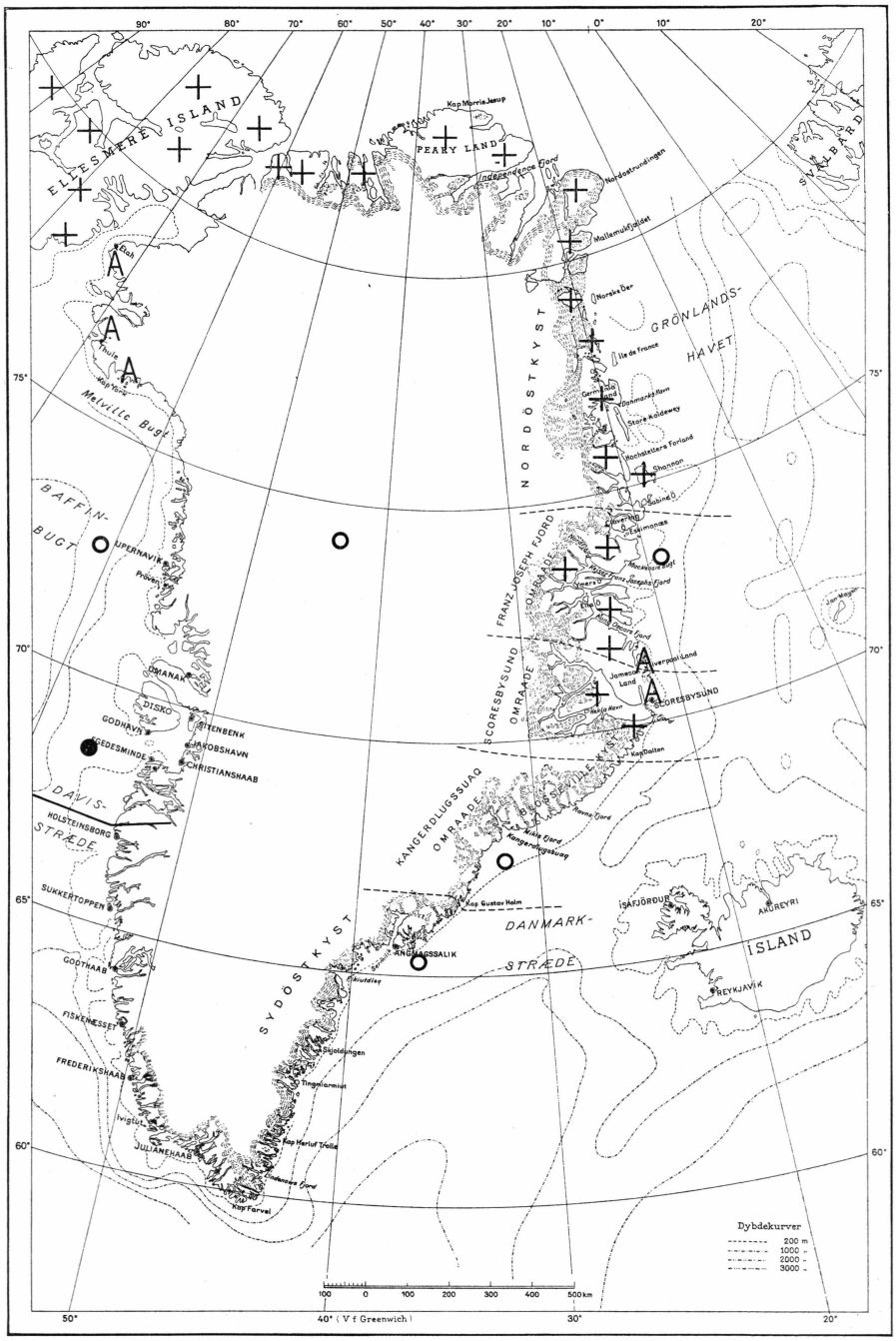

Fig. 3. Map of Greenland indicating the position of the principal trading posts. The line north of Holsteinsborg, which indicates the division between the administrative provinces of North Greenland and South Greenland, coincides with the southern limit of the districts in which periodic invasions of white foxes usually make themselves felt in the catches.

++ Area inhabited by lemmings.

AA Rich breeding places of the Little Auk on the Liverpool Coast and in the Thule District.

O Positions where foxes were found on drifting ice or inland ice according to records in literature.

● Approximate locality where many white foxes were caught by a Norse sealer in the spring of 1931.

Table II. Total number and percentage of white.

Percentages based on figures less than six are in brackets.

Egedesminde.

	Oct.	Nov.	Dec.	Jan.	Febr.	March	April
1922	**121** 43,0	**24** 20,8	**21** 71,5	**21** 47,6	**20** 45,0	**4** (25)	**26** 50,0
1923	**103** 57,3	**35** 57,1	**1** (100)	**15** 86,6	**63** 77,7	**6** 66,7	**21** 66,7
1924	**134** 44,0	**9** 44,5	**4** (50)	**15** 66,7	**14** 64,4	**1** (100)	**42** 52,4
1925	**123** 48,8	**38** 50,0	**15** 26,7	**47** 63,8	**42** 40,5	**22** 54,5	**18** 50,0
1926	**233** 47,6	**18** 38,9	**3** (0)	**18** 44,5	**18** 38,9	**32** 56,3	**12** 25,0
1927	**136** 50,0	**25** 36,0	**2** (50)	**15** 46,7	**10** 40,0	**15** 53,3	**26** 53,8
1928	**255** 39,6	**57** 45,6	**12** 41,7	**14** 35,7	**36** 38,9	**48** 29,2	**59** 52,5
1929	**215** 32,6	**73** 46,6	**10** 20,0	**8** 0	**39** 35,9	**65** 29,2	**77** 46,7
1930	**232** 30,2	**121** 40,5	**9** 22,2	**9** 55,5	**26** 61,5	**94** 40,4	**22** 22,7
1931	**250** 38,8	**67** 20,9	**25** 32,0	**37** 27,0	**34** 53,0	**137** 52,6	**51** 60,7
1932	**218** 35,3	**75** 34,7	**24** 41,6	**26** 26,9	**15** 46,7	**128** 45,3	**69** 40,6
1933	**416** 38,7	**97** 30,9	**20** 35,0	**75** 30,5	**78** 41,1	**243** 49,8	**37** 27,0
1934	**191** 24,6	**197** 34,0	**17** 5,9	**28** 64,3	**147** 41,5	**72** 38,9	**25** 52,0
1935	**246** 30,9	**107** 45,8	**10** 30,0	**9** 45,5	**114** 51,7	**68** 60,3	**23** 43,5
1936	**320** 34,7	**96** 45,8	**8** 37,5	**9** 33,3	**39** 41,0	**88** 45,5	**84** 45,3
1937	**197** 30,4	**128** 32,1	**8** 25,0	**38** 39,5	**151** 35,2	**34** 32,4	..

the Arctic Fox in passing stretches of water with scattered pieces of ice has often been admired by observers (e. g. ARMSTRONG, 1857, 363, MANNICHE, 1910, 45).

Thus it seems that foxes may sometimes reach the shores of Greenland between the Melville Bay and the Holsteinsborg District by drift ice from the Thule District, from the Arctic American Archipelago, and from Baffin Land. Fortunately the yearly reports from these parts (as well as the published general reports) contain some information as to the occurrence of the Baffin Bay pack ice ("west ice") during the various years.

The pack ice is not a barren place to an Arctic Fox. The most important source of food here is probably remnants from the meals of the Polar Bears. It is a well known fact that the foxes habitually follow the bears in order to profit by their seal hunting. Remarks on foxes seen following bears, or of fox tracks and bear tracks going in the same direction close to one another are so frequent in arctic literature that one gets the impression that it is normal for a bear to be followed by one or more foxes. The fox usually waits until the bear has finished his meal, but there are even records of foxes which, forgetting their fear, steal meat "so zu sagen unter den Tatzen des glücklichen Fangers" (WRANGEL, 1839, 323, cf. also MANNICHE, 1910, 43). Human seal hunters

Table II (continued).

Disko Bay Settlements

	Oct.		Nov.		Dec.		Jan.		Febr.		March		April	
1922	**55**	45,5	**30**	33,3	**15**	33,3	**30**	50,0	**8**	75,0	**14**	64,4	..	
1923	**56**	85,7	**34**	88,2	**19**	94,8	**24**	75,9	**13**	76,9	**22**	86,4	**3**	(100)
1924	**70**	67,2	**29**	82,7	**12**	75,0	**21**	76,2	**7**	71,5	**16**	87,5	**16**	68,7
1925	**139**	72,7	**29**	55,1	**26**	42,3	**38**	57,9	**11**	63,6	**16**	50,0	**10**	70,0
1926	**69**	71,0	**17**	41,2	**8**	37,5	**10**	40,0	**14**	57,2	**22**	50,0	**15**	60,0
1927	**101**	61,4	**52**	69,3	**13**	46,2	**21**	81,0	**31**	64,5	**26**	69,2	**16**	62,5
1928	**160**	60,6	**47**	72,4	**22**	59,1	**22**	68,2	**32**	56,2	**7**	71,5	**9**	55,5
1929	**108**	59,3	**57**	50,9	**25**	56,0	**21**	47,6	**21**	66,7	**29**	72,5	**43**	44,2
1930	**196**	58,7	**47**	55,3	**36**	61,1	**40**	55,0	**14**	57,1	**21**	47,6	**17**	58,8
1931	**129**	80,6	**66**	72,7	**41**	78,0	**43**	81,4	**40**	75,0	**26**	76,9	**17**	64,7
1932	**101**	72,3	**62**	74,2	**27**	81,5	**60**	68,3	**29**	78,9	**21**	81,0	**13**	69,2
1933	**157**	68,8	**86**	54,7	**39**	59,0	**63**	68,3	**23**	78,3	**24**	62,5	**10**	50,0
1934	**88**	61,3	**37**	51,3	**14**	42,9	**42**	54,7	**52**	46,2	**26**	57,7	**10**	30,0
1935	**95**	65,3	**50**	68,0	**28**	50,0	**36**	75,0	**46**	50,0	**26**	53,8	**22**	63,6
1936	**161**	49,7	**32**	56,3	**21**	66,7	**12**	41,7	**18**	72,2	**14**	85,7	**14**	50,0
1937	**88**	51,1	**30**	53,3	**12**	33,3	**33**	42,4	**19**	47,4	**28**	57,2	..	

may sometimes leave ample meals for the foxes, carcasses may be found drifting, and at certain times birds may be secured. BAIELY and HENDEE (1926, 16), who in the spring of 1922 heard foxes upon the drifting pack in Bering Strait, remark that at that season they would probably have little difficulty in catching eider duck.

The fox may even catch certain lower marine animals among the drift ice. The small fish *Gadus saida*, which has been known since Fabricius' time as an arctic shore fish, also occurs among pack ice. This was observed several times at East Greenland (cf. A. S. Jensen, 1904, 267) and also north of Bering Strait (cf. JORDAN and EVERMANN, 1898, 2553). According to FABRICIUS (1780, 143) the Arctic Fox is able to catch this fish through cracks in the ice, alluring it by stirring the water. CRANZ (1770, 98) discribes the same thing, but he does not give the species of fish. Sometimes the fish may jump over the ice and the fox takes this opportunity of securing it. As a confirmation of this last statement may be mentioned that, according to Richardson, *Gadus saida* has been seen in Northumberland Sound to jump by hundreds on to the ice in endeavouring to escape the white whale (cf. JORDAN and EVERMANN, 1898, 2553).

Table II shows the number of foxes killed and the percentage of the white variety among them during the months of the years 1922—1937 in the Districts of North Greenland. As usual the districts of

Table II (continued).

Umanak

	Oct.	Nov.	Dec.	Jan.	Febr.	March	April
1922	**11** 9,9	**4** (25)	**2** (0)	**2** (50)	**0**	**0**	**1** (100)
1923	**8** 75,0	**12** 83,4	**1** (100)	**1** (100)	**1** (100)	**1** (0)	**0**
1924	**7** 57,2	**3** (33)	..	**1** (100)	**0**	**0**	**0**
1925	**13** 38,5	**7** 14,3	**3** (33)	**0**	**1** (100)	**0**	**0**
1926	**8** 50,0	**6** 33,3	**0**	**2** (0)	**1** (0)	**0**	**0**
1927	**34** 41,2	**6** 0,0	**3** (33)	**2** (0)	**1** (100)	**0**	**1** (100)
1928	**39** 25,6	**17** 17,7	**3** (0)	**7** 42,9	**2** (0)	**3** (33)	**1** (0)
1929	**41** 26,8	**17** 11,8	**9** 22,2	**9** 22,2	**6** 50,0	**2** (0)	**0**
1930	**33** 30,3	**7** 42,8	**8** 0,0	**12** 33,3	**0**	**3** (33)	**1** (100)
1931	**30** 53,3	**24** 79,1	**5** 80,0	**14** 78,5	**13** 69,3	**2** (50)	**2** (50)
1932	**22** 63,6	**10** 70,0	**11** 27,3	**12** 58,3	**3** (67)	**1** (0)	**3** (67)
1933	**36** 38,9	**8** 87,5	**10** 40,0	**19** 36,8	**3** (33)	**1** (100)	**0**
1934	**24** 37,5	**10** 30,0	**2** (50)	**17** 64,7	**7** 71,5	**5** (60)	**2** (50)
1935	**37** 75,6	**11** 90,9	**14** 100	**20** 90,0	**16** 93,7	**5** (80)	**2** (100)
1936	**40** 37,5	**11** 45,5	**6** 50,0	**13** 77,0	**6** 50,0	**6** 66,7	**1** (0)
1937	**29** 41,4	**11** 9,1	**2** (0)	**12** 58,4	**2** (0)	**1** (100)	**0**

Christianshaab, Jakobshavn, Ritenbenk, and Godhavn (Disko Bay Districts) are treated as a whole. This table is based on the original "hunting records" (Fangelister), which give the number of foxes caught by every hunter during each week. It was thought advisable, however, to treat each month as a unit in the table, partly because otherwise the numbers would be too small, and partly because at some dwelling places entrances on the list are evidently made only once a month. The units of course could not be made to agree exactly with the months, "October" includes a few foxes taken during September, "December" consists of five weeks.

Mr. Nielsen stated, as previously mentioned, that as a rule the white foxes do not arrive in the Thule District until February, and we should therefore expect them to arrive still later in the Upernavik District. On the contrary we find that during all four invasion years (1923, 1927, 1931, and 1935) the catch culminates in January, and during 1923 and 1931 the numbers caught are even abnormally high, made up almost exclusively of white foxes, from the very beginning of the trapping season. It is interesting that these years are the same as those cases in which the maximum in Canada is stated to cover also the previous year (1922, 1930, see Table I).

Fortunately a few lists are to hand stating the numbers of blue and white foxes traded in at Thule during each month in the calender

Table II (continued).

Upernavik

	Oct.	Nov.	Dec.	Jan.	Febr.	March	April
1922	**6** 50,0	**3** (33)	**1** (100)	**8** 25,0	**10** 50,0	**6** 33,3	..
1923	**19** 100,0	**31** 96,7	**35** 91,4	**50** 94,0	**38** 60,5	**5** (100)	**1** (0)
1924	**4** (100)	**3** (100)	**1** (100)	**0**	**0**	**0**	**9** 88,9
1925	**6** 83,3	**9** 66,7	**1** (100)	**2** (100)	**1** (0)	**0**	**1** (100)
1926	**13** 84,6	**10** 30,0	**5** (100)	**2** (50)	**4** (100)	**0**	**1** (100)
1927	**10** 70,0	**21** 61,9	**46** 91,3	**154** 96,8	**74** 93,2	**16** 87,5	**33** 81,8
1928	**8** 87,5	**6** 83,3	**5** (80)	**1** (100)	**1** (0)	**2** (50)	**1** (0)
1929	**11** 81,8	**3** (67)	**4** (50)	**2** (50)	**2** (100)	**2** (0)	**3** (67)
1930	**11** 54,5	**5** (80)	**4** (100)	**8** 75,0	**6** (100)	**1** (100)	**3** (67)
1931	**29** 100	**34** 100	**43** 97,7	**174** 92,0	**95** 97,9	**48** 91,6	**16** 87,5
1932	**16** 100	**16** 87,5	**40** 92,5	**61** 88,5	**38** 94,7	**11** 90,9	**13** 84,6
1933	**3** (67)	**3** (100)	**2** (50)	**1** (100)	**1** (0)	**1** (100)	**2** (100)
1934	**13** 69,3	**12** 91,6	**5** (100)	**26** 84,6	**21** 90,5	**9** 77,8	**2** (100)
1935	**4** (75)	**9** 77,8	**20** 90,0	**72** 93,0	**50** 96,0	**17** 82,4	**3** (67)
1936	**4** (100)	**5** (60)	**2** (50)	**8** 100	**5** (100)	**7** 71,4	**0**
1937	**6** 100	**2** (50)	**6** 33,3	**5** (20)	**1** (100)	**0**	**0**

years 1929, 1930, 1932, 1934, 1935, and 1936, which show that during the big invasion years the white foxes arrive early in Thule also (Table III).

The figures for the calender years 1929 and 1930 pertain to the whole district, while the rest are from the post of Thule proper, exclusive of two outposts.

In making use of these figures from Thule we have to keep in mind that some 2—300 skins yearly are retained by the natives and therefore the percentages are subject to some errors, but the differences are so great that we may be sure they are real.

It may be seen that during the trapping seasons 1929 and 1930 the white foxes do not seem to arrive until January or February, but during the winters of 1931 and 1935 they began arriving so early that the invasions into the Upernavik District may for that reason well have come via the Thule District.

There was apparently a minor invasion into N. W. Greenland in 1932 also. Not only are there caught abnormally many white foxes, but it may be seen that in the Upernavik District the catch, like in the preceeding year, did not culminate until January. This suggests that we have to do with a new invasion, because if these foxes were survivors from the previous year we should expect that most were caught during the first months, the more so as these months are the

Table III. Numbers of fox skins and percentages of white foxes traded montly in the Thule District.

	Oct.	Nov.	Dec.	Jan.	Febr.	March	April	May
1929	..	..	..	**61** 4,9	**113** 16,8	**140** 18,6	**171** 9,9	**70** 10,0
1930	**31** 0,0	**209** 1,9	**126** 3,2	**120** 26,7	**30** 16,7	**94** 17,0	**126** 43,7	**88** 26,1
1931	**57** 10,5	**97** 23,7	**295** 44,8	..	..	..	..	..
1932	..	..	..	**167** 72,5	**60** 68,4	**107** 58,9	**42** 66,7	**9** 44,5
1933	**11** 45,5	**28** 25,0	**54** 14,8	..	..	..	..	..
1934	..	..	..	**55** 52,7	**36** 44,5	**84** 27,4	**57** 33,3	**22** 54,5
1935	**79** 6,3	**61** 49,2	**164** 47,6	**67** 86,5	**54** 63,0	**65** 33,9	**77** 22,1	**32** 37,5
1936	**38** 7,9	**32** 21,9	**82** 13,4	**39** 23,1	**22** 13,6	**28** 10,7	**73** 2,7	**30** 16,7
1937	**46** 8,7	**39** 17,9	**99** 12,1	..	..	..	..	..

natural trapping season in North Greenland, because there is little other hunting at that time.

As to the districts south of Upernavik special interest attaches to 1923, during which an invasion made itself very plainly felt in the catch even as far south as the Egedesminde District. It may be seen that even in Egedesminde a surplus of white foxes is present from the very beginning of the trapping season. This is unexpected and at first sight rather puzzling. How could they arrive there at that season before the "west ice" comes near the coast and while the sea is still open? The explanation seems to be that they arrived during the late spring of 1922 and survived the summer in Greenland. There are two circumstances which lend support to this. Firstly, according to the "hunting records" three white foxes were caught at Kronprinsens Island far out in Disko Bay about May 1st, 1922, and also two white ones in the beginning of the trapping season 1923 (Oct. 1922). Since it is stated ("Grønland", I, 325) that there are no resident foxes on these islands there is reason to believe that these white foxes arrived there by ice during the late spring of 1922. Secondly, I had the good luck to find it stated in an ornithological report (LEWIS, 1923, 136) that the eiders of the southern coast of the Labrador Peninsula decreased in numbers rather than increased during the breeding season of 1922. "One cause for this", says Lewis, "was a notable invasion of Arctic Foxes, which appeared in the southern part of the Labrador Peninsula in April and May, 1922. I am informed that thousands of these animals were trapped before June 1st, but many of them remained on the southern coast, from Piashte Bay eastwards, throughout the summer, and destroyed large numbers of the ducks' nests on all but the most isolated islands. I am also informed that they killed some adult eider . . . .". These foxes were

probably brought by drift ice which may have the same source as that which brought the foxes to Greenland.

We may now proceed to discuss possible immigrations during the years as to which the evidence is more meagre and indirect. From 1852 onwards we have the advantage, however, of being able to compare the years showing abnormally high percentages of white with the maximum years in Canada of which from that time onwards we have a complete record from one or more sources (cf. table I, table V, and the plate).

1852.—The percentage of white foxes in "North Greenland" (i. e. from Egedesminde up to Upernavik)—68,5—is only surpassed by those of the big invasion years 1923 and 1927. The number of foxes caught at Upernavik—138—is unusually great. It may be thought that an invasion into Greenland during 1852 does not fit in well with the fact that, according to Hewitt's curve, a peak in numbers of skins taken by the Hudson's Bay Company was not reached before 1853, but to this it may be remarked that the figure for 1852 was almost equally high, which may mean that in a part of the region covered by the Company a maximum was reached during this year, and further we have evidence that in the region of Prince of Wales Strait at Bank's Land lemmings were already extremely scarce in the late winter of 1851. ARMSTRONG (1857, 303) states that in March 1851 the foxes along this strait were starving. In the stomachs of some of them which he examined he found either nothing at all or small pieces of dwarf willow. In one case the animal had swalloved a hoof of a rein deer.

During 1853 there may also have been immigrations into West Greenland; the Disko Bay figures especially suggest this.

A maximum in Canada during 1860 has made no impression whatever on the catch in Greenland, except possibly in Upernavik, but **1864** and **1868** are well marked invasion years. This is apparent at least as far south as Egedesminde, and at Upernavik also there are well marked maxima in the total catch. 1864 follows the Canadian maximum of 1863 (arrival in the spring of 1863?) while 1868 is simultaneous with a Canadian maximum. During **1873** and **1877** there are less well marked maxima in the percentages (marked by a ?). The 1873 maximum is simultaneous with a maximum at Ft. Chimo (also at Smith Sound N. W. Greenland, BESSELS, 1879, 278, 347) and 1877 agrees with a peak on the H. B. Co. curve and a Snowy Owl migration. In 1883 a maximum in Canada is indicated by all three sources, and the next year (**1884**) there is a tolerably well marked surplus of white foxes in northern West Greenland.

The percentages in **1888** suggest that this is a big invasion year during which foreign white foxes arrived at least as far south as Sukkertoppen and Godthaab. Opportunities for arrival of foxes from Canada during this year were apparantly very bad. It was a mild winter with

little local ice, and the "west ice" is stated to have kept away from the coast all winter. In the light of available information as to 1922 and 1923 we may assume that the many extra, white, foxes caught during 1888 arrived in the spring of 1887, during which there was much fast ice along the shores of northern West Greenland, and the "west ice" was said to approach the southern part of Egedesminde District in May. The foxes may have continued southward on the "Storis" i. e. "Big Ice" (drift ice brought by the current from N. E. Greenland round Cape Farewell) which during the winter of 1888 lay along the coast even up to Sukkertoppen, an unusual happening. An arrival during the spring of 1887 is in accordance with the data for Canada. There is a peak on the H. B. Co. curve in that year, and also a Snowy Owl invasion in the south (cf. above p. 27). At Ft. Chimo, however, the maximum was not reached until 1888.

