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KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. 204 • Nr. 6

ORNITHOLOGICAL AND ECOLOGICAL STUDIES IN S. W. GREENLAND (59°46′-62°27′ N. LAT.)

BY

FINN SALOMONSEN

WITH 43 FIGURES, 1 TABLE AND 3 PLATES

Nyt Nordisk Forlag Arnold Busck
København 1979

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Abstract

This work is the first in a series of papers describing the ecology of birds in Western Greenland, particularly the sea-birds.

In this paper the situation in S. W. Greenland has been described, including the districts of Nanortalik, Julianehåb, Narssaq and Frederikshåb. In the former three districts, which constitute the southernmost part of West Greenland, the East Greenland ice ("Storis") virtually prevents the formation of actual sea-bird colonies. On the other hand, the southern position of this area has given rise to the development of a more mitigated climate in the interior country and this has caused the formation of a subarctic zone, being part of the boreal, not the arctic biome. The climate, the plan-cover and other particulars of the subarctic zone are described, including the human trades in this zone as consequences of the climate. A detailed account of the immigration of six subarctic bird-species to Greenland is given as well as notes on their distribution and life-habits in Greenland.

In Frederikshåb District a number of sea-bird colonies have been developed, some of which are rather large. The natural history of these colonies are described in detail, and a methodical analysis is given of the factors governing their development, as well as the significant botanical consequences of the presence of avian guano, important even for the human population. Some new designations for various conceptions have been proposed, necessary for the discussion of these matters which have not previously been seriously studied. A description of each sea-bird colony in Frederikshåb District is followed by notes on the sea-bird migration and on local bird-names in the district and, finally, by a discussion on the transglacial migration.

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INTRODUCTION

The southernmost parts of West Greenland differ from the more northern parts of the country in their somewhat more mitigated life conditions for plants and animals. Usually these areas are said to constitute the northernmost fringe of the subarctic zone belonging to the boreal region, while the remainder of Greenland is arctic. A number of subarctic trees and plants and even a few birds of southern origin are found in these areas. Only little is known about the ornithology of subarctic Greenland, and this was the reason why I was interested in undertaking an excursion to this region. In the summer of 1971 I had the opportunity to carry out an expedition to the subarctic parts of Julianehåb District, and also to Frederikshåb District, which latter has practically never been ornithologically studied, apart from the southern parts around Arsuk Fjord.

The expedition, which was sponsored by "The Ornithological Committee of Greenland" under the Ministry of Greenland and "The Commission for Scientific Research in Greenland", had the following working program:

(1) An investigation of the subarctic birds.

(2) A survey of the ecology of seabird rookeries in Frederikshåb District.

(3) A visit to the American base "Dye II" in the DEW Line (Distant Early Warning Line) on the ice-cap in order to study bird visits and bird migration in this area.

In addition, several minor points were also taken care of, *e.g.*, local bird names, bird ringing, lectures in Godthåb for the Greenland Broadcasting System and for The Ornithological Society in Greenland, etc.

ITINERARY

The following areas were investigated in the summer of 1971:

(1) The outpost Qagssiarssuk at the Tunugdliarfik fjord, Julianehåb District, and the Tasiussaq area of Nordre Sermilik fjord, from June 14 to June 18.

(2) Narssarssuaq air-field and the mountain Mellemlandet between the main Tunugdliarfik fjord and the Qôroq inlet, from June 19 to June 21.

(3) The sheep farms Qanisartût and Eqaluit at the Igaliko Fjord, Julianehåb District, from June 22 to June 25.

(4) Frederikshåb District, northwards to the islands Ikermiut (at 62°23′ n.lat.) off the glacier Frederikshåbs Isblink, at the border of Godthåb District, and southwards to the islands Ydre Kitsigsut (at 60°43′ n.lat.) in the northern part of Julianehåb District, with the motor-boat "Korallen" of Frederikshåb, from June 29 to July 5.

(5) The station "Dye II" on the ice-cap (position 66°05′ n.lat., 47°06′ w.long.), from July 9 to July 13.

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My thanks are, also, due to the Carlsberg Foundation for submitting a substantial amount to the printing of this paper.