An invasion during **1892** or the previous spring is very distinctly indicated by the figures for Egedesminde, but not in those from other places. The H. B. Co. curve and the Ft. Chimo data both indicate a maximum during 1891, but curiously enough there was a Snowy Owl migration already in the preceding year 1890.—In **1898** also the most distinct peak in the percentage is found in Egedesminde. During this year the "west ice" appeared in the Egedesminde District in December and at Holsteinborg in January, and at both places it lay close to the shore for a considerable time (during 1892 this ice also approached the coast, at Holsteinsborg at least). The evidence of Arctic Foxes in Canada indicates a maximum in 1898 while the Snowy Owl migration again occurred the previous year.

In **1907** there is a rather well marked maximum in the percentage of white foxes in all North Greenland. In Upernavik the main invasion seems to have occurred during 1906. In 1906 and 1907 the "west ice" lay close to the shore in the Egedesminde District during December and the following months. All three sources indicate a maximum in Canada during 1906.—In 1910 there was a fox maximum in Canada according to the H. B. Co. curve and Elton's statement concerning Ft. Chimo. However, to judge from information given by HANTSCH (1913, 150, 154) migrations from Baffin Land did not occur until 1911. Lemmings were still numerous here during the summer of 1910, but during the winter of 1910/11 they were scarce, and most of the foxes disappeared. The Greenland figures from Disko Bay northward indicate invasion during **1910** and **1911** in agreement herewith. At Thule the invasion culminated during 1911 (cf. fig. 2).

There are no H. B. Co. figures available for 1914. Ft. Chimo is said to have had a maximum in 1914, but at Banks Land it did not occur until 1915 as is seen from a statement by STEFANSSON (1923, II, 25)

to the effect that during the autumn of 1914 there were many lemmings, foxes, and Snowy Owls, the owls disappearing during the winter. In Greenland there may have been an invasion into Egedesminde and the Disko Bay Districts in **1914**, but the maxima in the percentages are so faintly indicated that this is rather uncertain. In Thule, however, there was apparently a big invasion in 1914 and a minor invasion in 1915. Unfortunately, no skins were sent home in 1913 so the figures for 1914 (1062 skins of which 40.8 per cent white) pertain to 1913 and 1914 together, but the fact that the percentage in 1915 is also abnormally high makes it permissible to conclude that the main invasion occurred during 1914.

There is good evidence of immigrations into N. Greenland during **1919** and **1920**, especially in the former year. In Canada there was a maximum in 1918 in some parts, while in other regions it did not occur until 1919. According to Philemonsen's letter quoted above, white foxes arrived by the "west ice" in the Egedesminde District during the calendar year 1918.

The period 1923—35 was treated above, and we need only add that the figures for **1938** and especially **1939** again suggest immigration, though not, by far, so well marked as in 1923, 1927, 1931, and 1935. From Canada we have the statement by SPEIERS (1939, 415) that there was a Snowy Owl invasion in the Toronto region in the winter of 1938, and further DAULT (1939, 234) at Belcher Islands in Hudson's Bay observed that lemmings declined rapidly to a minimum from March, 1938 onwards.

In column V of table I are indicated the times at which foxes were observed in northern Greenland (Upernavik-Egedesminde) showing symptoms of a disease which is commonly referred to as a sort of madness, the exact nature of which is, however, imperfectly known. (When not otherwise stated the observation was made during the winter ending in the year indicated. For instance "1907" refer to an observation made in December, 1906).

The reasons for supposing that there may be a connection between the occurrence of this disease in Greenland and immigrations of foreign foxes are as follows: ELTON (1931 b) described an epidemic disease among Canadian sledge dogs, which he thinks may be related to the fox encephalitis described by Green and others in silver foxes. "The disease is shown by strange behaviour on the part of the dogs, which foam at the mouth and run about in a peculiar way, finally becoming weaker and weaker until they die" (ELTON,1931 b, 674). The symptoms may vary considerably even when such cases are excluded as have nothing to do with this disease (some of the cases recorded are evidently true distemper, as suggested by Elton himself). The same symptoms are also

seen in Arctic Foxes and there is reason to believe that dogs may contract the disease by being bitten by "mad" foxes, or by eating dead foxes (ELTON, 1931 b, 690). This "madness" seems to attack the foxes especially or exclusively at the times when the lemmings disappear, which means that the migrating foxes are especially liable to have this disease which they may spread to other regions (ELTON, 1931 b, 689, also 1934, 64). If migrating foxes arrive in Greenland from Canada in certain years we should expect "mad" foxes to occur during these years.

As a matter of fact sledge dog epidemics of the same nature as those described by Elton have been known in Greenland for many years[1]), and it is also well known up there that the disease may be derived from "mad" foxes which often attack the dog teams. It is, indeed, the serious consequences of such happenings which cause them to be put on record. This disease in foxes and sledge dogs is commonly referred to in Greenland as "rabies", and HJORTLUND (1908), who was sent out to investigate it in 1906, diagnosed it as such. The fact that not a single case of transmittance to man is known from Greenland or Canada is strongly against this assumption, and Hjortlund's attempts to explain this fact were unconvincing, as pointed out by BAASHUUS-JESSEN (1935, 315). The latter (1935, 312) thinks that we have to do with a deficiency disease. There seems to be good evidence, however, of transmission by bite from dog to dog and from fox to dog, the period of incubation being as a rule three weeks, sometimes less, but on the other hand it appears from evidence given by ELTON (1931 b, 681) and also from the Greenland reports, that there is a various predisposition to the disease, depending apparently on the state of nutrition. It is quite probable that some of the cases described as madness are deficiency diseases, while others are of an infectious nature.

The earliest record of a sledge dog disease in Greenland thought to be derived from foxes is to be found in the published general report for 1874/75 ("Ministerialtidende" for 1876, 127): "The dog's disease has appeared in several places: in the districts of Upernavik, Umanak, and Ritenbenk, further at Christianshaab where it is said to have originated by the dogs being bitten by mad foxes and from where it spread to Jakobshavn". This is the only case on record where there is absolutely no agreement with a supposed invasion. 1868, 1894, and 1902 (marked by a ? in table I) are years during which HJORTLUND (1908, 194, 195)

[1]) Apparently, the first reference to this disease is found in KANE (1856, I, 123, 156), who observed it in the Thule District during the winter of 1854. A very good description is given by HAYES (1867, 196) from experiences near Etah in the Thule District during the winter of 1861, and important contributions are made by Danish investigatiors in Greenland (RUDOLPH, 1860, HAMANN, 1866, and HJORTLUND, 1908).

supposes that the disease started in some place or other by infection from foxes, because other sources of infection seem to be impossible. 1868 is a year showing a surplus of white foxes. In the two other years invasions have not made themselves felt in that way, but from conditions in Canada we should expect that foxes arrived in those years.

As to the rest of the years listed, details are as follows:

1884. In a report covering January—June from the Christianshaab District at Disko Bay it is stated that the disease broke out at Claushavn and at the Settlement of Christianshaab "being caused apparently by the dogs at the former place being bitten by mad foxes".

Summer 1906. At a place called Rode-Bay in Disko Bay in the middle of July a fox came in between the houses attacking all dogs which came in its way. After an interval of three weeks the disease broke out among the dogs (HJORTLUND, 1908, 195). In this same summer HANTSCH (1913, 153) saw a fox in Baffin Land which from its behaviour was evidently "mad". ("Im Magen Lemmingsreste. Scheint sich nicht in Fortpflanzung zu befinden").

1907. In December 1906 at the dwelling place Southern Upernavik a fox came up to a man who was fishing through the ice, bitting the leg of his trousers. Terrified the man scared it away, but, wishing to secure its skin, he threw his tin bait at the fox which at once "took the bait" and was thus caught (HJORTLUND, 1908, 195).

1910. According to the yearly report from Umanak three cases occurred of mad foxes fighting with dog teams at various placet within the district during January and February 1910. In all three cases precautions were taken according to the law: The fox and those dogs which were thought to have been in contact with it were killed and let down through the ice without being skinned. In two cases no epidemic ensued while in the third case (at Nugssuak) some dogs caught the disease.

(?)**1911.** According to a report from Egedesminde dated April 8th, 1911 "rabies" occurred among the dogs at Nivak (in the northern part of the district) in the end of January. "The natives think that the disease was derived from foxes, but nobody has actually seen a fox or tracks of one at the houses".

(?)**1919.** Report from Christianshaab covering October—March, 1919: "During the last days of January a few of the dogs at this place have been fighting with a fox which was killed, and therefore the settlement has been shut out from intercourse with other places. . . . Later a disease broke out among the dogs and not a few died. . . . This disease is neither rabies nor true distemper. The symptoms are cramps, ex-

haustion and no appetite, but after a few days well nourished dogs recovered while under-nourished dogs died".

1920. Report for Upernavik, January 26th—May 7th: ". . . One single place in the northern part of the district has been quarantined because some dogs have been fighting with a fox". (No disease resulted).

1931. Upernavik, March 16th, 1931: "Some dogs at Prøven said to have been fighting with and killed a fox on February 8th, but no case of disease up to now, neither at Prøven nor at other places".

1932. Upernavik, winter: "At the most northern dwelling place Karusulik a dog team killed a fox in January". (No disease resulted from this).

1935. Upernavik, winter: "Several places quarantined, because several hunters have caught foxes by means of dogs". (No disease ensued).

It may be seen that in most cases no disease resulted from intercourse between dogs and mad foxes, but it is important to note that since 1908 the drastic precautions described unter the heading of "1910" were always carried out, so the cases in which fighting was observed are the least likely to start an epidemic.

As a summary of the above we may say that there are nine cases in which it is expressly stated that foxes were seen fighting with dogs, and in addition this was observed "several" times during 1935. All of the seven winters during which these cases occurred are marked as invasion years by surplus of white foxes in the catch. One case occurred in summer, viz. 1906. This is also in accordance with the assumption that the mad foxes are immigrants, because the percentages suggest migration into Upernavik in 1906 and a major invasion into North Greenland in 1907. Among the seven winters 1919 is listed as slightly doubtful, because the disease was said to be atypical. It is probable, however, that it was the same disease in a mild form. In three cases (1875, 1884, 1911) it is stated in a general way that the disease was derived from foxes, or that the natives thought so without any facts to back up this assumption (1911). Two of these years are marked as invasion years by the percentages while 1875 is the only year during which we should not expect immigrations from Canada. Finally in 1868, 1894, and the summer of 1902 the evidence is only circumstantial, as mentioned above.

Thus, among some fifteen cases, of varying certainty but most of them absolutely reliable, only one case (and that not one of the most well founded) pertains to a year—1875—during which no invasion from Canada is probable, and thus the times at which they are observed lend support to the belief that these mad foxes are—most

often at least—immigrants. Unfortunately, the color of the "mad" fox is never stated.

We do not find agreement between the occurrence of this disease among sledge dogs and the times of supposed immigrations of foxes. Nor could we expect this, because in Canada there is no such agreement. This fact may be explained by assuming "that periodically there might be outbreaks of disease derived from foxes, which would lead to a succession of dogs epidemics at intervals, probably trailing on until the next fox year" (ELTON, 1931 b, 690).

In the period before 1852 we have very little control of the correctness of assumed invasions, because there is scarcely any evidence as to fluctuations in the numbers of foxes in Canada. Therefore we may now consider whether the facts brought together in the foregoing are sufficient to prove the existence of such immigrations, or whether there may be some other way of interpreting the facts.

In the first place it may be emphasized that there is nothing unexpected in finding evidence of immigrations of Canadian foxes into Greenland. On the contraty, from available information of the usual behaviour of lemming foxes during times of lemming scarcity—as reviewed above—and from what is known of their opportunities for reaching Greenland by drift ice or by crossing Smith Sound we should expect this beforehand. During the present investigation the curious periodicity in the percentages was the starting point which induced the author to enquire into the possibility of such large-scaled migrations, but a person who started with the knowledge of the extent of Arctic Fox migrations as hitherto known, of these animals' habit of going out on the drift ice, of their opportunities for finding food there, with a knowledge finally of the extent and movement of the Baffins' Bay pack, which during certain years allows a fox to pass directly from Baffin Land to the shores of Greenland—, such a person would no doubt look for evidence of such immigrations expecting their existence, only wondering perhaps whether any eyewitness to such happenings could be found, or whether there might be indirect evidence of their reality.

Since it is certain that the dark and the winter white variety of the Arctic Fox are hereditary types which cannot be altered one into another, and since alterations in the proportions between the genes in a large natural population must be a comparatively slow process, the only other way of explaining the large variations found in the percentages within the northern districts, the simultaneousness of the variations, and the fact that peaks tend to appear at intervals of four year—, seems to be the assumption that there are two or more ecological types which are to some extent genetically separated and which contain very different

percentages of the white variety. If one of these were dependent on food the amount of which fluctuated according to a four year period, then of course we should have such variations in the percentages which we actually find, without any assumption of migrations being necessary.

We have seen that lemming foxes and coast foxes may be regarded as such ecological types containing very different percentages of white, and at Scoresby Sound we have, according to Alwin Pedersen, to some extent a realization of the hypothetical case mentioned above (cf. 12). As there are no lemmings in these parts of West Greenland conditions cannot be identical, but there are some interesting statements in the literature indicating that there may be still further ecological differentiations within this species. LOTZ (1931, 224) on the authority of J. Gudmundsson mentions three types of Arctic Foxes in Iceland: "Aasfresser", "Jäger", and "Reisser", which are also different in their behaviour towards man, and BOITSOV (1937, 22) cites investigations by Turmainen, who found that the foxes introduced into the Solowezki Islands (Onega Bay) could be classified into three types according to the sizes of the territories in which they seek food. There are no statements, however, as to differences in the blue to white ratio between these populations, but such differences may well have existed.

The possibility of this explanation has been constantly kept in mind, but nothing could be found to support such a view. A study of local differences in the composition of the populations, as judged by the catch at the various dwelling places, failed to reveal any correlation with local conditions such as presence of bird cliffs, position near the outer coast or within a fiord etc. It is true that foxes are often hunted far from dwelling places, so this method is not absolutely reliable, but it is obvious that enormous differences would be necessary to cause variations of such magnitude in the percentages within the total catch, and further there are no facts which point to a four year cycle in any important food item. On the other hand there are local differences within the districts, and such factors may well play a part in causing variations in the percentages. These considerations make it clear that we cannot get more convincing results by a mathematical treatment of the variations in the percentages, but there is absolutely no ground for the assumption that such factors could explain the variations found.

As to the other hypothesis we find, on the contrary, so good evidence in its favour that next to a successful marking experiment no better could be desired. White foxes, said to be different in appearance from the resident ones, have been actually observed on the "west ice". In the Thule District where it is easy to see when foxes disappear or arrive because special feeding is carried out, it is known that invasions occur.

Finally, there is a perfect agreement as to time between the supposed invasions into Greenland and lemming scarcity in Canada.

It is somewhat amazing that the West Greenland foxes could maintain racial characters as to sizes and skull proportions and a blue to white ratio different from those of the Canadian foxes. The latter, as previously mentioned, are larger on an average than Greenland foxes with broader brain cases. In racial characters we find, as we should expect, an enormous variation in West Greenland (BARETT-HAMILTON and BONHOTE, 1898; WINGE, 1902, 388). Many Greenland foxes are indistinguishable from Canadian specimens, and it is mentioned several times in the literature that white foxes are generally larger than blue ones (e. g. FABRICIUS, 1788, 434). MÜLLER (1906, 295) remarks that "curiously enough ..... the skins of white foxes seem to be generally larger and with longer guidehairs than blue ones. It may be due to chance, but it is a fact that the largest fox skins I have seen—and I have seen a good many—were always white foxes, though unusually large specimens may also occur among blue foxes". The large white specimens may be actual immigrants.

It may be seen from the plate and table V that at Julianehaab and Holsteinsborg the white variety has become comparatively more frequent in the course of time. In the other districts, while the general level has varied somewhat, there is not much change. These variations, which are probably not caused primarily by invasions, will be treated in a special paper. It is clear that the invasions do not cause a steady rise in the percentages. If this had been the case we should expect that an almost pure white population would have resulted long ago.

As an explanation of this it may be remarked that the immigrants are not likely to leave any progeny in Greenland since they are probably not able to breed during the year in which they arrive, are very easily caught, (cf. Philemonsens letter p. 29), and are liable to diseases as mentioned above. Further the conditions of life in West Greenland are very different from those in Canada where the lemming is the all important food animal, and there is reason to believe, as pointed out in the previous chapter, that a certain ecological differentiation exists in accordance herewith, which means that lemming foxes arriving in West Greenland will be at a disadvantage in competition with the resident foxes. In any case, the fact that a low percentage of white is maintained cannot be used as an argument against the existence of immigrations, because in the Thule District, where the existence of immigrations on a large scale is especially well founded, the percentage of white is nevertheless especially low.

In the extensive, not glaciated, areas in North East Greenland there is a rather large population of foxes, depending, like the Canadian,

on lemmings which are found here. As pointed out above we may exclude the possibility that the rise in percentages of white in northern West Greenland in certain years is due to invasions of foxes from there via the inland ice—during the years 1923—1935 at any rate,—because in this period the fluctuations in numbers of lemmings and foxes in N. E. Greenland have been decidedly out of step with the Canadian, and the supposed invasion years show absolute agreement with the Canadian fluctuations, but not with those of N. E. Greenland.

There is still another way, however, by which N. E. Greenland foxes may reach West Greenland, namely by the east Greenland pack (the "Storis"—"Big Ice"—) which flows down along the east coast of Greenland and then around Cape Farewell continuing north-wards along the west coast in spring, sometimes reaching as far as Godthaab. The presence of foxes in this pack is testified by members of the Second German Nordpolarekspedition, who saw foxes far from land at about $73^1/_2°$, $67^1/_2°$, and $65^1/_2°$ north while drifting along the east coast during the winter of 1869/70 (Nordpolarfart, 1873, 63, 85, 95).

Foxes in N. E. Greenland are known, like other lemming foxes, to migrate on a large scale at times when lemmings disappear (Giæver, 1938 b, 387), and we shall expect that at such times considerable numbers may arrive in southern Greenland with the pack. The possibilities of finding evidence of such immigrations in the catch are in the first place hampered by the fact that the population of foxes in N. E. Greenland is not, as in Canada, composed nearly exclusively of winter white foxes. The percentage of the white variety in the region from Scoresby Sound to a little south of Dove Bay is about 90, at Dove Bay somewhat lower, and at Scoresby Sound much lower. It is true that, as previously mentioned, a good many of the blue foxes, at least at Scoresby Sound, are dependent on bird cliffs and do not partake in these migrations, but we cannot expect more than about 90 per cent white in a migrating population from N. E. Greenland.

The first place where such migrating foxes could be caught further south is at Angmagssalik whence we have records for some forty years. The percentage here is much the same as in N. E. Greenland so we should not expect any influence on the composition of the catch, but it may be seen from fig. 4 that in the recent period during which we have a continous record of numbers of lemmings and foxes in N. E. Greenland the catch is generally larger at Angmagssalik in the years in which we should expect migrations, and this was apparently also the case after the lemming year of 1906, but unfortunately nothing was sent home in 1907, so we can only make sure that the combined catch of 1907 and 1908 was comparatively very high. (The number traded yearly at Angmagssalik, as at Scoresby Sound, is no guide to the catch of the

season, because a large proportion are traded after April 1st). The next point at which such migrants would reach a trading post is at Julianehaab where the percentage since about 1860 has been about 50, which means that migrants with about 90 per cent white would leave little impression on the catch, unless they make up a large proportion of it, and since large numbers of resident foxes are caught here it is no wonder that we do not find much variation in the percentages during recent years. Immigrants in fair numbers may well be caught for that reason. Before 1860 when the percentages were generally lower, we find distinct peaks, as we should expect, and peaks are also found further north during the same years (e. g. 1820, 1845). It is impossible to decide, of course, when a peak is caused by east Greenland foxes, and when we have to do with Canadian ones. We are admittedly on quite uncertain ground when discussing the period before 1852 because we lack information on lemming and fox years in the neighbouring regions. It is apparent that during the first 50—60 years the peaks in the percentages may as a rule be traced much farther south than in recent years. This was to be expected assuming that the abnormally high percentages are due to immigrations, because the efficiency of trapping is rising steadily, especially by expansion of the area trapped in the direction of the inner ends of the fiords. As the immigrants, which are easily caught, are probably mostly taken near the open coast, we may assume that the numbers of immigrants caught have been nearly constant all the time while the total catch is much greater nowadays. Consequently, immigrants make up a much smaller part of the total catch in South Greenland nowadays than was the case in former times. Therefore it is concluded that foreign foxes (which are probably mostly brought by the "west ice") are still caught all over West Greenland. It is interesting to note that the last time an immigration made itself very distinctly felt in South Greenland was in 1888, being a year in which the total catch was exceptionally low.

It is possible that a future analysis of all available data will make it possible to get some idea of the fluctuations in the Canadian Arctic, also in the period before the middle of the previous century. From the Greenland records one may venture the guess that in the Canadian Eastern Arctic there were lemming maxima (with subsequent maximum catch of foxes and migrations) in the following years (or possibly the previous year): 1794, 1801, 1805, 1810, 1816, 1819, 1823, 1832, 1836, 1839, and 1844.

III

FLUCTUATIONS IN NUMBERS OF LEMMINGS AND FOXES IN NORTHEAST GREENLAND

As previously mentioned the north coast of Greenland and the east coast down to and including Scoresby Sound differ from the rest in being inhabited by lemmings, and we shall expect, therefore, to find a well marked four-year cycle in the numbers of foxes here. It may be seen from the curve fig. 4 that the numbers of foxes caught in the only Danish settlement in this area, Scoresby Sound, do show such a cycle during the short period since the settlement was established. There are peaks in 1929, 1933, and 1938[1]) separated by intervals of four and five years. As to fluctuations of lemmings in the Scoresby Sound region during this period we have the following statements: In the autumn of 1927, and spring and summer of 1928, lemmings were very numerous, then followed a sharp decline, and during the winter and spring of 1929 no lemmings were seen. During the summer of 1929 these animals were extremely scarce. Snowly Owls and Long-tailed Skuas bred in great numbers in 1928, but apparently not in 1929. Snowy Owls wintered at the fiord in 1927/28 (PEDERSEN, 1930, 378, 478, 493). In the summer of 1933 there was again an extreme scarcity of lemmings, and at the same time Snowy Owls and Long-tailed Skuas did not breed (BERTRAM, LACK and ROBERTS, 1934, 826). During the summers of 1936 and 1937 lemmings were numerous at Scoresby Sound, but as early as November 1937 they were scarce (private information from Mr. Eigil Nielsen, M. Sc.).

Thus it will be seen that the fluctuations in the catch of foxes at Scoresby Sound are in excellent agreement with the known facts concerning lemming numbers in the same period. A maximum catch of foxes occurred in the winter following the lemming maximum of 1928. The peak in 1929 was even more well marked than it appears from the number of skins. The number of foxes taken during the winter is stated in the report

[1]) In this paper a trapping season is always designated according to the year in which it ends. 1929 means winter of 1928/29 etc.

as 65 + 164 = 229 (71,6 per cent. white) while the number of skins is 214. This difference is explained by the statement in the report that "more foxes could have been taken, but for the circumstance that the traps in which foxes had been caught were often ravaged by other foxes". The 15 missing skins were no doubt spoilt by the animals having been partly eaten by other foxes.—On the other hand the great augmentation in numbers of skins between 1928 and 1929 is due partly

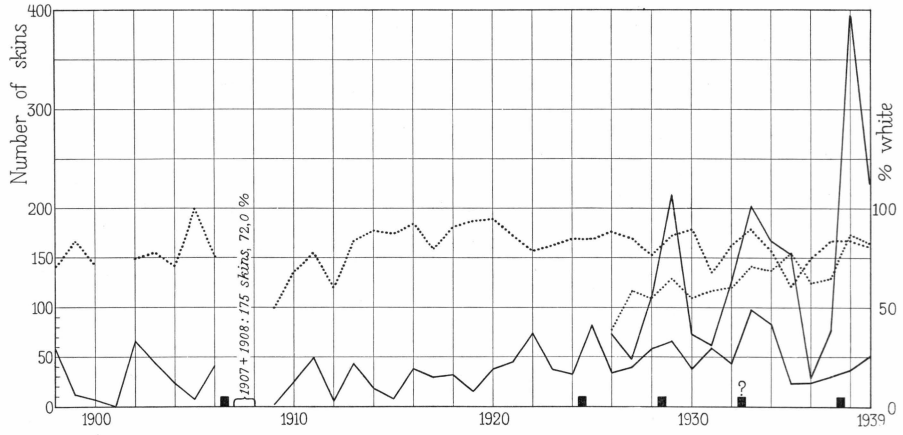

Fig. 4. Numbers of skins received from Scoresby Sound, 1926—1939, and from Angmagssalik, 1898—1939. Dotted lines: percentages of white skins. Lemming years at Scoresby Sound (1924, 1928, 1932, and 1937) and Germania Land (1906) are indicated by black squares.

to an extension of the region over which trapping operations were carried out (Report 1929).

The comparatively high figures for 1934 and 1935 may be due to a rich supply of hares and ptarmigan. There are no statements concerning these animals in the report for 1934 and 1935, but further north they were very numerous during these years (ANTHONSEN, 1940). The report for 1935/36 complains of a scarcity of hares and ptarmigan.

A peak in numbers of lemmings and foxes 4 years before that in 1928—1929 is apparent from the following statement by ALWIN PEDERSEN (1926, 164, 165, 166):

In the months of September—October, 1924, lemmings were numerous, during the following winter no traces were seen, and none were found in the stomachs of foxes which were numerous at the coasts of the fiord. Next summer (1925) a decline of foxes was noticed as compared with the previous autumn, and lemmings were scarce.—This carries the continuous record of fluctuations of foxes at Scoresby Sound through four maxima (1925, 1929, 1933, 1938) with intervals of 4 years in two cases and 5 years in one case.

Further north along the coast up to Germania Land (c. 77° north) trapping operations were carried out during the same years by Danish and especially by Norwegian trappers. A good report of the Norwegian activity is given by GIÆVER (1939a). It contains a table stating the amounts of skins taken by the various expeditions and the number of trappers partaking in them. In some cases the result of two years trapping is given without further specification, and the use of the figures for estimating fluctuations in the numbers of foxes is also hampered by the fact that the regions trapped are seldom quite the same in consecutive years. Also, the efficiency of trapping has been constantly improved by building of small huts in which the trapper may take shelter while travelling, which makes it possible to cover larger areas. On the other hand it appears from the report that in some years the labour of erection of new huts has affected the catch unfavourably. Nevertheless, two maxima simultaneous with those in Scoresby Sound in the years 1929 and 1938 are so well marked that there is no doubt that they correspond to especially favourable trapping seasons, and moreover it is mentioned in the report (GIÆVER, 1939a, 20, 36) that in these two winters (especially in 1938) foxes were unusually numerous.

A peak in numbers of foxes corresponding to that of 1933 at Scoresby Sound is, however, not apparent, except, possibly, in the most southern region, nearest Scoresby Sound. This may be seen from the figures cited below. They are based on GIÆVER (1939a) when not otherwise stated.

In the middle parts of the region defined above, with Myggbukta ($73^1/_2°$ north) as a center Norwegian trappers have worked every winter since 1926/27 (Foldvik Expedition, 1927, 1928; Devold Exp., 1929, 1930, and, since 1929/30, Arktisk Næringsdrift). The limits if this area have varied somewhat, maximally it is limited towards the south by Vega Sound — Kempe Fiord ($72^1/_2°$) and towards the north by Tyroler Fiord ($74^1/_2°$). In the winters 1927 and 1928 the catch was on an average 24 foxes pr. trapper and winter. During 1929, the peak year, this figure amounted to 38, but next winter it fell to 18.[1]) In 1931 the result was again bad. It is stated in the report that during 1930 and 1931 great masses of snow made travels difficult and induced the foxes to go up into the mountains. From the last statement we may only conclude that foxes were scarce, their presence in the mountains is, apparently, entirely hypothetical. In the following years the average numbers of foxes caught by each trapper were as follows, 1932: 46, 1933: 38, 1934:

[1]) Like those of the preceding years the figures for 1929 and 1930 are not given separately by Giæver, but ORVIN (1930, 111) stated the amount caught during 1929. His figures appear to be usually inexact, so the above averages (38 and 18) may be taken as approximations only.

61, 1935: 70, (1936: 34[1])), 1937: 71, 1938: 233. In 1939, according to another paper by GLÆVER (1939b, 428), each trapper caught on an average about 100 foxes in the central parts of the areas trapped by Norwegians, while in the northern and southern parts the catch was not so good.—No distinct peak in numbers between those of 1929 and 1938 is thus apparent in this region. (Confer postscript on p. 54).

The information concerning the most southern parts, where we should most likely expect fluctuations simultaneous with those at Scoresby Sound, is unfortunately scanty. The Møre Expedition operated during 1931 and 1932, partly north of the area worked by Arktisk Næringsdrift, between Jackson Island and Kuhn Island (74—75° north), and partly in the extreme south, at King Oscar's Fiord. In 1931 there were three trappers south and three north, and the total catch was 31 foxes pr. trapper. During 1932 there were only one man north and two south, and the average catch was no less than 95 foxes pr. man. During 1933 and 1934 the Ingstad Expedition (5 men and 4 men respectively) caught a total of 380 foxes in this southern region, that is 84 foxes pr. trapper in two years. It is not stated whether most of these were trapped in the first year, as we should expect. It must be remembered that during 1933 and 1934 five and four trappers worked in about the same area as three and two men during 1931 and 1932, so the catch pr. trapper may be expected to be smaller during the first mentioned years, other conditions being equal. Later there are only figures for 1937 pertaining exclusively to this region. During that winter two men caught only 38 foxes each.—At the whole it may be seen that the available information, unsatisfactory as it is, agrees with the assumption of a maximum in the numbers of foxes at King Oscar's Fiord during 1932 or 1933.

Now, as to available information concerning lemming numbers in the region north of Scoresby Sound up to Germania Land during this period we find again good agreement with the fluctuations in the numbers of foxes.

According to ORVIN (1931, 369) the poor results of the trapping in 1930 was thought by the trappers to be caused by scarcity of lemmings during the summer of 1929, while during 1928 there were plenty of lemmings and consequently good trapping the following winter. Hares and ptarmigan were also scarce during the winter of 1930. DEVOLD (1940, 8) also states that 1928 was a rich lemming year at Myggbukta. As previously mentioned lemmings were very scarce at Scoresby Sound during

[1]) This figure is not comparable to the others because during 1936 only the northern huts were occupied. The ship did not reach the southern ones owing to unfavourable ice conditions and delay caused by rescuing some Danish trappers. Full compensation for resultant loss was paid by the Danish Government.

the summer of 1933. The same is said to have been the case at Frans Josefs Fiord (73½° north) (BERTRAM and others, 1934, 826), but at Hochstetter Foreland (75¼° north) during 1932 and 1933 lemmings were "weder besonders häufig noch auffallend selten" (PEDERSEN, 1934a, 26). This is in agreement with the absence of any distinct peak in numbers of foxes during the winter of 1933 in these more northern regions, as opposed to Scoresby Sound and possibly the region immediately north thereof. The Norwegian trapper ANTONSEN (1940, 157), who worked during the years 1932 to 1939 at a place called "Revet" behind Clavering Island (74°20′ north), states as follows: "Up to 1936 north-eastern Greenland had a very large population of lemmings which formed an important part of the food of foxes, weasels, and even the birds of prey. The rainy autumn of 1935[?] destroyed a lot of lemmings, the invasion of foxes during 1937/38 put an end to a great deal, and finally it appears that the last rainy winter [1938/39] was destructive to the rest of the population. During the spring and summer of 1939 not a single lemming was seen in the whole of north-eastern Greenland". (Interpolations mine). Antonsen's statement that there were many lemmings up to 1936 probably means including 1936, at least Dr. Bütler (in MANDACH, 1938, 10) writes that 1936 was an unusually rich lemming year at Hudson Land (73½° north), so the decline in the autumn of 1935 cannot have been of much consequence. GIÆVER (1938b, 387) gives further particulars about the invasion of foxes during the late winter of 1938. According to the trappers the foxes came in from the south "eating up practically all the supply of small game and lemmings". This interpretation of the lemming-decline is probably wrong, but the statement shows that the lemmings were reduced to a minimum at that time. The statement that migrating foxes came in from the south agrees with the early decline of lemmings at Scoresby Sound (cf. above p. 48).

It would seem that the decline of lemmings in the region covered by the Norse trappers occurred so late in the winter that many foxes were able to survive, since next summer they were still extremely numerous (GIÆVER, 1938b, 388), and the following winter (1938/39) the catch, while lower than during 1937/38, was nevertheless very good in some parts, as mentioned above. During the winter of 1938/39 there was also much migrating of foxes (GIÆVER, 1939b, 428).

The older faunistic literature, which up to 1901 has been summarized by WINGE (1902), contains some scattered information concerning fluctuations of lemmings in north-eastern Greenland. In the following three instances we find evidence of the exact year in which a lemming maximum was abruptly followed by a minimum.

1869. At Sabine Island and thereabout (74¾° north) lemmings were present in some numbers during the autumn of 1869, and there

were indications that the animals had been very numerous a short time previous. During 1870 lemmings were extremely scarce (PETERS, 1874, 164, cf. WINGE, 1902, 386).

1891. On the peninsula Hold with Hope (c. 73$^1/_2$° north) in July 1891 many traces, including winter nests, showed that until lately the animals had been extremely numerous, but not a single lemming could be found alive (BAY, 1894, 15).

1906/07. At Germania Land (c. 77° north) there were plenty of lemmings in the autumn of 1906. Next summer they were very scarce. The decline had occurred during the winter. In April and May they had already grown scarce.—In the following summer (1908) some improvement was noticed in the number of lemmings, and the Long-Tailed Skuas, which had not bred during 1907, were able to do so in 1908 (MANNICHE, 1910, 22, 23, 175).

There is some fragmentary information concerning lemming numbers in North-East Greenland during the years (1908—1913) following the period covered by Manniche's report, but unfortunately they pertain to widely separated localities, and there are no records of decline. They may be worth mentioning, however, even if they do not allow definite conclusions to be drawn.

During 1908/09 the Liavaag trapping expedition wintered at Wollaston Forland (74$^1/_4$° north), 2—300 km south of Germania Land. A diary kept during this stay (July 1908—June 1909) has been published (BRANDAL, 1930). Lemmings are not mentioned in the diary, no weasels were seen or caught, and the catch of foxes was very small, less than five foxes pr. trapper. Next winter (1909—10) the Landmark trapping expedition operated partly in Wollaston Forland like the preceding, and partly on Pendulum and Sabine Islands in the north, and western Clavering Island in the south. Even allowing for the larger area trapped, the much larger catch (16$^1/_2$ fox pr. man) strongly suggests that the foxes had grown less scarce, and further the fact that five weasels were caught also suggests that lemmings were more numerous than during the previous year. The weasels like foxes, owls and skuas seem to undergo fluctuations in numbers simultaneously with those of the lemmings. (Particulars on the trapping expeditions are from GIÆVER, 1939a).

During July 1910 EJNAR MIKKELSEN (1922, 117, 120) saw a Snowy Owl at Dijmpna Sound (c. 80° north), and a little further to the south at Hovgaards Island he saw another owl and a few lemmings.

During the following summer (1911) MIKKELSEN (1922, 134) found plenty of lemmings in southern Shannon Island (75° north) and "a very large number of their winter nests were scattered over the plain".

FREUCHEN (1915, 402) and KNUD RASMUSSEN (1921, 112, 113) found lemmings very numerous in extreme northern East Greenland

(Peary Land—Danmarks Fiord) during the summer of 1912. The animals wandered far out over the sea-ice towards the open sea. Tracks were also found on the inland ice.

At the end of March 1913 many traces of lemmings and weasels were found by I. P. KOCH (1913, 180) on Lindhards Island (at Dove Bay, $76^1/_2°$ north).

Finally it may be mentioned that certain observations by NATHORST (1900, 124, 130, 160) make it probable that about the year 1898 a lemming maximum with subsequent decline had occurred in N. E. Greenland. During the summer of 1899 lemming holes which were not inhabited (as was ascertained by means of dogs), were found commonly at Sabine Island and Wollaston Forland. At the entrance of Frans Josefs Fiord even old winter nests made of grass could be seen here and there on the ground. The only locality where the dogs scented lemmings was at the western end of Sofia Sound (73° north), and this happened later in the summer, on the 16th of August. One lemming was caught here.—Next summer (1900) lemmings were numerous in these parts (Scoresby Sound, King Oscars Fiord, Hold with Hope) (SØREN JENSEN, 1909, 9, KOLTHOFF, 1901, 122, 128, 132, 138, 161).

It will be seen from the compilation in this chapter that in N. E. Greenland, as elsewhere, the lemmings are subject to violent fluctuations in numbers, and that the records of the catch of foxes show a general agreement between fox numbers and lemming numbers. As to the lenght of the cycle we have only reliable data from the last fifteen years. While at Scoresby Sound a four year period is apparent, it seems that further north no well marked lemming maximum with subsequent decline has occurred between 1928/29 and 1937/38. It remains to be seen whether this is a general feature of the region, or whether we have to do with an unusual happening.

After this paper was given to the printers I received from Mr. Jennov, director of the Danish hunting Company "Nanok" some interesting information pertaining to the region immediately north of these Norse hunting grounds (Hochstetter Forland — Germania Land). Concerning lemmings and foxes it is stated that 1928 and 1937 were good lemming years in accordance with the Norse statements and figures, but in addition 1932 is given as an outstanding rich year like the Scoresby Sound area but unlike the intervening country. At my request Mr. Jennov made further inquiries concerning this year.

At Hochstetter Forland there was an unusually large number of lemmings in the season of 1931—32, and the catch of foxes was good in that season. A comparison between the catch in this season and the next is said to be of no value owing to various circumstances. Further

north at Dove Bay there was an obvious drop in the catch from 1933 to 1934. The actual numbers were 106 and 73 skins in spite of the fact that the larger number was caught by unexperienced trappers in a smaller area. Mr. Jennov is of opinion that if conditions had been the same in these respects the catch of the second year would have been only one third of that of the first year, in accordance with an observed decline of lemmings.

Furthermore it is stated that lemmings declined violently in the later part of the spring of 1938. Many more females than males were caught in the season of 1937—38, of 33 foxes caught in April 1938 29 being females. Many of the females seemed not to have copulated —at least they were not with cubs.

The foxes willingly entered traps in the season of 1938 in spite of the fact the region was swarming with lemmings.

Mr. Jennov also mentiones a migration of foxes in the season of 1938. Apparently the foxes moved from Ole Rømers Land and Hudson Land, partly northwards and towards the coast of Wollaston Forland and partly southwards towards Muskoxen Fiord and Strindberg Land. There were many cases of foxes eating their comrades caught in traps, and a good many instances were observed of foxes eating each other out on the sea ice.

In a telegraphic report received March, 1941 it is stated that "more lemmings are observed this year".

I beg to express my sincere thanks to Mr. Jennov for placing this information at my disposal.

IV

FLUCTUATIONS IN NUMBERS OF FOXES IN WEST GREENLAND

As previously mentioned the largest areas inhabited by Arctic Foxes which have no access to lemmings or other *Muridae* are to be found in Greenland, and the records of the numbers of fox skins traded annually at the old settlements from Julianehaab in the south to Upernavik in the north are no doubt the most important source of information of past fluctuations in populations of coast foxes which could be procured anywhere in the world. It is true that records of the catch at the Komandorski Islands (Stejneger, 1884, 88; Boitsov, 1937, 101), the Pribilof Islands (Osgood and others, 1915, 107; Preble, 1923, 105; Boitsov, 1937, 103), and Jan Mayen have been published for a considerable period, but it appears that in these small islands the activities of man have overshadowed all other influences. At the Komandorski Islands overtrapping has sometimes reduced the stock to such an extent that it has been necessary to suspend trapping for one or two years (Stejneger, 1884, 88). The figures for Jan Mayen published by Norges Svalbard og Ishavs Undersøgelser (Norsk Geogr. Tidsskr. II, 433, 1929) show that the best catches have been taken by expeditions which happened to arrive after an interval of some years during which no trapping was carried out. In the Pribilofs the numbers of foxes taken show correlation with the numbers of fur seals killed by man, the bodies of seals left on the killing places being a main food item. During recent years special feeding of the foxes has been carried out. (Osgood and others, 1915, 106, 110).

There are no available records of foxes killed in Iceland. As to Spitsbergen I have had access to a short series of Norwegian trapping results. They are important as indications of the percentage of the white variety there in our times (about 10 per cent), but no deduction as to fluctuations in numbers can be made without knowledge of the numbers of trappers etc.

In estimating the value of the West Greenland records, which are presented in the tables and graphs at the close of this paper, it is important

to note in the first place that they represent practically the whole catch. Fox skins have not been used by the natives in these parts of Greenland during the last hundred years at least. RINK (1857, 177) expressly states that these skins are never used by the Greenlanders. FABRICIUS (1788, 443), who left Greenland about twenty years before the beginning of the period with which we are concerned, saw fox skins used by a few Greenlanders for caps or edgings on seal-skin-overcoats, and sometimes clothes for children were made of fox skins, but apparently these pelts were already falling into disuse at that time. Fabricius says that in his time the Greenlanders did not care to use fox skins themselves because they were so well paid for by the Europeans.

Since 1776 the Royal Greenland Trading Company has possesed an absolute monopoly, but some illicit trading no doubt occurred in former times. Even as late as during the difficult years after the English war (from 1815 onwards) some corruption of this kind took place (cf. BOBÉ, 1929, 138, 147). A few foxes caught during recent times at the kryolith mine at Ivigtut (Frederikshaab District) are not included.—On the whole the figures may be taken, however, as a reliable representation of the total catch.

Up to and including 1865 the trading year ends on the 30th of June, which is fortunate for our present purposes, because at that time we may be reasonably sure that all skins caught during the previous winter have been traded in. After that year the figures for, say, 1876 represent the number of foxes traded in between April 1st 1875 and the 31st of March 1876. Since a few foxes are normally received after the 1st of April, the figures will include a few skins taken during the season ending 1875, while on the other hand, a few skins which were really caught during the winter of 1875/76 will be included in the next years catch etc.—I have been able to make sure, however, that normally this is only a slight source of error. The reports from South Greenland sometimes contain statements of the numbers of skins traded during the first few months of the trading year. When we find such statements pertaining to the same settlement in consecutive years it is possible to calculate the actual catch. Out of fifteen instances examined in this way the error was less than five per cent in 8 cases, and only in one case did it exceed ten per cent, amounting to fifteen per cent. These small errors, which attach to the figures from 1866 onwards, will generally tend to make the fluctuations appear slightly less well marked than they really are.

The next problem which arises is whether the fluctuations in the catch in West Greenland represent fluctuations in the numbers of foxes. Most opinions on this question, which are to be found in print or in the records, do not admit the existence of fluctuations in the numbers of

foxes from natural causes. This is not surprising, remembering that nearly all writers on similar subjects up to the last few decades stubbornly believed that the numbers of vertebrates remain practically constant, with a few exceptions such as exterminations by man. This dogma was even adhered to in cases where it was quite obvious that the numbers of an animal varied tremendously at any locality (i. e. the lemming); in such cases it was believed that the animals went elsewhere at certain times, returning after an interval of a few years (the migration theory, cf. chapter I). Nowadays it is known that these fluctuations are due in the main to an abnormally high death rate from disease or starvation at those times, followed by improvement owing to the natural increase.

The trader Myhlenphort in a description, written 1799, of the Egedesminde district (immediately south of Disko Bay) considers it most likely that a bad year for trapping foxes is due to the drifting ashore of many carcasses of whales or seals which provide the animals with ample food, while in winters with little food, the foxes are more apt to enter the traps (OSTERMANN, 1937, 50). It is no doubt true that, other conditions being equal, a population of starving foxes will yield a better catch than an equally large population of animals with plenty of food, but it is seen e. g. from the graph (fig. 4) representing fluctuations in the catch at Scoresby Sound that an increase is apparent every time during the winter before the decline of the lemming (1928, 1932, 1937) when there is ample food. The catch expressed as percentage of the population present is probably especially small at that time, but nevertheless the increase in the numbers of foxes makes itself plainly felt. Thus the factor emphasized by Myhlephort is here only a modifying one, and the same is no doubt the case in West Greenland. It means that we cannot expect a strict proportion between the number caught and the number present in the district, but nevertheless we have no reason to doubt that the ups and downs in the curve is the result of simultaneous fluctuations in the numbers of foxes.

RINK (1857, II, 178) is of the opinion that the highly variable success which marks the hunting of foxes in South Greenland chiefly depends on the weater. When the winter is severe and there is much snow the foxes seek the coast to a greater extent than usual. (The hunting and trapping take place exclusively on or very near the coasts). Rink does not regard this explanation as exhaustive, however, for he points out that after the exceptionally fine season of 1831/32, during which 2300 foxes were caught in the Julianehaab district alone, a series of bad years followed. Later the general level of the catch becomes again higher. Rink is inclined to believe that the small catch during the years following the peak years is due to a diminution of the numbers of foxes owing to overtrapping.

This last assumption has been refuted by RYBERG (1894, 96, 99) and R. MÜLLER (1906, 313), and there is certainly nothing in the figures up to now which suggests that the foxes in West Greenland are too much persecuted. The last mentioned authors agree with Rink in thinking that the weather is a main factor determining the profit of the fox hunting, but Müller, who was particularly well aquainted with Greenland wild life, admits that exceptions to the above mentioned connection between the weather and the catch of foxes are frequent, "one never knows when it may please him (the fox) to enter the traps" (MÜLLER, 1906, 313).

Attempts to explain deviations from the normal catch are frequent in the reports from the southern districts up to and including Egedesminde, and here too the weather is the most popular factor. In 19 reports a failure is explained as a result of peculiarities in the snowfall, but out of these nineteen 11 complain of too scanty snow, while the other 8 are of opinion that the trapping was spoilt by too much snow! A heavy snowfall may make the trapping difficult because the traps are filled with snow and have to be cleaned. The experienced trapper, however, knows how to place the trap on a spot where the snow will usually blow away.—Failure owing to lack of snow is mentioned four times in reports from Julianehaab with the further explanation that it was consequently difficult to trace the animals (shooting of foxes is more common in this district than usual). The report from Julianehaab for 1894 says that the catch was good in spite of much snow, while the report from the same place the next year speaks of "good catch in spite of too scanty snow".—In eleven cases a mild winter is thought to explain a failure of the fox trapping. It is not surprising that sometimes a bad fox year will coincide with a mild winter, but it will be easily seen by consulting meteorological data that there is no such general connection (cf. p. 77 and the plate).

It was also suggested by RYBERG (1894, 99) and MÜLLER (1906, 313) that fluctuations in the catch of foxes may sometimes be brought about partly by the varying success of other industries. In case of good hunting for seals or sea birds or profitable fishing these occupations may be pursued more eagerly at the expense of the fox trapping. It appears, however, that in South Greenland, where most foxes are trapped, this cannot play an important part, because here summer and autumn are the good seasons for hunting and fishing, while the winter is the slackest hunting season during which the population have largely to get along by means of a little fishing for the household and the provisions put by in summer. At the dwelling places lying farthest out towards the sea the kayak hunting for saddleback seals etc. may be continued during part of the winter, but at places inside the fiords where the vast majority

of foxes are caught, there is very little to draw the interest from fox hunting (cf. BIRKET-SMITH, 1928, 148—150). In North Greenland, it is true, much hunting is carried out in winter from the ice, but there the fox hunting is quite insignificant[1]) compared with South Greenland, partly because the trapping season coincides with good hunting of seals etc. as just mentioned, and partly because the foxes are less numerous. Thus there is reason to believe that fluctuations in the comparatively small, but growing, catch of foxes in North Greenland is considerably influenced by other factors than the numbers of foxes present. These influences may be somewhat mitigated by the fact that, in some places at least, there are hunters who make a speciality of catching foxes. WANHØFFEN (1897, 19) was told that at Claushavn (at Disko Bay) fox trapping was carried out by only two Greenlanders, but on the other hand these were exclusively occupied in this industry during the winter.

It is interesting in this connection that in the reports from North Greenland—with the exception of the most southern district, Egedesminde—fluctuations in the catch of foxes are very seldom commented upon, and in one of these cases other hunting is mentioned as an influential factor (Upernavik, 1887: Results of fox trapping better than usual, because other hunting bad) while among the many reports from South Greenland and Egedesminde which attempt to explain an unusually good catch of foxes or (more commonly) a failure, the effect of other hunting is only mentioned once, from Holsteinsborg, the most northern district in South Greenland proper (1909; small catch of foxes owing to good seal hunting).

Finally, it may be mentioned that epidemic diseases such as influenza, which now and then interfere with the hunting, occur mostly during spring and summer (RYBERG, 1894, 114), and therefore the fox trapping is little disturbed by this factor—in the last hundred years at least.

We have been speaking hitherto of such fluctuations in the catch which are apparent within any few decades. The situation is naturally very different when the general trends of the figures are considered, if we are to compare for instance the average catch between the years 1840 and 1860 with the average catch between 1910 and 1930. Here

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[1]) Except at a few fiord dwelling places in the southern part of Egedesminde district, near the boundary towards South Greenland.

Here as elsewhere in this paper when not otherwise stated North Greenland means the old districts from Egedesminde to Upernavik, which up to 1937 made up the administrative province of North Greenland. The Thule district, which was only recently incorporated therein, is very rich in foxes, and the fox trapping is an important industry.

many factors are involved of which some are obvious while others are complicated, and perhaps even impossible to make out. The numbers of Greenlanders are of course an important factor. The graph fig. 3 gives an idea of the changes in the numbers of inhabitants in North and South Greenland. The present populations of the various districts are in round numbers as follows (the districts are mentioned from south to north): Julianehaab 3800; Frederikshaab 1100; Godthaab 1600; Sukkertoppen

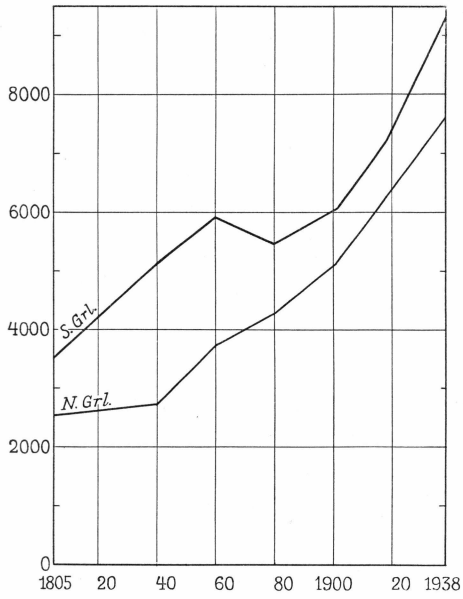

Fig. 5. Changes in the numbers of inhabitants in North Greenland (N. Grl.) and South Greenland (S. Grl.).

1650; Holsteinsborg 1200; Egedesminde 2000; Christianshaab 600; Jacobshavn 800; Ritenbenk 1000; Godhavn 420; (Disko Bay Districts i. e. sum of the four preceding 2800); Umanak 1500; Upernavik 1300. —Thule District in north-western Greenland is inhabited by 270 natives, while the figures for East Greenland are given as follows: Angmagssalik 872; Scoresby Sound 199.

Changes in the size of the population have not been quite parallel in the various districts. Details—except for Upernavik—may be found in the work "Grønland" (II, 39, 128, 215, 331, 463 S. Greenl., and I, 19, 105, 168, 229, 295, 362 N. Greenl.). Here it is not thought advisable to enter into more detail concerning this matter, since there are so many other, incalculable, factors.

The work "Grønland" (I, 90—93) also contains a table stating the population (in 1918) at the various small dwelling places, the positions of which may be looked up in the accompagning Atlas. The opportunities

for fox hunting depends a good deal on the distribution of the dwelling places within the districts, since places within the fiords are more favourably situated for fox trapping than those situated farther out towards the open sea. This is well illustrated in the district of Egedesminde, where most foxes are caught in the southern parts, while at the northern dwelling places, which are mostly on islands far from the mainland, extremely few are caught, the sole exception being Nivak, which is situated, like most of the southern settlements, further away from the open sea behind some islands.

RYBERG (1894, 95, 96) has calculated the following average yearly catches of foxes for the years 1875—91, in column I per individual, and in column II per breadwinner (i e. all hunters and fishers) for the districts in South Greenland:

	I	II
Julianehaab	0,3	1,4
Frederikshaab	0,2	1,1
Godthaab	0,4	2,6
Sukkertoppen	0,2	1,3
Holsteinsborg	0,3	1,8
All S. Greenland	0,3	1,6

As suggested by MÜLLER (1906, 313) these differences are probably mainly connected with differences in the distribution of the Greenlanders in the various districts. The profitable fox hunting in the Godthaab district is explained by the fact that a large proportion of the population live far inside the large fiord, while in the Frederikshaab District fox hunting is especially hampered by the circumstance that most of the dwelling places are situated far out towards the sea. These conditions are not absolutely stable. Now and then a dwelling place is given up and new ones are founded, so in the long run there may be sufficient change to influence appreciably the catch of foxes.

Another varying factor is the payment received by the Greenlanders for fox skins. The prices are fixed by the administration, and as a rule they are only changed at long intervals. A full understanding of this factor would require a profound study of Greenland economics during the past 150 years. It is, however, possible to see that changes of price cannot disguise the usual fluctuations in the catch. In 1919 prices, which had been stable since 1906, were raised by more than fifty per cent, but nevertheless a large and sudden drop in the numbers caught in the southern districts occurred during the following years. Two reports from 1890, it is true, express the opinion that a rise in the numbers of skins, which was apparent in the season of 1889/90, was due to the raised prices in 1889, but there is no doubt that a recovery from the

deep minimum in 1887—89 would have occurred in any case. It is possible to put forth a biological explanation for this, as well as for the drop in numbers after 1919 (fluctuations in the numbers of ptarmigan and hares, cf. below), on the other hand, it is not improbable that the general high level of the catch during the last few decades, especially in North Greenland, has something to do with the fact that the prices were raised several times between 1919 and 1925 so as to be nearly tripled.

As a result of the above discussion of the factors which may influence the catch of foxes in West Greenland it is concluded that it is very difficult to analyse such changes as would appear for instance by smoothing the curves by thirty years moving averages. Here it would be difficult, or perhaps even impossible to make out whether the numbers of foxes have changed, or whether we have to do exclusively with the result of other factors,—but on the other hand there is good reason to believe that those considerable fluctuations in the catch—at least in southern West Greenland[1])—which make themselves felt within a few decades, are caused in the main by corresponding fluctuations in the numbers of foxes, just as it is known to be the case with lemming foxes which fluctuate in numbers according to the supply of their favourite food, the lemming. Coast foxes are not in the same measure dependent on a single animal, but there is no doubt that their food also varies widely. It is thought, therefore, that an understanding of the causes which bring about the considerable fluctuations in the catch, which appear in the graphs, is dependent on knowledge of the food habits of the animals, as well as on the available data on variations in the amount and accessibility of the food.

Fabricius (1780, 1788) and Müller (1906) in particular have published very good accounts from personal studies of the biology of the Polar Fox in West Greenland. In the following a brief compilation of the food habits is given, supplemented by information pertaining to other regions.

If we draw a distinction between those food items which owe their origin indirectly to the production of organic substances by terrestrial plants and those which, directly or indirectly, are products of the sea we find that the latter group make up a very large part of the nutrition of the Arctic Fox in western Greenland—and indeed in all parts of its area of distribution where there are no lemmings.

All authors acquainted with West Greenland foxes emphasize the

[1]) In chapter II we have attempted to prove that in the most northern parts, especially Upernavik (as well as in Thule District) periodic invasions of foreign foxes may sometimes make themselves plainly felt, not only in the composition of the catch (percentage of the white variety), but also as to absolute numbers.

importance of the sea shore as a feeding place, especially when there is scarcity of other food. CRANZ (1770, 98) wrote: "Sie leben von Vögeln und Eyern, und wenn sie die nicht haben können, von Kräkebeeren, Muscheln, Krabben, und was die See aufwirft". FABRICIUS (1788, 437) gives a detailed enumeration of lower animals, which are procured at ebb tide in the littoral zone, such as the mollusks *Mytilus edulis*, *Mya arenaria* and *truncata*, crabs (*Hyas araneus* and the large *Chionoecetes opilio*) and other Crustaceans, further various small fishes, especially Gunnel (*Pholis gunellus*), a species of snake blenny (*Lumpenus Fabricii*), Capelin (*Mallotus villosus*) and a small arctic species of the cod family (*Gadus saida*). The two last mentioned fishes come to the shore at certain times for breeding purposes. The Capelin comes during late spring or summer when there is plenty of other food, but *Gadus saida* is present in winter, especially in the more northern parts, and it occurs also among the drift ice (cf. p. 33); its importance as food is confirmed by a statement in the letter previously mentioned from the Greenlander Philemonsen that in the Egedesminde District the foxes within the fiords subsist mainly on this fish in winter, if they have not happened to find some large carcass drifted ashore. MÜLLER (1906, 306) mentions sea slugs, star fishes, and sea urchins in addition to mollusks and crustaceans. WANHÖFFEN (1897, 18) from observations in the Umanak District also sea weeds.

In quite small islands with a large population of foxes, such as the Pribilofs and Komandorski Islands the vast majority of the food is of course derived from the sea, and here again the lower marine animals are very important. BARABASH-NIKIFOROV (1938, 424, 425) has published some quantitative data on the food of foxes on Copper Island (Komandorski Isl.), in which the percentage of various foods is given from 296 stomachs and a number of excrements. In this list birds come first with 39,5 per cent, but sea urchins are not far behind with 30,1 per cent, crustaceans 25,0, mollusks 23,0, holothurians, ascidians, sponges, worms 16,2 per cent. Other items are: sea mammals (carcasses, placentas) 6,8, garbage from human dwellings 13,5, vegetable remains (including sea weeds which are said to pass the intestinal tract undigested) 14,5 per cent. From further statements given it is clear that analyses made for each season separately would reveal great differences, sea birds far preponderating in spring and summer, and lower animals in winter.

In the Pribilofs conditions are much the same. Birds seem to be preferred to any other food, but in winter various invertebrates and other forms of marine life are of great importance as food. Tunicates and sea eggs (Echinids) are especially mentioned (OSGOOD and others, 1915, 109).

In Iceland marine life is also said to be an important source of food. For instance the Lump-Sucker (*Cyclopterus lumpus*) is said to be secured by the foxes when left in pools by the tides (SÆMUNDSSON, 1932, 117; 1939, 4). This fish, which comes to the shore for spawning during late winter (in Greenland April—May), is probably taken in Greenland too.

Among the classes of food which are less directly derived from the sea, marine birds no doubt come first. They are persecuted at the breeding places (eggs, young, and adults) and indeed at any time when they are present on land or ice or so near that they may be reached by one jump into the water. It is a generally recognized fact that the breeding habits of arctic sea birds are mainly determined by the menace from foxes. Some breed on steep clifs (Kittiwakes, Fulmars, various Alcidae) or in crevices among rocks (Little Auk), while others seek to avoid foxes by choosing isolated islands (eiders). Of these two biological groups so to say, the former is by far the most important to foxes as far as the breeding places are concerned, and one reason for this seems to be a very appropriate instinct in the island nesting birds which make them give up breeding if a fox has happened to reach the island. FREUCHEN (1935, 129) mentions two instances of this. Of one of them, concerning Dalrymple Rock near Thule (N. W. Greenland) the following particulars are given: "There were huge numbers of eiders, and we had collected eggs, but ice drift and walrus hunting had meantime engaged us elsewhere, so that we were away from the island a whole week. There had been no communication with it, however, except for small drifting ice floes. Now a fox had got out to it and the eiders had flown. This was so much the more remarkable as we had gone there daily to collect eggs, and sometimes people even lived on the island, remaining quiet except once a day when collecting eggs, and the eiders had always come back. The fox, however, had scared them". The fox was shot, and after two days the eiders had once more resumed egg-laying. A similar case is cited by OSGOOD and others (1915, 108): "On one occasion, on June 11th, 1892, a fox was found on Walrus Island [close to St. Paul, Pribilofs]. Its activities had prevented the birds from beginning to nest, and it was shot. On June 27th, when the island was next visited, a boatload of eggs was gathered."

No wonder then, that the foxes do not seem to be able to breed on such small outlying islands even if they may often reach them by drift ice and subsist there during the summer.[1])

[1]) While populations of eiders are thus well able to hold their own against foxes they have proved, unlike cliff birds, to be very vulnerable to human persecution. This is well illustrated by the fate of the Common Eider in Greenland (cf. KRABBE 1907).

Bird cliffs, on the contrary, are important feeding places, and the foxes often have their dens in the neighbourhood of them (VANHØFFEN, 1897, 18; Umanak District, N. Greenland). The Arctic Fox is a very good climber. MÜLLER (1906, 307) from experiences in South Greenland says: "—unless the bird cliffs are very steep the fox is able to find its way to them, for he is a master at climbing, he easily ascends slopes or steep snow drifts which would seem to be unaccessible to a quadruped unless it were provided with sucking disks like a fly,—and yet the foxes which live near bird cliffs visit them every day". This agrees with statements from other regions. OSGOOD and others (1915, 108) say of the Pribilof foxes that "they make their way about cliffs which appear absolutely inaccessible to a quadruped".

In the Thule District the myriads of Little Auks, which breed among boulders, form the chief subsistence to a large population of foxes.

MÜLLER (1906, 306) gives convincing evidence that Greenland foxes are able to catch live sea birds in winter. He has often observed from the tracks in the snow leading away from the shore that the fox has carried an eider or a guillemot which was still able to flab its wings. He says that the fox takes them by surprice when sleeping, either on the land or in the water, provided the bird is near enough to be reached by jumping from the ice or the shore.

Sea mammals are utilized mostly as carcasses, and in the case of seals, also as remmants from the meals of bears, as previously mentioned (p. 32). In West Greenland this can only play a part in the extreme north and south. Several authors (KUMLIEN, 1879, 50, Baffin Island; PAYNE, 1888, 114, Prince of Wales Sound; SOPER, 1928, 35, Baffin Isl.) have stated that in spring the foxes dig out the young Ringed Seals in their snow dens on the ice. Kumlien says that he has often found the remains of these pups so well skinned and cleaned by foxes that the Eskimos, when they find such skins, always make use of them. There is no record of this habit in Greenland, but since the Ringed Seal breed commonly it is reasonable to suppose that the young are persecuted by foxes here as on the other side of the Davis Strait.

Rather significant quantities of seal meat and fish are also procured by parasitizing on man. Unless stores of such provisions are very well protected foxes make their way to them. (FABRICIUS, 1788, 438; MÜLLER, 1906, 307). They may also profit by man's hunting by finding wounded birds etc.

The various species of salmon may be said to form a transition between the marine and the terrestrial kinds of food. No European seems to have actually seen an Arctic Fox catch a salmon, but there is no doubt that they do so to a considerable extent. MÜLLER (1906,

307) found deep paths trod by foxes along most rivers. The experienced fox hunter, Filemonsen, from the Egedesminde District, (by letter) regards salmon as a favourite food in summer. FREUCHEN (1935, 127) states that Eskimos told him that they had seen foxes leap into the water after a salmon that has lain under a rock shelf or the like. On the Komandorski Islands fishes coming into the rivers for spawning are said by BARABASH-NIKIFOROV (1939, 425) to play an important role in the feeding of the Arctic Fox in summer, and SÆMUNDSSON (1939, 4) mentioned trout and charr in lakes and rivers as food items in Iceland.

As to those kinds of food which are derived from the land less positive evidence is at hand from West Greenland, which is natural remembering that people live on the coast and here the foxes are caught or shot when they come to seek food at the shore.

FABRICIUS (1788, 437), however, says that the foxes in Greenland feed principally on hares and ptarmigan especially by taking them by surprise in their night quarters. BROWN (1868, 346) mainly on the authority of Danish officials in North Greenland, states that in summer foxes live in the mountains preying on the young ptarmigan. MÜLLER (1906, 314), who emphasizes the shore as the all important feeding place, admits that he has seen traces of foxes in summer as far inland as he has been, and by conversation with Greenlanders he learnt that during reindeer-hunting foxes are met with very commonly even close to the inland ice. These foxes are too far from the nearest fiord to visit the shore regularly in summer. It is said that far more remains of birds and hares are found at the entrance of the dens far inland than is the case at the fiords. In the opinion of the Greenlanders a considerable part of the foxes seek the interior in spring when the migratory birds arrive, and they do not return till autumn (MÜLLER, 1906, 315).

Statements from other regions make it probable that ptarmigan are very important to the Greenland foxes. COLLETT (1912, 277) regards these birds as the principal food of Arctic Foxes in Norway next to lemmings. HØST (1935, 211) found the remnants of five or six adult ptarmigan in a fox den on the Hardangervidda (Norway) and he says that it is certain enough that throughout the year the Arctic Fox takes a number of ptarmigan. On the Button Islands off Labrador GROSS (1937, 22) in the summer of 1934 "found many remains, chiefly masses of feathers, of ptarmigan which apparently had been killed by the Arctic Fox. An examination of numerous fox dropping also revealed that the chief food of these predators was ptarmigan and other birds that inhabit the islands". According to SÆMUNDSSON (1939, 4) the Iceland foxes hunt the ptarmigan especially in winter.

As to the importance of adult hares in the nutrition of the Arctic Fox opinions differ somewhat. MANNICHE (1910, 46) in East Greenland

observed instances of absolute fearlessness on behalf of Arctic Hares towards foxes, but conditions may perhaps be very different on a dark night when the hare is surprised in its quarters. PEDERSEN (1926, 172) during the winter of 1924/25 at Scoresby Sound found remains of hares in eight out of sixty fox' stomachs examined (ptarmigan in three). These hares, however, may have been found dead or in a diseased condition by the foxes. It is stated that hares were scarce at the time. Some were caught in fox traps baited with meat. From experiences pertaining to other countries and other species of hares it seems not improbable that hares were suffering from some disease at Scoresby Sound during the period in question.

Even if adult hares are mostly taken by Arctic Foxes as carcasses or in a diseased condition they may nevertheless play an important part, for this fox is no doubt very clever at finding dead animals. On the whole carcasses seem to make out a considerable part of the food of the Arctic Fox.

Reindeer also may be important to foxes inland in some districts in West Greenland. At the present time these animals are not found in the Julianehaab District and on the Island of Disko.

In Canada the usual method by which Arctic Foxes get hold of reindeer meat seems to be by following the wolf in the same way as the foxes on the drift ice follow the bear (BLANCHET, 1925, 34). In the part of West Greenland with which we are concerned there are no wolves except as very rare stragglers, but man may to some extent play the part of the wolf by leaving large quantities of reindeer meat on the hunting grounds. It is a common complaint in the reports of Danish officials that when there are many reindeer the Greenlanders kill far more than they can possibly take away with them. This hunting, however, is only carried out during a couple of months, in South Greenland in summer, and in the north, where only few are killed, mostly during the winter. The foxes may, however, also profit by animals which have perished at other times, and they are also said by the Eskimo to be able to kill new born calves if left by the mother (FREUCHEN, 1935, 126).

In autumn large quantities of berries are said to be eaten by foxes in Greenland (CRANZ, 1770, 98; FABRICIUS, 1788, 438; MÜLLER, 1906 307) especially the very common black crowberries, *Empetrum nigrum*, which keep fresh under the snow all winter (RINK, 1852, 162). Mosses, lichens, and roots of Angelica (Iceland, THIENEMANN, 1824, 12) are mentioned from other regions, even dwarf willow, and blue berry stalks (BAY, 1894, 10). The last mentioned objects have probably no nutritive value, but are taken when there are no better means of filling the stomach.

It is pointed out by many authors (e. g. MIDDENDORFF, 1875, 946; MÜLLER, 1906, 307) and it is indeed obvious, that the amount of available

food is much larger in summer than in winter, and we should therefore expect that the food supply in winter is the limiting factor, in other words that an increased amount of summer food would not result in an increased population of foxes if the amount of winter food remained constant. This is not the case, however, because the Arctic Fox has a habit of storing provisions on a large scale when there is plenty of food. Knowledge of this important feature in the biology of the Arctic Fox has been gained comparatively lately. LYON (1824, 105) described a well marked storing habit in captive animals. MCCLINTOCK (1859, 77) heard from his Danish interpreter, Petersen, that he once saw a fox carry off eggs in his mouth from an eider duck's nest, and that in winter he had observed a fox scratch a hole down through very deep snow, to a cache of eggs beneath (probably Upernavik District, Greenland). HAYES (1867, 239) says that it is a popular belief in Greenland that foxes gather enormous stores of eggs for their winter provender, but he did not see this himself. The first more direct evidence is due to FEILDEN (1877, 319) who in Grinell Land in the neighbourhood of a fox' den found many lemmings stored singly or in heaps, with the major part of a hare and two ermines. This observation was made in the summer of 1876, a rich lemming year in these parts. According to MÜLLER (1906, 307) the fox in South Greenland carries away all eatable objects which are not consumed at once, burrying them singly "an egg here, a fish there, a crab in a third place, a piece of skin in a fourth etc., and he always knows how to find it again with an astonishing precision even if covered with a deep layer of snow". Carcasses which are too large to be moved as a whole are carried away piece by piece. Some more recent authors (DUBROVSKY, 1937, 13; STEFANSSON, 1923, 26) have asserted that a fox is not able to find its own stores again and that the importance of the storing instinct lies in the possibility that another fox may find it. MÜLLER (1906, 321) gives his reasons for concluding that the Arctic Fox is very good at finding its own stores. He described how one may follow the track of a fox which suddenly leads away from its course to a spot where the animal, by scratching in the snow, has procured and eaten a hidden delicacy.

In regions where the foxes are chiefly dependent on bird cliffs the storing of food for winter seems to play an especially important role, which is quite natural considering that the foxes here have access to a very rich food supply for a limited part of the year. From those coasts where the Little Auk (Alle alle) breeds by the millions we hear of single stores containing very large quantities of these birds or their eggs. GIBSON (1922, 354) found a cache of "twenty or more" Little Auks on Hakluyt Island in the Thule District. FREUCHEN (1935, 130) has seen as many as twenty-seven Little Auks and forty eggs in the same store.

Pedersen (1930, 381) in the month of February found a large store on Rathebone Island off the Liverpool Coast, N.E. Greenland, which is also an important breeding place for this bird. This store contained no less than 36 Little Auks, two young divers, four snow sparrows, and a great number of eggs.

Freuchen (1935, 130) writes of the foxes in the Thule District that in November and December they go hunting away from their stores spreading in every direction. "There is not much to catch, with the result that the fox becomes distinctly thinner; its determination is so great, however, that it is only in the month of March, when it has almost reached the limit of its endurance, that it returns to its store to eat. This can be proved by setting a trap before one of these food stores; invariably the total bag consists of one animal, and never until March". This may seem astonishing, but it is in agreement with Mr. Hans Nielsen's statement (cf. p. 23) that as early as November the blue foxes disappear from the breeding grounds, migrating southwards. It is clearly an adventage to the species that the stores are saved until the commencement of the breeding time.

As previously mentioned the main cause for the fluctuations in the catch of foxes in Greenland is to be sought in variations in the amount and accessibility of food. In endeavouring to make out which items are most responsible for the variations we may clearly exclude beforehand one of the most important, viz. cliff birds at their breeding places, because it is common to these species that their breeding rate is so small that well marked fluctuations are impossible unless they have very long amplitudes. In many of these species (*Fulmarus glacialis*, various *Alcidae*) the same individual does not breed every year (intermittent breeding, cf. Wynne-Edwards, 1939). This fact, while demanding a longer average period of life in these species, makes it possible that the number breeding may vary from year to year owing to variation in the size of the non-breeding population, but there is apparantly no ground whatever for such an assumption.

Some other arctic birds, it is true, are known not to breed in certain years ("non-breeding", cf. Bertram and others, 1934, 826). These authors point out that during the lemming minima of 1907 in Germania Land (Manniche, 1910) and in 1933 at Scoresby Sound (also N.E. Greenland) it was not solely the species dependent on lemmings (Long-tailed Skuas, Snowy Owls) which did not breed, but there was also extensive non-breeding in other species such as Eider, King Eider, Long-tailed Duck, Red-throaded Diver, Glaucous Gull, Arctic Tern, and apparently Pink-footed Goose. Wading birds and passerine birds were unaffected in both cases. Disturbance by foxes may be suggested as the cause, or at least a contributory one, in these cases. In years of

lemming scarcity bird nests will of course be disturbed much more than usual also on small islands, because the foxes roam over the ice to a larger extent. This may induce the birds to give up breeding (cf. above p. 65). On the other hand, cases are also cited by Bertram and others of this phenomenon occurring in places where there are no lemmings, and in West Greenland Arctic Terns and other birds nesting on small islands are known not to breed, or very little, in some years. A late spring or a wet summer are given as causes (1914 and 1938, reports) —but, as previously mentioned, breeding places on small islands are not important to foxes.

The presence of marine birds at the coast in the various districts in South Greenland no doubt varies considerably according to weather and ice. The success or failure of the Greenlanders hunting for such birds (guillemots, eiders) are regularly commented upon in the reports, but it is abvious for instance that foxes may sometimes be successful at times when thin ice is a hindrance to human hunters.

The most important land bird, the Rock Ptarmigan, is known to vary enormously in numbers in Greenland as elsewhere. This bird is seldom eaten by the Greenlanders when other food is to be had, but, like hares, it is important to the Danish officials, and therefore we find comparatively good information concerning the numbers of these animals in the reports.

It has been sometimes asserted (e. g. by Holbøl, 1843, 43) that Greenland ptarmigan migrate southwards in winter, but recent authors seem to agree that movements are only towards the coast in autumn and back again in spring as already stated by Cranz (1770, 102): "(sie) werden erst im Winter vom allzuhäuffigen Schnee genötigt, sich näher an die See zu begeben, wo der Wind den Schnee von den Felsen so viel wegweht, dass sie ihre Speise suchen können". Gelting (1937) has recently elucidated this point further by a combination of crop examinations and botanical studies.

In order to be able to present the data contained in the reports in a brief and perspicuous form, the statements are transcribed according to a scale ranging from 0 to 4 (table IV). 0 means extremely scarce ("hunting never so bad within human memory", "almost impossible to secure a single ptarmigan", and the like), 1 means "scarce" or "hunting bad", 2 normal, 3 "Numerous", "good hunting, 4 "exceptionally numerous", and the like. Sometimes fractions have been used to meet the requirements. Expressions are extremely varied, and some statements could as well be classed a fraction higher or lower, but it is thought that as a whole these values give a fair impression of the contents of the reports. Brackets means that the importance of the hunting is stated to be so and so. This introduces a source of error, because for

Table IV. Fluctuations in numbers of hares (H.) and ptarmigan (P.) in the transscribed according to a scale 0—4. L. means

	Juliane-haab	Frederiks-haab	Godthaab	Sukker-toppen	Holsteins-borg	Average South Greenland	Egedes-minde
1882	..	L 1	..	..	..	1,0	..
1883	..	L 1	..	..	..	1,0	..
1884	..	..	..	..	P 1	1,0	..
1885	..	L 1	..	Lb (1)	..	1,0	..
1886	..	1	1½	..	Lb 1	1,2	½
1887	0	L ½	½	..	½	0,4	P 1, H 2
1888	..	P 2, H 1	..	PH ½	P 3, H 2	1,8	1
1889	..	P 4	Lb 3	P 2	P 3, H 1	3,0	1½
1890	P 2½	L 1	Lb 3	P 3	P 3, H ½	2,5	P 3
1891	P 3	P 3	P 2	P 4	P 4	3,2	..
1892	4	4	P 3	P 3	P 3	3,4	2
1893	L 3	P 2	P 1	(½)	P ½	1,4	½
1894	P 4, H 1	P 4	P 2	..	2½	3,1	..
1895	P 1, H 2	P 1	1	1	..	1,0	½
1896	½	L ½	½	LbH ½	P 0, H ½	0,4	½
1897	1	L ½	0	0	P 0, H 2	0,3	½
1898	L ½	½	P ½	Lb ½	P ½, H 3½	0,5	½
1899	L (0)	L ½	½	½	½	0,4	..
1900	L 2	2	2	LbH 1	3	2,0	L 1
1901	3	L 2	2	P 1½	2	2,1	1
1902	..	..	..	..	..	..	..
1903	..	..	..	..	..	1,5	..
1904	..	..	..	..	..	4,0	..
1905	½	L ½	1	L 1½	3	1,3	L(P) 2½
1906	½	(1)	L 1	½	L ½	0,7	L 2
1907	L ½	L(P) ½	½	½	½	0,5	L ½
1908	L(P) ½	L (0)	½	0	1	0,4	L(P) ½
1909	L 1	..	½	½	L 1	0,7	2
1910	L 3	L 2	2½	2	P 3	2,5	1
1911	L 2½	3½	2	2½	1½	2,4	½
1912	L 1	(1)	1	P 2	P 4	1,8	P 3
1913	L 1	1	P 3, H 2	P 3	P 4	2,4	L ½
1914	3	P 3	2	P 3	P 2½	2,7	L ½
1915	L(P) 3½	P 4	(1)	1	P 1	2,1	P 3
1916	L(P) 3	2	½	L ½	2	1,6	..
1917	L(P) 3½	2½	(1)	P ½	½	1,6	P ½
1918	4	4	3	L 1	1½	2,7	..
1919	L(P) 0	L (0)	½	L 0	L ½	0,2	..
1920	½	½	½	½	½	0,5	..
1921	0	½	½	L 0	3	0,8	L 2½
1922	L ½	½	1½	L ½	3½	1,3	P 2½
1923	1	½	½	P ½	½	0,6	..
1924	1½	3	2	L 1	3	2,1	P 3
1925	1	1	P 3, H(0)	P 2	3	2,0	P 3
1926	2	½	..	P 1½	L(P) 1½	1,4	..
1927	3	2	3	LP 3	..	2,7	P 3
1928	½	2	P 2, H 1	P 1	..	1,4	P 3
1929	3	2	3	(0)	0	1,6	..
1930	2	3	2	P 0	P 0, H 1	1,4	1
1931	(2)	..	½	L 1	0	0,9	P ½
1932	(2)	½	(½)	L 0	0	0,6	P 1
1933	(0)	(0)	½	(0)	0	0,1	P ½
1934	(0)	(0)	1½	L (0)	L 1	0,5	P ½
1935	½	L (0)	2½	P 1	2	1,2	P ½
1936	2	2½	2½	P 1	P 2, H 1	2,0	P 1½
1937	3	2½	LP 3	P 1	P 2, H 1	2,3	P 2
1938	2½	1½	..	2	P 2, H 1	2,0	P 3½
1939	L (½)	½	..	2	2	1,2	P 3

various districts in West Greenland according to reports. The statements are "land-game". (Further explanation in the text).

Christians-haab	Jacobs-havn	Ritenbenk	Godhavn	Umanak	Upernavik	Average North Greenland	
..	..	..	..	P 3 1/2	..	3,5	1882
..	..	L 1/2	..	L (1/2)	..	0,5	1883
..	..	..	..	..	..	..	1884
..	..	..	..	..	..	..	1885
..	..	..	..	P 1	..	0,8	1886
1/2	L 1	..	..	P 1/2	..	0,8	1887
1	P 3	..	..	..	..	1,7	1888
P 3	..	..	..	L 1/2	P 1/2	1,4	1889
P 3	..	..	..	..	P 1	2,3	1890
P 3	..	..	P 3	..	..	3,0	1891
P 3 1/2	..	..	3	P 3	..	2,9	1892
..	..	P 2	P 1	..	..	1,2	1893
P 1/2, H 3	P 3	1	3	..	P decr.	1,9	1894
P 1	L 1/2	P 1/2	1/2	L 1/2	P (1/2)	0,6	1895
3 1/2	L 1	..	P 1/2	1/2	..	1,2	1896
L 1	L 1	P 2 1/2, H 3	2	P 1/2, H 2	..	2,1	1897
1 1/2	..	1/2	2 1/2	0	P 1	1,2	1898
..	..	1/2	L(P) 1/2	..	..	0,5	1899
3	L(P) 3	L 3	3	..	..	2,6	1900
3	L 3	..	P 1	1	..	1,8	1901
..	..	..	..	..	..	..	1902
..	..	..	..	..	..	..	1903
..	..	..	..	..	..	..	1904
3	..	L 1/2	2	1/2	P 1	1,6	1905
2 1/2	3	L 1	L 3 1/2	1/2	P 1/2	1,9	1906
L 1 1/2	1/2	L 0	L 1/2	P 1/2, H 2	P 1	0,9	1907
L 0	P 1/2	1	1/2	0	P 1/2	0,3	1908
3	1 1/2	L 1	L 1/2	P 1	..	1,5	1909
3	P 2 1/2	4	4	L(P) 2 1/2	..	2,8	1910
H 1/2, P 1	P 1	1/2	1	L(P) 3	P 1/2	1,1	1911
2 1/2	..	3	1 1/2	L 3	P 1/2	2,3	1912
L 1	L 2	3	P 3	L 3	P 3	2,2	1913
2	3	3 1/2	P 3, H (0)	L 3	P 1	2,3	1914
P 3	L 1	L 1	L 1	L (0)	L 1/2	1,4	1915
P 1 1/2	L 2	3	1/2	L 1	P 1/2	1,4	1916
P 1/2	L 1/2	P 3	L 1	L 1	..	1,1	1917
..	..	1/2	L 2	L 1/2	..	1,0	1918
..	1/2	P 1/2	Lb 1/2	L 1/2	..	0,5	1919
..	L 1/2	1/2	Lb 1/2	1/2	..	0,5	1920
..	1 1/2	..	Lb 1	2	..	1,8	1921
..	2 1/2	..	Lb 2	3	..	2,5	1922
3	L 1/2	2	P 2, H 1	2	..	2,1	1923
P 3 1/2	L 2	P 3	3	3	..	2,9	1924
2 1/2	L 2	..	..	..	1	2,1	1925
3	L 2	1	L 3	2 1/2	..	2,3	1926
3	L 3	..	..	L 1	..	2,5	1927
2	L 2	L 1	P 2	..	1 1/2	1,9	1928
P 1 1/2	L 1/2	L 1/2	1	P 1/2	..	0,8	1929
1	L 1/2	1	0	P 1	..	0,8	1930
1	L 1/2	1	0	..	..	0,6	1931
1	L 1	(0)	1/2	L 1/2	..	0,7	1932
1/2	L (0)	(1/2)	1/2	L 1/2	(0)	0,4	1933
1 1/2	L (0)	1	L 0	L 1	..	0,7	1934
2	L (0)	..	..	1	..	0,9	1935
2 1/2	..	..	..	2	..	2,0	1936
2 1/2	P 2	2	1/2	3	2	2,0	1937
L (0)	P 3	L(P) 3	3 1/2	4	P 3 1/2	2,9	1938
3	2	L 2	P 2	1/2	L 1/2	1,9	1939

instance "ptarmigan hunting of little importance" may mean that this hunting was little pursued though the birds were present in fair numbers. One gets the impression, however, that these statements are about as reliable as the others, as they generally agree with neighbouring districts. In calculating averages these values are included. Table IV also summarizes information on hares, which are almost always commented upon together with ptarmigan, and these two animals seem to fluctuate in numbers together on the whole, it is only seldom that the relative numbers of ptarmigan and hares are said to differ. Statements on ptarmigan are the more complete, and the averages are made without regard

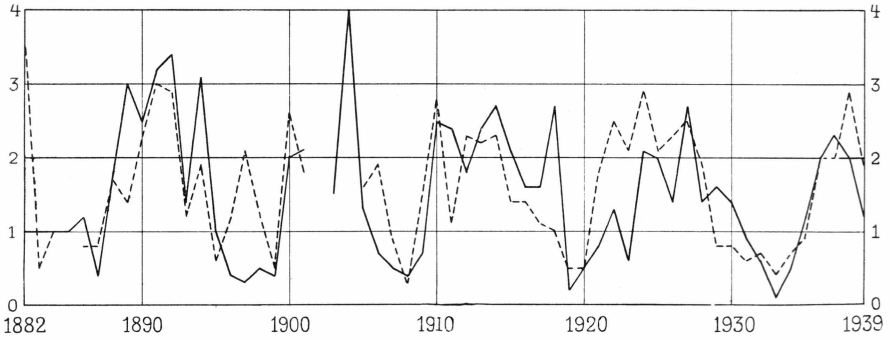

Fig. 6. Fluctuations in numbers of ptarmigan in North Greenland (dotted line) and South Greenland. Based on reports. (See the text).

to hares. P means ptarmigan, H hares, a figure alone means P and H. L stands for "land-game" ("Landvildt" or "Landjagt"), this is evidently almost always used synonymously with P + H. The possibility that reindeer is aimed at is usually excluded by a separate reference to this game. L(P) means that ptarmigan is expressly stated to be included, for instance "land-game (especially ptarmigan) numerous". Lb which occurs a few times in the table means "land-birds" (Landfugle), this almost certainly applies chiefly to ptarmigan.

The curves in fig. 6 are based on the averages of the figures expressing the frequency of ptarmigan in North and South Greenland during the various years. It may be seen that good and bad periods alternate at fairly regular intervals. It is possible that the numbers of these birds (and of hares) in Greenland fluctuate according to a period of about ten years,—as seems to be the case for all species of grouse in Canada (CLARKE, 1936, 29),—though the average is somewhat larger during the period investigated. Letters and diaries are in existence from more distant times, containing information of the same nature as that in the reports, and it is hoped that future studies in the archives may carry the records further back.

The cause of the fluctuations in numbers of this and other plant-eating vertebrates is still not thoroughly elucidated. The present author has recently (BRAESTRUP, 1940c, cf. also 1940a and 1940b) endeavoured to give reasons for the assumption that the periodic drop in health observed in such species is due to some mineral deficiency owing to variations in the mineral contents of plants, which in their turn are dependent on processes in the soil, regulated by or adjusted to climatic cycles. This hypothesis can only be finally proved or disproved by future biochemical work and by investigations of the nature of the diseases which attack plant eaters at the times of decline. It is mentioned here, because a certain feature in the behaviour of ptarmigan in Greenland and elsewhere may be worthy of consideration in this connection. SOPER (1934, 44) found Willow Ptarmigan to be very numerous at Camp Kungovik (W. coast of Baffin Island 65°35′ north) from May 24th when the camp was established until nearly the middle of June. "By late June and early July the species had shrunk in numbers to such a extent that a walk of many miles on any day would not reveal more than 3 or 4 individuals. . . . During the latter part of July, Willow Ptarmigan was observed on only one occasion on the Bowman Bay plain". This disappearance was no doubt a result of die-off, because it happened far too late in the season to be caused by migration toward breeding places elsewhere. According to information compiled by BENT (1932, 178) this species usually begins nesting in the latter half of May.

When the birds at Camp Kungovik were still numerous "flocks numbering from a few individuals up to about 200, made a practice of sweeping in and alighting noisily at the camp. Here, so long as no one appeared, and quiet was maintained, the birds held high carnival. They walked briskly about the tents, under the guy ropes, pecked at the canvas, flew to the ridge poles of the tents, and inspected boxes, cans, and the big canoe with consuming interest. The very existence of the camp appeared to be a magnet for their overwhelming curiosity". This description is so much like that published by the same author (SOPER, 1921, 104) of the behavour of the Canadian Varying Hare (*Lepus americanus*) during its peak of abundance that if one accepts the explanation advocated in the above mentioned paper (BRAESTRUP, 1940c) that we have to do with a result of an abnormal appetite, then the above may be taken to indicate that the same is the case in Willow Ptarmigan immediately before the decline sets in.

In Greenland it is often stated that as a climax of a ptarmigan maximum the birds even come in among houses (MÜLLER, 1906, 52). This is mentioned in the reports for 1925 and 1938. In the trading year 1925 at Holsteinsborg large flocks alighted in the outskirts of the settlement, even swarming in over the houses. The report from Umanak

covering October—April 1938 says that during that period there was a superabundance of ptarmigan and hares, which, in many places, even came down among the houses. In both cases the abundance was followed by a decline a short time afterwards.

Whatever is the cause of these fluctuations we should expect parallel fluctuations in the numbers of foxes, since hares and especially ptarmigan are said to be important food items to foxes. In order to faciliate comparison the curve illustrating fluctuations of ptarmigan in South Greenland is repeated on the plate over the curve representing the total catch of foxes in South Greenland.

The ptarmigan curve begins with a bad period simultaneous with decline and a low ebb in the fox curve. Then the ptarmigan population recovers during 1888 and 1889 followed by a rise in the fox curve which remains at a high level in 1895, the year after the culmination of the ptarmigan curve. This lag of a year was to be expected from analogy with what is known about lemming foxes, i. e. the maximum catch during the first winter after the decline in the food supply. A minimum on the fox curve is reached in 1897 simultaneously with the lowest ptarmigan value, but after that we find the first obvious disagreement between the two curves: the fox curve begins rising rapidly while the ptarmigan population is still low, and it drops after a maximum in 1900 at a time when ptarmigan and hares are tolerably numerous. The numbers of this game reach a peak in 1904, and we find accordingly a pronounced rise in the numbers of foxes the following year, but the drop in 1906 is only small, and the fox curve remains on a high level simultaneously with an ebb in the ptarmigan curve until 1910, then it drops at a time when, from the high numbers of hares and ptarmigan, we should expect it to rise. During the following year the fluctuations in the numbers of ptarmigan and hares in the various districts are strickingly out of step, the maximum with subsequent drop in numbers occuring at different times in the various parts of the country. In the three most southern districts where there was a violent drop from very high numbers in 1918 to extreme scarcity in 1919 we find accordingly a high peak in the fox numbers in 1919 followed by decline. Since then, however there was an absolute disagreement between numbers of hares and ptarmigan and those of foxes. The very large catches after 1930 are simultaneous with an ebb in ptarmigan numbers, and the ptarmigan maximum of 1937 only causes a short stop in a violent drop in fox numbers, which was initiated in 1934.

One gets the impression that, while in some periods the numbers of hares and ptarmigan distinctly influence the size of the fox population, there are also other factors which sometimes are so dominating as to entirely overshadow this influence.

Climate, especially that of winter, may be important in influencing the availability of the food. A severe winter with much ice along the shore means difficulties in securing mollusks, crabs etc. These important items may at such times only be had at places where the ice has been broken by the tides. On the other hand, when the sea is covered by ice to an unusual extent sea birds often perish in large numbers, affording plenty of food (MÜLLER, 1906, 308), thus the matter is complicated. The numbers of shore animals may of course also fluctuate. The reports contain some information concerning the occurrence of the fishes *Gadus ogac* and *Gadus saida*, which come to the shore in winter, but as the importance of this fishing is so much dependent on the Greenlanders varying access to other food this information cannot give a reliable picture.

In order to give an impression of the severity, or the opposite, of the winters in South Greenland the average deviations from the mean temperatures for the months December—April in the years 1880—1938 at Ivigtut in the Frederikshaab District was calculated and represented by a curve, which will be found on the plate between the fox curves for Julianehaab and Frederikshaab. There are a few winters in which no temperature observations were carried out at Ivigtut: 1919 is designated in the general report as rather cold, but in South Greenland often interrupted by periods of mild weather. 1927—1929 were all mild winters, 1928 coldest "on the whole colder than the previous winters", but nevertheless it is designated as warmer than the average. 1929 was "everywhere in Greenland milder than ever before". This temperature curve affords no obvious explanation of the deviations between the ptarmigan curve and the fox curve. A general rise in temperature in recent times is very apparant as in most arctic countries. It has attracted much attention among meteorologists and biologists (cf. A. S. JENSEN, 1939). The fox curve also has become generally higher in recent years, but caution is required in connecting this with temperature, because rising prices have no doubt caused the fox hunting to be pursued with more vigour.

There is still another feature, however, which is characteristic of the fox curve during the milder climate in recent years: the disagreement between fluctuations in the numbers of foxes and of ptarmigan and hares is especially great here. If this disagreement is due to one or more other factors it is reasonable to suppose that this factor (or factors) is favoured by the higher temperatures. Apart from the shore fauna of which, as far as fluctuations are concerned, we know almost nothing, the animals' access to charr (*Salvelinus alpinus*)[1]) is also much dependent on temperature because as the winters become less severe the period during which the rivers are frozen is shortened.

[1]) *Salmo salar* is also found in Greenland but only in a few rivers.

Unfortunately, there are no satisfactory records on fluctuations in numbers of charr in Greenland. There are some figures to hand stating the amount of salted charr sent to Danmark during the last few decades, but it is apparent from the reports, which Mr. P. M. Hansen has kindly confirmed, that these amounts, which are only small fractions of the total catch, are influenced by so many other factors that they cannot give any idea of the relative numbers of fishes present during the years in question. The reports are not satisfactory either for our present purposes, but now and then there are some references to the frequency or scarcity of charr, and, scanty as it is, this information is favourable to the view that the numbers of this fish is an important factor in determining the size of the fox population, in South Greenland at least. As previously mentioned, a rise in the numbers of foxes caught in South Greenland during 1908—10, with a subsequent drop, is not in accord with the fluctuations in numbers of ptarmigan and hares. During the summers of 1905 and 1906 the charr fishery is stated to have been good at Sukkertoppen (Sn). From the summer of 1907 we have a report from Godthaab (Gb) using the rare expressions that the fishery of charr was especially successful and yielded remarkably good catches. In 1908 it is said to be less successful in Gb and the southern parts of the Sn district (northers part good), but in 1909 the Gb report says "almost everywhere in the district unusually successful, catch exceptionally great", and at Sn the catch is stated to have been good everywhere. During 1910 and 1911 this fishery is described as less successful and the Sn report from 1911 speak of smaller numbers of charr than usual.

In the summer of 1931 the salmon fishery at Sn is designated as exceptionally good, and at Gb "good catch". During the previous years it is generally described as of little importance. Again, after 1935 we hear of small catches, and a report from Sn states that in 1936 these fishes did not arrive in such large shoals as usual. This agrees with the decline in fox numbers after the exceptionally large numbers of 1930—1934. It must be emphasized once more, however, that these reports should be used with caution as records of fluctuations, and no final conclusions should be drawn from them. We may only say that, imperfect as they are, they seem to agree with the assumption that charr is an important factor.

As a result of the discussion in this chapter, we may say that it is not possible at present to elucidate satisfactorily the factors which are responsible for the fluctuations in the catch. Matters are too complicated, and the information which we should wish to have is too scanty. Only concerning hares and ptarmigan are there satisfactory reports for a certain period, and it is reasonably certain that the numbers of these animals influence fox numbers. But this is obviously only one

among several factors, other influences may at some periods be completely dominant. It is probable that varying numbers of charr is one of these factors, though no definite conclusions can be drawn in this respect. Better understanding of the factors involved is only possible by field work, especially stomach analyses, and it is hoped that the above compilation and discussion may be of some service during this work.

CONCLUDING REMARKS

From the facts brought together in this paper it is evident that the Arctic Fox in Greenland cannot be treated as an ecologic unity. In the first place we find a striking difference between the conditions on the northern coast from Hall Land eastwards and along the east coast down to Scoresby Sound on the one hand, and the rest of Greenland on the other. The former parts are inhabited by lemmings which provide by far the most important food item to the foxes while in the rest of Greenland lemmings are absent, the foxes subsisting largely on products of the sea. A comparison between the graph of fig. 4, which represents fluctuations in numbers of foxes at Scoresby Sound in the lemming district, with the graphs on the plate representing the catch in West Greenland, shows that at the former place there are regular fluctuations with maxima at intervals of about four years while in West Greenland there is usually no such regularity. This difference, which has been previously pointed out by Elton, is easily explained by the fact that years rich in lemmings succeeded by years of extreme scarcity, occur at intervals of about four years while the food supply at the disposal of foxes where there are no lemmings does not fluctuate so regularly.

The difference does not, of course, exclude the possibility that the foxes in Northeast Greenland are absolutely identical in instincts, physiology etc. with those of West Greenland, the conditions alone being different, but we have seen that certain facts suggest that the two groups, which we have named "lemming foxes" and "coast foxes", may be considered as physiological races, a certain genetic differentiation having occurred in accordance with the widely different conditions. As a peculiarity in lemming foxes which is obviously connected with the violent fluctuations in the food supply, we have pointed out, as a result of a survey of the literature pertaining to the whole range of the species, that the maximum number of young is double that recorded for coast foxes. We cannot be absolutely sure, it is true, that coast foxes, when receiving the same food, could not produce an equal number of young, though it seems improbable, but we have further cited a most amazing

instance of coast foxes which, even when starving, did not—at least not to any large extent—take lemmings which were present in considerable numbers (St. Paul Isl., Pribilof Group, see p. 12). It is difficult to escape the conclusion that these foxes differ genetically from lemming foxes. It may seem curious that the population of lemmings on St. Paul does not support a population of lemming foxes which might have descended from the foxes which are said sometimes to arrive there by drift ice, but the area inhabited by lemmings in this small island is probably not large enough to support such specialists.

Finally there is a peculiarity of outward appearance distinguishing all coast foxes, viz. a high percentage of the "blue" variety, which, in small islands, may approach a hundred per cent.

It seems that a population of coast foxes may sometimes live side by side with lemming foxes. In North East Greenland we have an especially convincing case of this, the foxes at the bird cliffs on the Liverpool Coast containing a higher percentage of the blue variety and producing a moderate but constant number of young every year (Alwin Pedersen, 1931). It is probable that all Arctic coasts support foxes with the same mode of living as the foxes in West Greenland, Spitsbergen etc. In support of this assumption we may mention the fact that in the region of the estuary of the Mackenzie River there is a comparatively high percentage of blue foxes which do not—or to a very small extent—partake in the periodic migrations inland (cf. p. 12).

There are even a few independent observations recorded in recent literature which indicate that there may be even further ecological differentiations within the species, several ecological types living side by side (see p. 44). In Greenland it is not improbable that foxes resorting to bird cliffs form such a group differing from other coast foxes in accordance with the peculiar conditions. As a biological feature characteristic of such foxes may be mentioned the specially large food stores put up, and Freuchen's interesting observation that the stores are not resorted to until the beginning of the breeding season (cf. pp. 69—70).

The fact that no complaint is heard in Greenland of damage to sheep by foxes, while in Iceland they are a serious menace, is no doubt connected with the tendency to ecological differentiation in this species. It is probably only a matter of time for the foxes of southern West Greenland to begin profiting by the new possibilities, thus starting a serious conflict between two important industries. If this happens it is recommended that an energetic persecution of the actual animals which take sheep should be started immediately, because it is probable that, in the beginning, this habit would be

taken up by only a few individuals from which a breed of sheep eaters might perhaps originate.

Apart from the native lemming foxes in N. E. Greenland we find this group represented in northern West Greenland—and apparently in all of Greenland in certain years—by periodical immigrants from Canada, on drifting ice and via Smith Sound, and no doubt also to some extent from the lemming regions in Greenland itself (see chapter II).

The foxes caught in Greenland may thus be said to include at least the following categories: Autochtonous lemming foxes in the region from Hall Land to Scoresby Sound, lemming foxes caught as immigrants in other parts of Greenland, coast foxes occurring side by side with the lemming foxes in the North East and as the breeding population in all the rest of the Greenland territories.

The question of ecologic types, apart from its great scientific interest, is also very important from a practical stand-point, firstly because the numbers which may be trapped without damage to the population is not the same in the various groups, and secondly because trapping may alter the proportion between the blue and the less valuable white variety by affecting the various groups differently.—For instance, it is obviously advisable to trap as far as possible all the white immigrants in West Greenland. Fortunately they seem to be far more easily trapped than the resident foxes.

In discussing the advisability of introducing lemmings into West Greenland we have to take into consideration that this measure, if successfully carried through, would no doubt favour the white variety to the disadvantage of the more valuable blue one.

The chromatic dimorphism of the Arctic Fox will be further discussed in a special paper on the variation of the blue to white ratio of the West Greenland resident population in time and space. In the present connection we may only mention the possibility that the higher percentage of the blue variety in coast foxes may be a matter of climate, not of ecology. While coast foxes are certainly mostly found in regions with less severe winters, it is enough to point to the Thule District for proof that there is no absolute correlation in this respect. The Thule District has a very high percentage of blue in spite of the fact that its winter temperatures are much lower than e. g. in Baffin Island where the foxes are nearly all white in winter.

SUMMARY

I. A certain ecological differentiation seems to exist between Arctic Foxes dependent on lemmings and such as live in places where these rodents are not found. The latter are to a very large extent dependent on products of the sea, and therefore they may be designated as "coast foxes" as opposed to "lemming foxes". The recorded maximum number of young in the latter group is nearly double that of the former, in accordance with the much greater need for fertility at certain times in lemming foxes, which fluctuate violently in numbers according to variations in the amount of their principal food, lemmings.

II. It is well known that when the lemmings at any place are rapidly reduced from maximum numbers to extreme scarcity, the hungry foxes migrate very far. Such migrating foxes arrive in West Greenland in considerable numbers. They come from Canada and extreme Northern Greenland (where almost all foxes are white), and probably also (via the East Greenland pack) from N. E. Greenland. The arrival of Canadian foxes in northern West Greenland is indicated by a rise in the percentages of white foxes in the catch in certain years which coincide with or follow immediately after years during which we should expect emigrations from Canada's Eastern Arctic.

These immigrants seem to come partly via the Thule District, where it is well known that foreign white foxes arrive every winter, but in especially great numbers every four years (which is confirmed by figures at hand),—and partly they may be brought by the Baffin's Bay pack ice. Direct observations of foxes having arrived with this ice are quoted. There is reason to believe that sometimes a rise in the percentages in a certain winter is due to white foxes which came the previous spring and spent the summer in Greenland (e. g. 1922—23).

The recorded instances of "mad" foxes in northern W. Greenland are confined, with a single exception, to years during which, to judge from the percentages, an immigration has taken place, or to years during which an immigration from Canada was to be expected even if this is not apparent from the percentages. Thus it is probable that this disease,

which is transmissible to dogs, is brought to Greenland by migrating foxes, in accordance with the fact that Arctic Foxes are most liable to this disease at times of lemming minima.

III. A short record of fluctuations in numbers of lemmings and foxes at Scoresby Sound in N. E. Greenland shows a cycle of about four years in the numbers of lemmings and a corresponding cycle in foxes with maximum catches in the winters following a maximum of lemmings. This is in accordance with known facts from other regions where lemmings are found. On the coast further north one of the cycles seems to be missing, there being an interval of 9 years between two successive maxima (1929 and 1938). The maxima of lemmings and foxes in N. E. Greenland 1924—1938 were out of step with those in most parts of eastern Canada.

IV. In West Greenland, where there are no lemmings, we do not find the regular four year period in numbers of foxes so characteristic of lemming foxes. There are very considerable fluctuations in the catches, however, and these are no doubt caused in the main by real fluctuations in the numbers of foxes, in South Greenland at least, because here there is little other industry to compete with fox hunting.

The food biology of the West Greenland foxes is too complicated and knowledge of the variations of the factors involved is too scanty to allow a complete analysis of the reasons for the fluctuations in the numbers of foxes. It is possible to get a fair idea of the fluctuations in numbers of hares and ptarmigan since 1882, and a comparison between these fluctuations and those of foxes, as gauged by the varying catch in South Greenland, makes it reasonably certain that the size of the fox population is influenced to some extent by this factor, but it is clear that there are also other factors at work, which at certain times completely overshadow the influence of hares and ptarmigan. This has been especially the case during the last few decades, a fact which is possibly connected with the exceptionally mild winters. There is some reason to suppose that variation in the amount of charr in the rivers is an important factor, but the knowledge of these variations is far too incomplete to allow definite conclusions.

Table V. Arctic foxes. Total

An asterisk means that a few summer skins are included.

	Julianehaab		Frederikshaab		Fiskenæsset		Godthaab		Sukkertoppen		Holsteinsborg	
		%		%		%		%		%		%
1793	**237**		**70**	31,6	..		..		**139**	20,2	**57**	26,3
1794	**226**		**66**		..		..		**123**	26,0	**164**	25,6
1795	**521**		**136**		..		**182**		**165**	21,2	**147**	
1796	**635***	27,0	**120***	42,1	..		**152**	19,7	**109**		**116**	
1797	**986***	18,5	**357***	31,2	..		**165**	15,1	**125**		**112**	
1798	..		**197***	26,6	..		**173**	23,7	**76**		**86**	
1799	**271***	20,4	**81***	23,2	..		**51**	21,6	**60**		**40**	
1800	**290***	28,3	**181***	24,4	..		**169**	25,4	**120**	17,5	**100**	34,0
1801	**653***	34,2	**299***	31,2	**95**	6,3	..		**170**	16,5	**57**	33,3
1802	**436***	35,2	**106**	25,5	**52**	13,5	**138**	35,5	**96**	17,7	**75**	30,7
1803	**252***	36,8	**57**	24,6	**9**	11,1	**42**	31,0	**40**	10,0	**43**	27,9
1804	**131***	47,6	**21**	47,6	**25**	4,0	**21**	28,6	**57**	38,6	**21**	47,6
1805	**354***	45,6	**64**	35,9	**24**	20,8	**21**	47,1	**70**	27,2	**29**	41,4
1806	**251**	46,6	**79**	36,7	**31**	19,4	**99**	38,4	**54**	35,2	**82**	32,9
1807	**294**	50,0	**37**	29,7	**33**	18,2	**245**	18,7	**114**	29,0	**131**	26,7
1808	**997***	22,4	**247**	20,6	**262***	15,5	**393**	20,1	**220**	25,9	**286**	28,3
1809	**927***	18,1	**459**	18,5	**113***	22,6	**183**	21,3	**146**	28,1	**117**	38,5
1810	**177**	31,6	**94**	10,6	**38***	10,8	**30**	23,3	**95**	20,0	**61**	36,1
1811	..		**58**	29,3	..		**23**	47,9	**29**	82,7	**26**	57,7
1812	..		**104***	12,5	..		**51**	25,5	**43**	41,8	..	
(1813—15 no information)												
1816	**472***	21,1	**136**	27,2	**113***	18,9	**144**	22,9	**136**	25,0	**166**	34,4
1817	**535***	21,9	**136**	28,7	**52***	32,0	**136**	21,3	**58***	29,1	**119**	31,1
1818	**336***	16,6	**78***	34,9	**66**	12,1	**97***	22,4	**69***	33,3	**141**	32,6
1819	**172***	30,3	**78***	31,9	**69**	30,4	**132***	23,4	**53***	28,6	**77**	26,0
1820	**95***	48,7	**41***	50,0	**51**	29,4	**144**	18,8	**67***	20,6	**159**	34,6
1821	**92**	43,5	**84***	48,1	**58**	13,8	**147***	22,9	**86***	30,8	**117**	23,9
1822	**182***	32,0	**106**	29,2	**46***	10,5	**176**	25,0	**66***	20,0	**93**	35,5
1823	**181***	33,1	**115**	34,8	**113***	20,7	**221**	37,5	**63**	28,6	**154**	39,6
1824	**223***	28,8	**87**	55,2	**70***	23,9	**140**	20,7	**105***	27,5	**89**	18,0
1825	**256***	37,2	**114**	35,1	**82***	22,1	**126**	27,0	**81**	32,1	**168**	30,4
1826	**504***	12,3	**144***	18,7	**94**	9,6	**150**	20,0	**99***	23,5	**197**	26,9
1827	**550**	17,6	**181***	20,6	**128***	11,8	**466**	31,8	**171***	20,8	**315**	30,2
1828	**708**	22,4	**209***	17,0	**102***	24,0	**421***	24,1	**234***	20,7	**391**	28,1
1829	**236**	14,8	**55**	23,6	**38***	28,6	**254***	34,0	**115**	27,8	**144**	28,5
1830	**368**	15,5	**105***	22,4	**85**	20,0	**338**	26,9	**209**	23,4	**240***	21,9
1831	**972**	15,5	**223***	27,0	**197**	17,8	**315**	24,5	**272**	22,4	**383**	23,8
1832	**2260**	13,8	**505**	27,0	**390**	17,9	**735**	29,5	**420**	23,6	**634**	33,3
1833	**1019**	20,2	**223**	28,3	**243**	18,5	**364**	29,4	**227**	23,3	**154**	36,4
1834	**352**	26,7	**193**	23,3	**128**	30,5	**459**	29,4	**230**	27,4	**175**	28,0
1835	**397**	18,4	**193**	23,8	**84**	21,4	**160**	37,5	**182**	23,6	**165**	25,5
1836	**312***	17,0	**153**	28,1	**86**	31,4	**247**	41,0	**124**	16,9	**263**	32,3
1837	**403***	15,1	**93**	35,5	**31**	29,0	**138**	46,4	**47**	49,0	**61**	49,2
1838	**178**	24,2	**80**	16,3	**85**	21,2	**222**	51,8	**86**	16,3	**177**	28,8
1839	**290**	13,4	**95**	10,5	**30**	30,0	**115**	50,4	**84**	17,9	**50**	30,0
1840	**218**	22,5	**101**	19,8	**82**	31,7	**157**	44,0	**131**	35,2	**224**	32,2
1841	**880**	20,3	**134**	25,4	**109**	34,9	**314**	52,3	**188**	29,2	**437**	39,4

number and percentage of white.

Percentages based on figures less than six are in brackets.

Egedesminde		Disko Bay Settlements		Umanak		Upernavik		South Greenland		North Greenland		
	%		%		%		%		%		%	
102	26,5	**109**	24,8	**17**	82,3	**7**	0,0	..		**235**	28,9	1793
97	35,1	**176**	20,5	**15**	66,7	**0**		..		**288**	27,8	1794
100	37,0	**36**	50,0	**35**	91,4	**25**	64,0	**1151**		**196**	52,6	1795
54	16,7	**74**	33,8	**1**	(100)	..		**1132**		**129**	27,1	1796
19	31,6	**35**	31,4	**0**		..		**1745**		**54**	31,5	1797
24	33,3	**73**	37,0	**7**	100,0	..		..		**104**	40,4	1798
19	15,8	**18***	38,5	**6**	50,0	..		**503**		**43***	29,0	1799
49	30,6	**39**	43,6	**0**		..		**860**		**88**	36,4	1800
9	11,1	**28**	17,9	**0**		..		**1274***	28,7	**37**	16,2	1801
21	9,5	**32**	50,0	**1**	(100)	..		**903***	30,5	**54**	35,2	1802
15	13,3	**16**	37,5	**2**	(100)	..		**443***	30,4	**33**	30,3	1803
19	21,0	**20**	30,0	**0**		..		**276***	39,6	**39**	25,6	1804
31	16,1	**44**	29,6	**3**	(33)	..		**562***	40,9	**78**	24,4	1805
62	29,0	**51**	27,5	**3**	(100)	**47**	72,3	**596**	39,7	**163**	42,3	1806
53	5,7	**82**	40,2	**8**	75,0	**53**	98,1	**854**	32,6	**196**	48,0	1807
38	18,4	**77**	15,6	**17**	64,7	**5**	(100)	**2405***	22,2	**137**	25,5	1808
31	19,4	**52**	13,5	**16**	43,8	..		**1945***	20,8	**99**	20,2	1809
54	22,2	..		**5**	(60)	..		**495***	23,9	..		1810
49	55,1	**4**	(50)	**2**	(100)	..		**136**	49,3	..		1811
32	15,6	..		..		..		..		..		1812
70	24,3	**97**	60,8	**8**	50,0	..		**1167***	24,5	**175**	45,7	1816
58	22,4	**44**	77,2	**3**	(0)	..		**1036***	24,9	**105**	44,8	1817
40	10,0	**46**	45,7	**9**	55,6	..		**787***	23,3	**95**	31,6	1818
55	40,0	**111**	44,1	**6**	33,3	..		**581***	28,1	**172**	42,4	1819
30	53,4	**91**	46,1	**2**	(100)	..		**557***	31,1	**123**	48,8	1820
34	26,4	**107**	46,7	**1**	(0)	..		**584***	30,2	**142**	41,6	1821
47	21,2	**133**	50,4	**23**	34,8	..		**669***	27,6	**203**	41,8	1822
50	16,0	**191**	50,2	**27**	59,3	..		**847***	33,8	**268**	44,8	1823
51	27,5	**137**	54,7	**15**	46,7	..		**714***	28,4	**203**	47,3	1824
34	5,9	**93**	46,2	**6**	66,7	..		**827***	31,9	**133**	36,9	1825
128	29,7	**197**	39,1	**18**	72,2	**21**	19,1	**1188***	17,3	**364**	36,3	1826
132	26,6	**124***	38,2	**7**	85,7	**10**	30,0	**1811***	23,8	**283***	33,5	1827
92	34,8	**112**	37,5	**18**	61,1	**29**	24,2	**2065***	23,2	**251**	36,7	1828
43	14,0	**95**	36,8	**14**	28,6	**78**	16,7	**842***	25,9	**230**	25,2	1829
50	32,0	**75**	38,7	**2**	(50)	**1**	(0)	**1345***	21,7	**128**	35,9	1830
110	19,1	**100**	44,0	**2**	(50)	**1**	(0)	**2362***	20,1	**213**	31,0	1831
237	19,8	**240**	49,2	**5**	(40)	**11**	54,5	**4944***	21,1	**493**	35,1	1832
54	52,8	**172**	68,6	**27**	77,8	**64**	73,4	**2230***	23,7	**317**	67,5	1833
118	22,0	**157**	41,4	**17**	70,6	**19**	52,6	**1537**	27,7	**311**	36,4	1834
109	28,4	**71**	32,4	**1**	(0)	**4**	(100)	**1181**	23,9	**185**	31,4	1835
274	35,0	**97**	48,5	**1**	(0)	**54**	64,9	**1185***	28,0	**426**	41,8	1836
105	36,2	**99**	74,7	**15**	46,6	**108**	54,6	**773***	28,6	**327**	54,4	1837
88	39,8	**125**	45,6	**11**	27,3	**9**	55,6	**828**	30,6	**233**	42,9	1838
164	28,7	**148**	43,9	**3**	(67)	**9**	33,3	**664**	22,0	**324**	36,1	1839
57	40,3	**92**	73,9	**5**	(80)	**70**	52,9	**913**	30,9	**224**	58,9	1840
354	41,2	**115**	60,0	**10**	70,0	**10**	60,0	**2062**	31,1	**489**	46,6	1841

Table V

	Julianehaab		Frederikshaab		Fiskenæsset		Godthaab		Sukkertoppen		Holsteinsborg	
		%		%		%		%		%		%
1842	**628**	24,1	**98**	29,6	**68**	17,6	**127**	63,7	**140**	28,6	**241**	34,0
1843	**780**	24,0	**77**	31,2	**52**	28,8	**253**	55,0	**239**	35,6	**781**	39,8
1844	**540**	18,9	**117**	35,1	**79**	34,2	**312**	48,4	**139**	36,7	**152**	39,5
1845	**499**	46,5	**85**	68,2	**89**	48,3	**149**	54,4	**71**	53,5	**141**	39,7
1846	**647**	27,5	**114**	48,3	**89**	39,3	**378**	44,2	**179**	46,9	**446**	34,8
1847	**363**	27,6	**57**	35,1	**76**	34,2	**98**	59,2	**127**	47,3	**334**	48,5
1848	**615**	27,4	**146**	32,2	**73**	50,7	**398**	39,4	**158**	33,6	**127**	50,4
1849	**616**	24,2	**131**	35,1	**79**	45,6	**393**	42,5	**174**	29,9	**307**	54,7
1850	**508**	29,1	**58**	46,5	**80**	36,2	**132**	44,0	**95**	35,8	**165**	46,1
1851	**762**	35,6	**163**	41,7	**125**	40,8	**286**	47,5	**123**	53,7	**151**	62,3
1852	**605**	48,9	**83**	47,0	**102**	41,2	**309**	46,9	**101**	54,5	**389**	53,2
1853	**745**	33,7	**105**	41,0	**80**	18,7	**246**	39,0	**97**	42,3	**200**	55,5
1854	**1449**	25,4	**282**	29,1	**278**	21,6	**340**	33,0	**143**	33,6	**320**	54,1
1855	**673**	29,1	**91**	33,0	**95**	21,1	**251**	33,4	**96**	35,4	**364**	48,3
1856	**252**	29,4	**77**	45,5	**48**	22,9	**225**	40,9	**192**	33,9	**150**	65,4
1857	**670**	25,4	**90**	48,9	**50**	30,0	**136**	42,6	**86**	34,9	**188**	54,8
1858	**555**	34,1	**155**	19,4	**131**	19,1	**286**	35,3	**55**	23,6	**140**	42,9
1859	**438**	22,6	**65**	27,7	**52**	34,6	**260**	37,7	**117**	27,4	**360**	43,6
1860	**625**	36,5	**132**	32,6	**106**	40,6	**361**	30,7	**161**	36,6	**314**	51,9
1861	**569**	40,8	**202**	33,7	**64**	25,0	**242**	29,4	**132**	22,0	**258**	48,8
1862	**315**	43,9	**93**	31,2	**30**	50,0	**122**	49,2	**173**	28,3	**173**	49,7
1863	**1023**	35,8	**209**	30,1	**83**	42,2	**97**	43,3	**120**	22,5	**131**	49,6
1864	**440**	49,5	**73**	41,1	**40**	42,5	**79**	50,6	**66**	30,3	**112**	57,2
1865	**109**	65,2	**64**	20,3	**34**	23,5	**76**	46,0	**63**	38,1	**52**	53,8
1866	**72**	61,1	**45**	26,7	**57**	12,3	**100**	35,0	**48**	20,8	**46**	45,7
1867	**87**	57,5	**36**	36,1	Since 1867		**167**	28,8	**94**	23,4	**117**	54,7
1868	**292**	57,2	**189**	34,9	included in		**326**	25,2	**104**	29,8	**120**	43,3
1869	**457**	48,4	**83**	37,4	Godthaab		**328**	32,6	**87**	34,5	**188**	58,5
1870	**439**	48,5	**110**	32,1	..		**321**	36,2	**149**	37,6	**257**	55,3
1871	**359**	48,5	**56**	44,6	..		**134**	36,6	**131**	34,4	**173**	56,6
1872	**363**	60,3	**78**	30,8	..		**210**	32,9	**184**	32,6	**159**	58,5
1873	**716**	49,2	**236**	38,2	..		**664**	30,5	**338**	27,8	**192**	55,7
1874	**2215**	47,4	**581**	28,6	..		**1086**	24,8	**439**	28,7	**276**	54,0
1875	**1165**	45,4	**212**	27,4	..		**580**	29,5	**431**	19,5	**280**	44,0
1876	**567**	51,2	**248**	28,2	..		**504**	35,0	**473**	24,5	**245**	50,7
1877	**839**	47,3	**240**	27,5	..		**619**	29,8	**398**	22,4	**169**	46,1
1878	**569**	49,5	**231**	28,6	..		**392**	28,1	**253**	24,9	**172**	51,7
1879	**1022**	49,8	**247**	30,0	..		**816**	31,2	**460**	28,3	**286**	50,4
1880	**1344**	44,8	**346**	31,2	..		**522**	32,4	**278**	21,6	**304**	49,6
1881	**564**	41,9	**122**	28,7	..		**384**	34,4	**218**	25,7	**324**	53,5
1882	**743**	37,6	**196**	22,4	..		**493**	25,4	**248**	29,8	**341**	53,4
1883	**773**	39,5	**217**	27,2	..		**569**	26,2	**353**	30,3	**314**	56,7
1884	**913**	41,7	**268**	29,5	..		**434**	27,9	**213**	34,7	**195**	59,5
1885	**992**	46,4	**205**	36,1	..		**452**	27,6	**181**	31,0	**134**	52,2
1886	**523**	43,0	**147**	35,4	..		**279**	25,4	**127**	28,4	**105**	68,5
1887	**235**	43,4	**117**	35,0	..		**205**	21,4	**129**	33,3	**86**	55,8
1888	**485**	54,0	**113**	35,4	..		**239**	39,8	**110**	52,6	**107**	71,0
1889	**461**	47,7	**72**	43,0	..		**214**	23,8	**77**	35,0	**79**	73,5
1890	**708**	47,7	**198**	27,8	..		**580**	22,6	**181**	29,3	**246**	61,8

(continued).

Egedes-minde		Disko Bay Settlements		Umanak		Upernavik		South Greenland		North Greenland		
	%		%		%		%		%		%	
213	39,9	**99**	67,7	**6**	83,4	**46**	50,0	**1302**	30,4	**364**	49,5	1842
419	34,8	**120**	56,7	**3**	(100)	**4**	(75)	**2182**	34,9	**546**	40,3	1843
166	36,8	**188**	61,7	**8**	62,5	**6**	50,0	**1339**	32,4	**368**	50,3	1844
198	39,4	**131**	77,9	**26**	84,6	**38**	84,2	**1034**	49,2	**393**	59,6	1845
168	41,1	**103**	74,8	**20**	90,0	**41**	53,7	**1853**	36,4	**332**	56,0	1846
205	39,5	**79**	55,7	**1**	(100)	**1**	(0)	**1055**	40,3	**286**	44,1	1847
288*	31,9	**76**	56,6	**2**	(100)	**58**	60,3	**1517**	34,7	**424***	40,8	1848
248	30,2	**78**	71,8	**5**	(40)	**9**	44,4	**1700**	36,4	**340**	40,3	1849
94	38,3	**56**	58,9	**0**		**18**	44,4	**1038**	35,8	**168**	45,8	1850
124	36,3	**65**	61,5	**5**	(100)	**9**	88,8	**1610**	42,7	**203**	48,3	1851
133	54,9	**108**	75,9	**2**	(50)	**138**	76,1	**1589**	49,3	**381**	68,5	1852
137	51,8	**60**	90,0	**0**		**59**	67,8	**1473**	37,9	**256**	64,5	1853
227	44,9	**149**	69,1	**0**		**39**	76,9	**2812**	29,9	**415**	56,6	1854
142	42,2	**121**	63,7	**0**		**52**	53,8	**1570**	34,4	**315**	52,4	1855
50	60,0	**46**	73,9	**0**		**16**	68,7	**944**	39,9	**112**	67,0	1856
98	60,2	**65**	80,0	**0**		**3**	(67)	**1220**	34,5	**166**	68,0	1857
154	39,6	**98**	63,3	**0**		**5**	(60)	**1322**	31,6	**257**	49,1	1858
170	38,8	**150**	57,3	**9**	55,5	**42**	52,4	**1292**	32,7	**371**	48,2	1859
186	42,5	**161**	55,3	**1**	(100)	**38**	65,7	**1699**	38,1	**386**	50,3	1860
121	33,1	**115**	53,1	**2**	(50)	**5**	(60)	**1467**	37,0	**243**	43,2	1861
102	44,1	**96**	68,7	**1**	(100)	**21**	23,8	**906**	41,6	**220**	53,2	1862
117	28,2	**138**	55,1	**2**	(50)	**78**	37,2	**1663**	36,0	**335**	41,5	1863
74	71,6	**73**	75,4	**4**	(25)	**83**	56,6	**810**	48,1	**234**	66,7	1864
78	53,9	**106**	57,5	**4**	(75)	**31**	38,7	**398**	45,0	**219**	53,9	1865
39	51,3	**94**	46,8	**3**	(0)	**0**		**368**	35,1	**136**	47,1	1866
102	41,2	**110**	56,4	**11**	9,1	**40**	15,0	**501**	39,3	**263**	42,2	1867
81	58,0	**112**	62,5	**12**	75,0	**71**	71,8	**1031**	38,6	**276**	64,1	1868
148	43,2	**121**	42,2	**8**	75,0	**83**	50,6	**1143**	43,7	**360**	45,3	1869
227	41,8	**180**	48,4	**13**	46,2	**8**	37,5	**1276**	44,1	**428**	44,6	1870
79	48,1	**166**	47,0	**7**	85,7	**53**	24,5	**853**	45,8	**305**	44,3	1871
128	43,0	**112**	56,2	**2**	(50)	**35**	25,7	**994**	46,8	**277**	46,2	1872
86	50,0	**137**	62,0	**18**	94,4	**19**	52,7	**2146**	39,4	**260**	59,6	1873
211	42,7	**196**	49,0	**22**	45,5	**6**	83,4	**4597**	38,4	**435**	46,2	1874
198	45,0	**190**	49,5	**12**	33,3	**11**	63,7	**2668**	36,2	**411**	47,2	1875
102	54,0	**105**	42,9	**4**	(0)	**19**	15,8	**2037**	38,1	**230**	44,8	1876
85	53,0	**167**	52,7	**10**	70,0	**50**	46,0	**2265**	36,0	**312**	52,3	1877
163*	43,1	**139**	50,4	**21**	66,7	**23**	60,9	**1617**	37,7	**346***	48,8	1878
138*	31,8	**205**	47,3	**17**	76,5	**2**	(50)	**2831**	39,3	**362***	43,0	1879
148*	39,3	**201**	39,3	**12**	33,3	**18**	22,2	**2794**	39,1	**379***	38,3	1880
244	34,0	**159**	40,9	**16**	50,0	**37**	32,4	**1612**	39,2	**456**	36,9	1881
187	35,3	**163**	41,7	**9**	44,4	**31**	25,8	**2021**	34,8	**390**	36,4	1882
260	32,3	**181**	38,8	**14**	57,1	**25**	36,0	**2226**	35,8	**480**	36,0	1883
237	38,4	**244**	58,2	**18**	44,5	**14**	42,9	**2023**	38,1	**513**	48,1	1884
125	29,6	**151**	46,3	**26**	42,3	**6**	16,7	**1964**	40,0	**308**	38,6	1885
140	35,0	**156**	52,0	**57**	35,1	**39**	38,5	**1181**	38,6	**392**	42,1	1886
109	30,3	**98**	58,2	**36**	25,0	**82**	52,5	**772**	36,0	**325**	43,7	1887
91	50,5	**96**	84,4	**28**	60,7	**82**	68,3	**1054**	50,4	**297**	67,3	1888
77	46,8	**81**	59,3	**27**	44,5	**13**	23,0	**903**	42,9	**198**	50,0	1889
186	31,2	**203**	54,6	**41**	58,5	**17**	29,4	**1913**	38,1	**447**	44,3	1890

Table V

	Julianehaab		Frederikshaab		Fiskenæsset	Godthaab		Sukkertoppen		Holsteinsborg	
		%		%			%		%		%
1891	**446**	46,6	**168**	24,4	..	**437**	28,4	**195**	33,8	**222**	61,7
1892	**870**	48,8	**221**	32,6	..	**385**	24,2	**201**	39,8	**329**	59,3
1893	**747**	56,2	**195**	30,3	..	**347**	29,7	**275**	36,4	**324**	58,0
1894	**898**	47,0	**236**	33,5	..	**464**	32,6	**280**	49,3	**396**	55,8
1895	**755**	48,1	**304**	34,5	..	**782**	30,8	**268**	44,4	**420**	53,1
1896	**836**	43,4	**210**	33,3	..	**453**	32,5	**95**	41,0	**162**	55,0
1897	**589**	41,8	**109**	30,3	..	**360**	30,6	**123**	36,6	**181**	58,6
1898	**827**	46,0	**267**	40,0	..	**485**	39,8	**224**	50,0	**292**	54,1
1899	**948**	47,1	**315**	34,9	..	**534**	36,5	**204**	36,3	**309**	61,5
1900	**1014**	50,6	**294**	37,0	..	**671**	30,8	**170**	37,1	**196**	60,2
1901	**404**	51,5	**142**	38,7	..	**347**	30,8	**138**	27,5	**217**	62,7
1902	**607**	53,6	**166**	34,3	..	**359**	33,2	**117**	35,0	**278**	50,0
1903	**623**	47,6	**148**	37,2	..	**393**	29,0	**146**	36,3	**251**	51,4
1904	**458**	48,4	**91**	31,8	..	**384**	31,3	**202**	32,2	**354**	59,4
1905	**867**	41,4	**342**	42,4	..	**903**	30,8	**342**	33,9	**405**	52,4
1906	**685**	43,5	**255**	34,1	..	**764**	27,9	**317**	34,4	**333**	57,4
1907	**925**	42,7	**227**	40,5	..	**717**	32,6	**228**	35,5	**306**	53,0
1908	**653**	45,5	**279**	35,5	..	**925**	32,6	**314**	32,8	**369**	59,6
1909	**691**	42,1	**273**	40,7	..	**733**	28,0	**250**	32,0	**297**	57,2
1910	**859**	41,5	**357**	35,0	..	**954**	30,0	**352**	31,2	**263**	63,9
1911	**397**	41,5	**191**	38,2	..	**861**	30,0	**278**	25,9	**260**	60,4
1912	**563**	40,7	**188**	43,1	..	**553**	31,1	**238**	37,8	**285**	61,0
1913	**528**	47,7	**167**	30,5	..	**739**	28,9	**265**	32,4	**244**	61,5
1914	**870**	45,9	**243**	37,0	..	**746**	27,0	**378**	29,1	**452**	63,6
1915	**693**	50,0	**144**	38,9	..	**515**	25,2	**204**	30,9	**306**	60,8
1916	**820**	50,4	**258**	41,1	..	**732**	27,9	**350**	32,0	**316**	62,6
1917	**1006**	46,7	**207**	47,3	..	**658**	30,0	**235**	31,5	**273**	60,4
1918	**1210**	45,3	**317**	31,5	..	**724**	32,3	**244**	30,3	**231**	51,5
1919	**2065**	47,9	**651**	35,4	..	**1134**	30,0	**226**	31,0	**302**	57,0
1920	**1416**	47,9	**385**	33,2	..	**820**	29,0	**240**	29,2	**299**	59,5
1921	**1156**	46,1	**372**	33,3	..	**692**	30,2	**201**	20,4	**268**	56,4
1922	**959**	45,2	**213**	32,9	..	**583**	38,3	**198**	36,8	**302**	63,3
1923	**777**	52,6	**182**	33,0	..	**583**	29,8	**247**	28,8	**252**	69,0
1924	**568**	50,5	**203**	36,0	..	**540**	30,2	**268**	27,2	**287**	58,2
1925	**564**	51,2	**122**	39,3	..	**454**	29,6	**269**	31,2	**299**	56,2
1926	**1017**	46,6	**353**	24,9	..	**604**	29,0	**256**	28,1	**421**	51,0
1927	**659**	44,8	**233**	25,8	..	**434**	22,6	**201**	25,4	**345**	57,1
1928	**572**	47,9	**275**	22,5	..	**651**	27,6	**327**	31,2	**741**	54,7
1929	**759**	48,3	**299**	24,7	..	**612**	26,3	**385**	32,2	**490**	49,6
1930	**1504**	46,6	**885**	23,8	..	**1030**	27,1	**794**	36,5	**755**	51,3
1931	**1690**	43,6	**1079**	24,7	..	**1556**	26,8	**678**	32,9	**626**	50,8
1932	**988**	45,2	**515**	20,6	..	**1117**	27,5	**507**	31,9	**586**	53,4
1933	**1229**	44,4	**800**	22,0	..	**1724**	25,5	**719**	38,7	**831**	51,4
1934	**1415**	42,1	**577**	24,6	..	**1379**	24,4	**583**	29,5	**660**	50,1
1935	**1138**	43,6	**481**	26,6	..	**966**	28,8	**445**	27,9	**451**	48,6
1936	**945**	44,4	**439**	22,8	..	**854**	29,7	**522**	26,5	**397**	57,7
1937	**693**	44,9	**415**	19,5	..	**874**	22,3	**455**	26,4	**444**	53,4
1938	**815**	48,9	**370**	22,7	..	**906**	22,4	**341**	25,5	**425**	51,0
1939	**664**	55,1	**254**	31,5	..	**769**	23,8	**293**	21,5	**460**	49,8

(continued).

Egedes-minde		Disko Bay Settlements		Umanak		Upernavik		South Greenland		North Greenland		
	%		%		%		%		%		%	
165	36,4	**147**	57,1	**31**	35,5	**10**	50,0	**1468**	39,3	**353**	45,3	1891
233	54,5	**268**	54,1	**36**	50,0	**11**	36,4	**2006**	43,2	**548**	53,6	1892
203	43,8	**174**	58,0	**23**	34,8	**6**	0,0	**1888**	46,1	**406**	48,7	1893
209	35,4	**241**	59,7	**48**	33,3	**6**	50,0	**2274**	44,5	**504**	47,0	1894
240	32,9	**204**	59,8	**28**	39,3	**12**	58,4	**2529**	41,5	**484**	45,3	1895
118	27,1	**137**	52,6	**15**	33,3	**19**	15,8	**1756**	40,3	**289**	38,8	1896
145	32,4	**125**	52,8	**31**	45,1	**12**	58,3	**1362**	39,6	**313**	42,8	1897
178	49,5	**217**	53,0	**25**	56,0	**10**	80,0	**2095**	45,4	**430**	52,4	1898
252	34,1	**143**	50,3	**21**	47,6	**19**	36,8	**2310**	44,0	**435**	40,2	1899
261	36,0	**184**	46,7	**18**	27,8	**9**	66,6	**2345**	43,1	**472**	40,5	1900
200	30,0	**225**	40,0	**51**	35,3	**18**	27,8	**1248**	43,6	**494**	35,1	1901
171	27,5	**166**	36,2	**30**	23,3	**20**	35,0	**1527**	44,6	**387**	31,2	1902
168	25,0	**179**	40,8	**49**	36,8	**23**	43,5	**1561**	41,5	**419**	34,2	1903
188	34,6	**249**	37,8	**57**	47,4	**16**	18,7	**1489**	43,4	**510**	37,0	1904
333	35,7	**293**	38,2	**64**	29,7	**28**	42,8	**2859**	38,8	**718**	36,5	1905
261	35,6	**219**	37,0	**52**	34,6	**50**	58,0	**2354**	38,2	**582**	38,0	1906
256	43,8	**185**	47,6	**36**	50,0	**15**	66,6	**2403**	40,0	**492**	46,4	1907
309	30,7	**287**	44,6	**84**	23,8	**35**	22,9	**2540**	40,2	**715**	35,1	1908
221	39,4	**293**	37,5	**50**	14,0	**38**	31,6	**2244**	38,1	**602**	35,8	1909
284	39,1	**322**	65,2	**51**	64,7	**86**	55,8	**2785**	37,5	**743**	54,1	1910
283	39,9	**221**	67,9	**57**	63,1	**48**	79,1	**1987**	36,5	**609**	55,4	1911
288	37,8	**208**	49,0	**51**	25,5	**9**	55,5	**1827**	40,8	**556**	41,1	1912
358	38,0	**215**	52,1	**35**	31,4	**62**	66,1	**1943**	38,7	**670**	44,8	1913
325	44,3	**271**	57,9	**43**	30,2	**38**	57,9	**2689**	40,4	**677**	49,6	1914
312	40,7	**180**	51,7	**43**	27,9	**64**	67,1	**1862**	42,0	**599**	46,0	1915
307	38,2	**303**	59,7	**65**	40,0	**24**	83,3	**2476**	41,8	**699**	49,3	1916
263	35,0	**269**	65,8	**100**	34,0	**32**	62,5	**2379**	42,2	**664**	48,7	1917
218	34,9	**294**	64,6	**75**	33,3	**17**	29,4	**2726**	39,4	**604**	49,0	1918
278	49,0	**206**	75,3	**52**	38,5	**48**	64,6	**4378**	41,2	**584**	58,5	1919
254	41,7	**179**	73,8	**54**	40,7	**62**	64,5	**3160**	40,9	**549**	54,6	1920
242	40,9	**176**	58,0	**32**	9,4	**25**	12,0	**2689**	39,3	**475**	43,5	1921
270	41,1	**198**	48,5	**32**	15,6	**50**	38,0	**2255**	41,7	**550**	42,0	1922
339	67,6	**263**	76,7	**42**	66,6	**231**	85,6	**2041**	43,5	**875**	75,1	1923
237	46,0	**211**	74,9	**25**	32,0	**42**	78,5	**1866**	40,9	**515**	59,8	1924
351	47,6	**335**	62,1	**83**	26,5	**28**	67,9	**1708**	42,3	**797**	52,2	1925
355	45,3	**208**	60,2	**67**	34,3	**30**	70,0	**2651**	38,6	**660**	50,0	1926
235	40,9	**291**	69,0	**73**	37,0	**397**	92,7	**1872**	37,4	**996**	69,5	1927
450	39,8	**385**	64,7	**84**	27,4	**123**	88,5	**2566**	39,9	**1042**	53,7	1928
482	34,9	**274**	57,0	**107**	24,3	**33**	63,7	**2545**	38,0	**896**	41,4	1929
528	36,2	**488**	56,7	**149**	50,3	**45**	66,6	**4968**	37,5	**1210**	47,4	1930
562	37,2	**467**	73,5	**97**	71,1	**362**	97,0	**5629**	34,9	**1488**	65,4	1931
565	42,8	**368**	71,5	**78**	60,2	**233**	92,6	**3713**	36,0	**1244**	61,6	1932
916	39,2	**502**	64,1	**88**	45,5	**45**	84,5	**5303**	35,2	**1551**	48,9	1933
834	37,7	**337**	53,4	**73**	52,0	**54**	79,6	**4614**	34,2	**1298**	44,3	1934
582	37,6	**306**	61,5	**108**	77,7	**198**	93,9	**3481**	35,8	**1194**	56,7	1935
646	43,4	**389**	49,6	**101**	55,5	**57**	86,0	**3157**	36,1	**1193**	48,4	1936
712	35,8	**239**	53,2	**66**	39,4	**37**	62,2	**2881**	32,8	**1054**	40,8	1937
587	35,3	**296**	52,0	**40**	42,5	**79**	81,0	**2857**	34,6	**1002**	44,0	1938
617	38,8	**354**	61,0	**77**	59,7	**89**	87,6	**2433**	37,8	**1137**	50,9	1939

LITERATURE

ANDERSON, R. M., 1930: Notice in: Canad. Field Nat. **44**, 98.

[ANTONSEN, GERHARD], 1940: Litt om naturforholdene på Nordøst-Grønland vinteren 1938—39. — Naturen Bergen **64**, 156—158.

ARMSTRONG, A., 1857: A personal narrative of the discovery of the North-West Passage. London.

AUDUBON, JOHN JAMES and JOHN BACHMAN, 1854: The quadrupeds of North America. III. New York.

BAASHUUS-JESSEN, J., 1935: Arctic nervous diseases. — Skandinavisk Veterinär-Tidskrift Oslo **1935**, 310—345.

BAER, K. E. v., 1841: Nachricht v. d. Erlegung eines Eisfuchses, C. l., an der Südküste des Finnischen Meerbusens, nicht weit von St. Petersburg, und daran geknüpfte Untersuchungen über die Verbreitung dieser Thierart. — Bull. Ac. St. Petersb. **9**, 89.

— 1844: Neue Belege für die Auswanderung von Eisfüchsen nach Süden. — Bull. Classe Phys.-Math. Ac. St. Petersb. **2**, 47.

BAILEY, A. M. and R. W. HENDEE, 1926: Notes on the mammals of Northwestern Alaska. — J. Mammal. Baltimore **7**, 9—28.

BARABASH-NIKIFOROV, I., 1938: Mammals of the Commander Islands and the surrounding Sea. — J. Mammal. Baltimore **19**, 423—429.

BARRETT-HAMILTON, G. E. H. and J. L. BONHOTE, 1898: On two subspecies of the Arctic Fox (*Canis lagopus*). — Ann. Nat. Hist. (7) **1**, 287—289.

BAY, E., 1894: Hvirveldyr. — Den østgrønlandske Expedition 1891—92. Medd. Grønland **19**, 1—58.

BENT, A. C., 1932: Life histories of North American gallinaceous birds. — Bull. U. S. nat. Mus. Nr. 162.

— 1937: Life histories of North American birds of prey. I. — Bull. U. S. nat. Mus. Nr. 167.

— 1938: Life histories of North American birds of prey. II. Bull. U. S. nat. Mus. Nr. 170.

BERTRAM, G. C. L., D. LACK and B. B. ROBERTS, 1934: Notes on East Greenland birds, with a discussion of the periodic non-breeding among arctic birds. — Ibis **1934**, 816—831.

BESSELS, E., 1879: Die amerikanische Nordpol Ekspedition. — Leipzig.

BIRKET-SMITH, KAI, 1928: The Greenlanders of the present day. — Greenland. II. Copenhagen and London.

BLANCHET, G. H., 1925: An exploration into the northern plains north and east of the Great Slave Lake, including the source of the Coppermine River. — Canad. Field Nat. Ottawa **39**, 32—34.

BOBÉ, L., 1929: History of the trade and colonization until 1870. Greenland. III, 77—164. Copenhagen and London.

BOITZOV, L. V., 1937: Arctic Fox. Biology, breeding, feeding. — Trans. Arctic Inst. Leningrad **65**, 1—144. [Russian only].

BRAESTRUP, F. W., 1940a: Kritische Bemerkungen über Sonnenflecken und Klima. — Ann. d. Hydrographie u. marit. Met. Berlin **1940**, 179—180.

— 1940b: Om periodiske Svingninger i Antal hos visse Pattedyr og Fugle — og et Forsøg paa en Forklaring. — Naturens Verden, København **24**, 97—109.

— 1940c: The periodic die-off in certain herbivorous mammals and birds. — Science **92**, 354—355.

BRANDAL, ADOLF, 1930: Dagbok ført af A. B. under en overvintring på Østgrønland 1908—1909. — Norges Svalbard- og Ishavs-Undersøkelser. Medd. Nr. 10.

BROWN, ROBERT, 1868: On the mammalian fauna of Greenland. — Proc. zool. Soc. London **1868**, 330—362.

BUNGE, 1., 1887: Bericht über die im Jana-Gebiet im Sommer 1885 ausgeführten Reisen nebst einem Verzeichniss der daselbst beobachteten oder erkundeten Säugethiere und Vögel". — Beiträge zur Kenntn. d. Russ. Reiches. (3) **3**, 73—144.

BÜCHNER, E., 1897: Notiz über das Vorkommen des Eisfuchses in Turkestan. — Annuaire Mus. St. Petersb. **1897**, 393—395.

CABOT, W. B., 1920: Labrador. Boston.

CHITTY, D. and C. ELTON, 1937: Canadian Arctic wild life enquiry, 1935—36. — J. Animal Ecol. **6**, 368—385.

CHITTY, D., 1938: Canadian Arctic wild life enquiry, 1936—37. — J. Animal Ecol. **7**, 381—394.

— 1939: Canadian Arctic wild life enquiry, 1937—38. — J. Animal Ecol. **8**, 247—260.

CLARKE, C. H. D., 1936: Fluctuations in numbers of Ruffed Grouse, *Bonasa umbellus* (Linné), with special reference to Ontario. — University of Toronto Studies, Biol. Ser. No. 41.

COLLETT, R., 1895: Myodes lemmus its habits and migrations in Norway. — Forh. Selsk. Christ. **1895**, art. 3.

— 1912: Norges Pattedyr. — Christiania.

CRANZ, D., 1770: Historie von Grönland. 2. Aufl. Theil 1. Leipzig.

DAVIS, D. E., 1937: A cycle in Northern Shrike emigrations. — Auk **54**, 43—49.

DEVOLD, H., 1940: Noen refleksjoner om lemenen og dens forplantning. — Norges Jeger- og Fisker-Forbunds Tidsskr. **69**, 7—9.

DOULT, J. K., 1939: The expedition to Hudson Bay. — Carnegie Magazine **12**, 227—236.

DUBROVSKY, A. N., 1937: Arctic Fox (*Alopex lagopus* (L.)) and Arctic Fox trapping in Novaya Zemlya. — Trans. Arctic Inst. Leningrad **77**, 5—31 [Russian only].

ELTON, C., 1924: Periodic fluctuations in the numbers of animals: their causes and effects. — Brit. Journ. Exper. Biol. Edinburgh **2**, 119—163.

— 1931a: The study of epidemic diseases among wild animals. — Journ. Hygiene Cambridge **31**, 435—456.

— 1931b: Epidemics among sledge dogs in the Canadian Arctic and their relation to disease in the Arctic Fox. — Canad. J. Res. Ottawa **5**, 673—692.

— 1934: Fluctuations in wild life. — In: Canada's Eastern Arctic, Ottawa.

FABRICIUS, OTHO, 1780: Fauna Groenlandiae. Hafniae et Lipsiae.

— 1788: Field-Ræven (*Canis lagopus*). — K. D. Vid. Selsk. Skr. København N. S. **3**, 423—448.

Feilden, H. W., 1877: On the Mammalia of North Greenland and Grinnell Land. — Zoologist (3) **I**, 313—321.

Freuchen, P., 1915: Report of the First Thule Expedition. Zoology — Medd. Grønland **51**, 389—411.

— 1935: Mammals II. Field notes and biological observations. — Rept. Fifth Thule Exp. 1921—24. **2**, Nr. 4—5, 68—278.

Gelting, P., 1937: Studies on the food of the East Greenland ptarmigan. Especially in its relation to vegetation and snow cover. — Medd. Grønland **116**, III.

Gibson, L., 1922: Bird notes from North Greenland. — Auk **39**, 350—363.

Giæver, J., 1938: Årets ekspedisjon til Nordøst-Grønland. — Norsk Pelsdyrblad **12**, 386—390.

— 1939a: Den norske fangstvirksomheten på Østgrønland. — Publikationer om Østgrønland. Nr. 8, B. København.

— 1939b: Efter en fimbulsvinter på Nordøst-Grønland. — Norsk Pelsdyrbl. **13**, 429—432.

Gmelin, I. G., 1760: Animalium quorundam quadrupedum descriptio. — Novi Commentarii Acad. Scient. Imp. Petrop. **5**, 338—372.

Gross, A. O., 1931: Snowy Owl migration—1930—1931. — Auk **48**, 501—511.

— 1935: Snowy Owl migration—1934—1935. — Auk **52**, 310.

Grønland i Tohundredaaret for Hans Egedes Landing. I—II. Medd. Grønland **60—61**. 1921.

Hamann, T. S., 1866: Beretning til Indenrigsministeriet angaaende den i Nordgrønland herskende Hundesygdom. Tidsskrift f. Veterinairer **14**, 5—30.

Hantzsch, B., 1913: Beobachtungen über die Säugetiere von Baffinsland. — Sitz Ber. Ges. naturf. Freunde Berl. **1913**, 141—160.

Hayes, I. I., 1867: The open polar sea. London.

Heuglin, M. Th., 1874: Reisen nach dem Nordpolarmeer in den Jahren 1870 u. 1871. III. Braunschweig.

Hewitt, C. G., 1921: The conservation of the wild life of Canada. New York.

Hilzheimer, M., 1908: Beitrag zur Kenntnis der nordafrikanischen Schakale. — Zoologica Stuttgart Heft 53.

Hjortlund, S. R., 1908: De smitsomme Hundesygdomme i Grønland. Maanedsskrift for Dyrlæger **20**.

Huxley, T. H., 1880: On the cranial and dental characters of the Canidae. — Proc. zool. Soc. London **1880**, 238—288.

Høst, Per, 1935: Trekk av dyrelivet på Hardangervidda. — Norges Jeger- og Fisker-Forbunds Tidsskrift **64**.

Jensen, A. S., 1904: The fishes of East-Greenland. — Medd. Grønland **29**, (1909), 214—276.

— 1928: Grønlands Fauna. — Festskrift udg. af Københavns Universitet. København.

Jensen, S., 1904: Mammals observed on Amdrup's journeys to East-Greenland 1898—1900. — Medd. Grønland **29**, (1909), 1—62.

Johnsen, S., 1929: Rovdyr og rovfuglstatistikken i Norge. — Bergens Mus. Aarb. **1929**, Nat.-Vid. rekke no. 2, 5—118.

Jordan, D. S.-and B. W. Evermann, 1898: The fishes of North and Middle America. III. — Bull. U. S. Nat. Mus. No. 47.

Kane, E. K., 1856: Arctic explorations in the years 1853, '54, '55. I. Philadelphia.

Kolthoff, G., 1901: Till Spetsbergen och Nordöstra Grönland År 1900. Stockholm.

Koch, I. P., 1913: Gennem den hvide Ørken. København.

KRABBE, T. N., 1907: Om de grønlandske Ederfugle, med særligt Henblik paa deres Aftagen og økonomiske Betydning. — Det Grønlandske Selskabs Aarsskrift **1907**.

KUMLIEN, L., 1879: Contributions to the natural history of Arctic America made in connection with the Howgate Polar Expedition 1877—78. — Bull. U. S. Nat. Mus. **15**,

LEMKEY, W. L. and F. A. LUCAS, 1902: Blue fox trapping (*Canis lagopus*) on the Pribyloff Islands. — Science. N. S. **16**, 216.

LEWIS, H. F., 1923: Additional notes on birds of the Labrador Peninsula. — Auk **40**, 135—137.

LITKE, F., 1835: Viermalige Reise durch das nördliche Eismeer. Übers. v. Erman. Berlin.

LOTZ, H., 1931: Beobachtungen isländischer Polarfuchsjäger. — Die Pelztierzucht **7**, 224—226.

LYON, G. F., 1824: Private journal .. during the recent voyage of discovery under Captain Parry. London.

LØPPENTHIN, B., 1932: Die Vögel Nordostgrönlands zwischen 73°00′ und 75°30′ N Br. — Medd. Grønland **91**, Nr. 6.

M'CLINTOCK, F. L., 1859: The voyage of the "Fox" in the arctic seas. London.

MACFARLANE, R., 1905: Notes on mammals collected and observed in the northern Mackenzie River district, North-West Territories of Canada. Proc. U. S. Mus. **28**, 673—704.

MACLULICH, D. A., 1937: Fluctuations in the numbers of the Varying Hare (*Lepus americanus*). — Univ. of Toronto Studies Biol. Ser. No. 43.

MANDACH, E., 1938: Skeletreste von Dicrostonyx groenlandicus Trail als Inhalt von Raubvögelgewöllen. Medd. Grønland **112**, Nr. 4.

MANNICHE, A. L. V., 1910: The terrestrial mammals and birds of North-East Greenland. — Medd. Grønland **45** (1912), 1—200.

MERRIAM, C. H., 1900: Descriptions of twenty-six new mammals from Alaska and British North America. — P. Washington Ac. **2**, 13—30.

MIDDENDORFF, A. T., 1853: Reise in den äussersten Norden und Osten Sibiriens während der Jahre 1843 u. 1844. Bd. **2**, Theil 2. Wirbelthiere. St. Petersburg. — 1875: Reise etc. Bd. **4**, Theil 2.

MILLER, G. S., 1912: Catalogue of the mammals of Western Europe. London Brit. Mus.

MIKKELSEN, EJNAR, 1922: Alabama-Expeditionen til Grønlands Nordøstkyst 1909—12. Report on the Expedition. — Medd. Grønland **52**.

MÜLLER, R., 1906: Vildtet og Jagten i Sydgrønland. København.

NANSEN, F., 1897: "Fram" over polhavet. II. Kristiania.

NATHORST, A. G., 1900: Två Somrar i Norra Ishavet. II. Stockholm.

NILSSON, S., 1847: Skandinavisk Fauna. Däggdjuren. Andra Uppl. Lund.

NORDMANN, A., 1861: Ueber das Vorkommem des Polarfuchses (*Canis lagopus*) am Amur. — Bull. Soc. Imp. Nat. Moscou **34**, 321—324.

Nordpolarfahrt, die zweite Deutsche. Herausgegeben von dem Verein für die Deutsche Nordpolarfahrt. I. Erzählender Theil. Leipzig 1873.

ORVIN, A. K., 1930: Ekspedisjonen til Østgrønland med "Veslekari" Sommeren 1929. — Norsk Geogr. Tidsskr. III, 89—146.

— 1931: Ekspedisjonen til Jan Mayen og Øst-Grønland [Sommeren 1930]. — Norsk Geogr. Tidsskr. III, 367—389.

OSGOOD, W. H., E. A. PREBLE, and G. H. PARKER, 1915: The fur seals and other life of the Pribilof Islands, Alaska, in 1914. — Senate Documents, Vol. **6**, No. 980. Washington.

Ostermann, H., 1937: Grønlandske Distriktsbeskrivelser forfattet av Nordmenn før 1914. — Norges Svalbard- og Ishavs-Undersøkelser. Medd. Nr. 39.

Payne, F. F., 1888: The mammals and birds of Prince of Whales Sound, Hudson's Strait. — Proc. Can. Inst. Toronto (3) **5**, 11—123.

Pedersen, Alwin, 1926: Beiträge zur Kenntnis der Säugetier- und Vogelfauna der Ostküste Grönlands. Medd. Grønland **68**, 149—251.

— 1931: Fortgesetzte Beiträge zur Kenntnis der Säugetier- und Vogelfauna der Ostküste Grönlands. — Medd. Grønland **77**, 343—507.

— 1934a: Die Ornis des mittleren Teiles der Nordostküste Grønlands. — Medd. Grønland **100**.

— 1934b: Polardyr. København.

Penant, T., 1784: Arctic Zoology. I. London.

Peters, W., 1874: Säugethiere. — Die zweite deutsche Nordpolarfahrt. Bd. **2**, 157—169.

Poland, 1892: Fur bearing animals in nature and in commerce. London.

Preble, E. A., 1908: A biological investigation of the Athabaska Mackenzie region. — North Amer. Fauna Washington Nr. 27.

— 1923: Mammals of the Pribiloff Islands. — North Amer. Fauna Washington Nr. 46.

Rasmussen, K., 1921: Min Rejsedagbog. 2. Udg. København.

Rink, H., 1852—57: Grønland geografisk og statistisk beskrevet. I—II. Kjøbenhavn.

Rudolph, Chr. N., 1860: Meddelelse om Hundegalskab i den grønlandske Colonie Upernavik. — Tidsskrift for Veterinairer **8**, 272—276.

Ryberg, C., 1894: Om Erhvervs- og Befolknings-Forholdene i Grønland. — Geografisk Tidsskrift København **12**, 87—110, 113—131.

Sæmundsson, B., 1932: Íslensk dýr. II. Spendýrin. Rvík.

— 1939: Mammalia. — In: The Zoology of Iceland **4**, Part 76. Copenhagen.

Schaaning, H. T. L., 1916: Bidrag til Novaja Semljas Fauna. — Kjøbenhavn Ornith. Tids. **10**, 145—190.

Schrenk, A. G., 1854: Reise nach dem Nordosten des europäischen Ruslands, etc. II. Dorpat.

Serebrennikov, M. K., 1931: On the polychromatism and albinism of the Sibirian Squirrels. Proc. Zool. Soc. London. **1931**, 493—495.

Seton, E. T., 1912: The arctic prairies. London.

Smith, E. H., 1931: Arctic ice, with especial reference to its distribution to the North Atlantic Ocean. — The Marion Expedition. Scient. Res. Part 3. U. S. Treasury Dept. Coast Guard. Bull. **19**.

Soper, J. D., 1928: A faunal investigation of southern Baffin Island. Bull. Canada Dept. Mines Ottawa Biol. Ser. no. **53**, 1—143. [Not seen by the author.]

— 1934: Interesting bird records for southern Baffin Island. — Canad. Field Nat. **48**, 41—44.

Spärck, R., 1936: Bidrag til dansk Zoogeografi og Faunistik. IV. Om Egernets Udbredelse og Hyppighed i Danmark. — Vidensk. Medd. naturh. Foren. Kjøb. **99**, 267—281.

Speiers, J. M., 1939: Fluctuations in numbers of birds in the Toronto region. — Auk **56**, 411—419.

Stefansson, V., 1923: Länder der Zukunft. I. Leipzig.

Stejneger, L., 1884: Contributions to the history of the Commander Islands. No. 1. Notes on the natural history, including descriptions of new Cetaceans. — Proc. U. S. Nat. Mus. **6** (1883), 58—89.

Thinemann, F. A. L., 1824: Reise im Norden Europas, vorzügl. in Island, in den Jahren 1820—21. I. Leipzig.

VANHØFFEN, E., 1897: Die Säugethiere. — In DRYGALSKI: Grönland Expedition der Ges. f. Erdkunde zu Berlin 1891—93. II. 11—45.

WINGE, H., 1902: Grønlands Pattedyr. — Medd. Grønland **21**, 319—521.

[WRANGEL, F. v.], 1839: Reise längs der Nordküste von Sibirien und auf dem Eismeere, in den Jahren 1820 bis 1824. (Bearbeitet von Engelhardt). Berlin.

WYNNE-EDWARDS, V. C., 1939: Intermittent breeding of the Fulmar (*Fulmarus glacialis* (L.)), with some general observations on non-breeding in sea birds. — Proc. Zool. Soc. London **1939** A., 127—133.

ZIEGLER, J., 1532: Quae intus continentur. Argentorati. — [Cited from Collett 1895.]

DANSK OVERSIGT

I Løbet af de sidste Par Aartier er Studiet af Svingninger i Individantal hos Pattedyr og Fugle og dertil knyttede Problemer blevet taget op som en særlig Gren af Økologien. Fangststatistiker og Tal for Skindmarkedernes Tilførsel af Raastoffer har herunder spillet en betydelig Rolle. Navnlig Hudson's Bay Kompagniets Regnskaber har vist sig af stor Værdi som Kildemateriale. Det er i nærværende Afhandling forsøgt paa lignende Maade for Polarrævens Vedkommende at foretage en Bearbejdelse af de grønlandske Regnskaber fra et biologisk Synspunkt.

Samtidig er der gjort Forsøg paa at samle de mange spredte Iagttagelser over Polarræve, bl. a. i Rejselitteraturen, til et Helhedsbillede af Dyrets Biologi.

Hovedindholdet af de 4 Kapitler kan kort gengives som følger:

I. Polarræve, der lever paa Steder, hvor der er Lemminger, som de for en overvejende Del lever af, adskiller sig ved visse biologiske Træk (der antagelig for en Del bunder i arvelige Forskelligheder) fra deres Artsfæller i Egne, hvor disse Gnavere mangler. Den sidstnævnte Gruppe er i vid Udstrækning afhængig af Havets Stofproduktion og kan derfor betegnes som »Kystræve« i Modsætning til »Lemmingræve«. Det højeste kendte Antal Unger i et Kuld Lemmingræve er næsten dobbelt saa højt som det maksimale Antal hos Kystræve, i Overensstemmelse med det Faktum, at Lemmingrævene har Brug for meget større Frugtbarhed til visse Tider, fordi deres Antal svinger voldsomt som Følge af Svingninger i Mængden af Lemminger (»Lemmingaar«).

II. Det er fra gammel Tid kendt, at paa de Tider, hvor en Egns Lemminger hurtigt reduceres i Antal efter et Maksimum, vandrer de forsultne Polarræve meget langt omkring. Saadanne vandrende Ræve naar Vestgrønland i betydeligt Antal kommende dels fra Canada og det allernordligste Grønland (hvor næsten alle Ræve er hvide om Vinteren) — og dels vistnok ogsaa fra Nordøst-Grønland med den østgrønlandske Drivis.

I Vestgrønland er der en høj Procent Blaaræve, og Ankomsten af fremmede Ræve, der næsten alle er hvide, giver sig Udslag i Fangsten i det nordlige Vestgrønland ved en Stigning i Procenten af hvide Ræve i visse Aar. Disse Aar viser sig at falde sammen med dem i Løbet af hvilke en Indvandring fra det østlige Canada maa formodes — eller følger umiddelbart efter saadanne Aar.

En Del af disse vandrende Ræve synes at komme via Thule Distrikt, hvor det er velkendt blandt Befolkningen, at der hver Vinter kommer hvide Ræve vandrende til, — men i særlig stor Mængde hvert fjerde Aar. Andre kommer med den saakaldte Vestis, f. Eks. til Egedesminde Distrikt. Det er direkte iagttaget, at denne Drivis kan bringe Ræve. Der er Grund til at tro, at en høj Hvidprocent i en given Vinter undertiden kan skyldes hvide Ræve, som er ankommet det foregaaende Foraar og har oversomret i Grønland (f. Eks. 1922—23).

De Tilfælde, der kendes af »gale Ræves« Optræden i det nordlige Vestgrønland, indskrænker sig med en enkelt Undtagelse til Aar, i hvilke der enten har været en abnormt høj Hvidprocent, eller hvor man ud fra Forholdene i Canada skulde vente at der har været Indvandring, selv om dette ikke har givet sig tydeligt Udslag i Hvidprocenten. Det er saaledes sandsynligt, at denne Sygdom, som kan overføres til Slædehunde, vedligeholdes af tilvandrende Ræve, og dette passer med det Forhold, at det særlig er de forsultne Lemmingræve under et Lemmingminimum, der er udsat for at faa denne Sygdom.

III. Fangststatistik fra en kort Aarrække ved Scoresbysund i Nordøstgrønland og Oplysninger om Lemmingernes Mængde i samme Tidsrum viser, at der har været Svingninger i Antallet af Lemminger med Maksimum ca. hvert fjerde Aar og tilsvarende Vekslinger i Rævenes Antal med Maksimumfangst i de Vintre, der følger efter Lemmingmaksimum. Dette er i Overensstemmelse med, hvad der kendes fra andre Egne, hvor der findes Lemminger. Paa en Strækning af Kysten længere mod Nord synes en af Maksimerne at mangle, saaledes at der er et Mellemrum paa 9 Aar mellem to paa hinanden følgende Rævemaksima (1929 og 1938).

Svingningerne i Mængden af Lemminger og Ræve i Nordøstgrønland 1924—1938 har været ude af Trit med dem, der har været fremherskende i det østlige arktiske Canada.

IV. I Vestgrønland, hvor Lemminger mangler, finder vi ikke den regelmæssige Fireaarsperiode i Rævenes Antal, som er saa karakteristisk for Lemmingræve. Fangsten er dog underkastet meget betydelige Svingninger, og der er næppe Tvivl om, at disse hovedsagelig er fremkaldt af virkelige Svingninger i Antallet af Ræve, — i det mindste i Sydgrønland, hvor Fangsten kun i ringe Grad kan være paavirket af andre Erhverv.

Det har ikke været muligt paa det givne Grundlag at foretage nogen udtømmende Analyse af Aarsagerne til Svingningerne i Antallet af Ræve i Vestgrønland, fordi Fødebiologien her er meget kompliceret, og fordi man ved for lidt om de forskellige Faktorers Variation. Der haves ret gode Oplysninger om Svingninger i Antallet af Harer og Ryper i Vestgrønland siden 1882, og en Sammenligning mellem disse Svingninger og Rævefangstens Variationer tyder ret bestemt paa, at Rævebestandens Størrelse paavirkes i nogen Grad af denne Faktor, men det er tydeligt, at ogsaa andre Faktorer spiller ind, og at disse andre Faktorer til visse Tider ganske overskygger Hare- og Rypemængden. Dette har i særlig Grad været Tilfældet i de sidste Aartier, noget der muligt staar i Forbindelse med de abnormt milde Vintre. Der er nogen Grund til at antage, at Variationer i Fjældørredens Mængde er en vigtig Faktor, men Kendskabet til disse Variationer er for ringe til at noget bestemt kan siges herom.

I et afsluttende Afsnit fremhæves, at Polarræven i Grønland ikke kan betragtes som en økologisk Enhed, men at man i det mindste maa skelne imellem *Lemmingrævene*, der dels udgør det meste af den ynglende Population i Nordøstgrønland, og dels optræder som Indvandrere i Resten af Grønland, særlig den nordlige Vestkyst, — og *Kystrævene*, der udgør den ynglende Population i den Del af Landet, hvor der ikke er Lemminger, og som ogsaa findes i Nordøstgrønland Side om Side med Lemmingrævene. Nogle nyere Iagttagelser fra andre Egne tyder paa, at der findes en yderligere økologisk Differentiering indenfor denne Art. I Grønland synes Fuglefjældsrævene at udgøre en saadan Gruppe indenfor Kategorien Kystræve.

Færdig fra Trykkeriet den 23. August 1941.

Plate 1. Numbers of fox skins traded annually in the various districts in West Greenland, and the percentages of these which belonged to the white variety (dotted lines). *N. B.* The graphs representing total catches in N. Greenland and South Greenland are drawn to a scale half of that employed for the other graphs. (Scale used for percentages is the same throughout).