THE SUBARCTIC ZONE

The subarctic zone is the northernmost part of the boreal taiga region and is so to speak a transitional zone between the high-boreal forests and the treeless arctic tundra. It corresponds in Greenland to the so-called *Hudsonian Zone* in North America and the *lesotundra* ("forest tundra") and *redkoles'ji* ("parkland") conceptions in northern Palaearctic (cf. TIKHOMIROV 1970, p. 38).[1] There is still much discussion about the limitation of the subarctic zone, as is the case with all transitional boundary belts. The vividness of the discussion was very apparent during the recent symposium on "Ecology of the subarctic region" held in Helsinki 1966, organized by UNESCO in cooperation with the International Geographic Union. However, the subarctic zone is more than a simple transiton belt, but is a biocenological entity in itself; cf. HUSTICH 1970, p. 237.

The subarctic zone is not only a phytogeographical conception, but is of great significance for the distribution of animals, although this has usually been noticed only in the higher vertebrates. As far as birds are concerned, there are six endemic subarctic species in the Old World, five in the New World, and two in the area of the Bering Sea, and altogether 30 species of birds have their predominant distribution within the subarctic zone (JOHANSEN 1963, p. 1122).

Boundaries and Climate in Greenland

In Greenland the subarctic zone is found in the interior parts of Julianehåb District in Southwest Greenland, to the south extending well into Nanortalik District, to the north into the interior part of southern Frederikshåb District. It is difficult to fix even a tolerably exact northern boundary of the subarctic zone, and botanists may even push the limit as far north as the innermost continental parts of the Godthåbsfjord. "There the willows and alder form man-high scrub, and the vegetation here and there has a subarctic appearance; possibly these parts should also be included in the subarctic zone as a separate continental area,

[1]) It is unfortunate that the term "subarctic" is frequently used in America to designate the lowarctic region, which is something quite different.

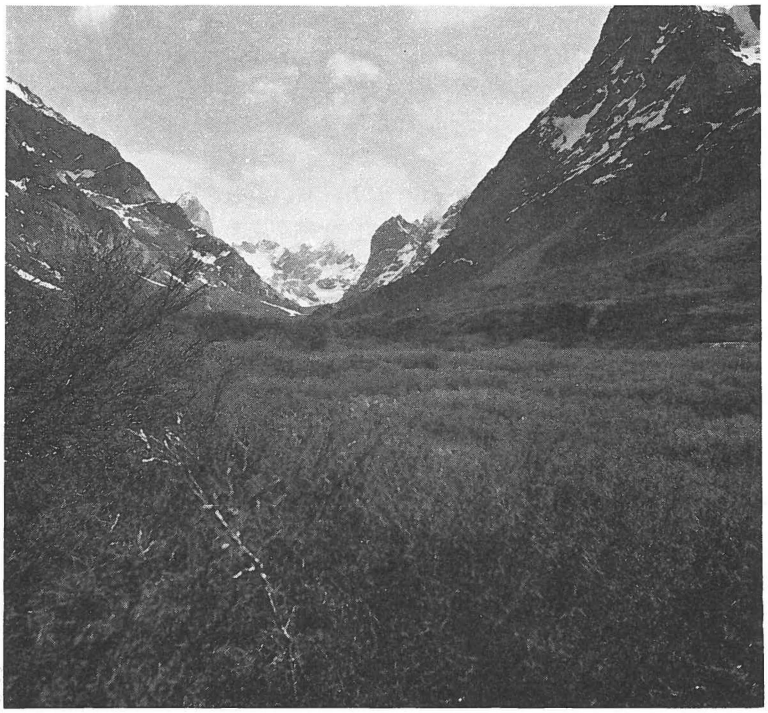


Fig. 1. Growth of Birch, *Betula pubescens tortuosa*, not yet in leaf, Qingua valley, Tasermiut fjord, Nanortalik District. (Phot. 19th June 1949 by F. SALOMONSEN).

which northwards gradually passes into a kind of lowarctic-subarctic steppe with salt lakes; cf. Canadian subarctic steppes" (BÖCHER 1938, p. 303). These "lowarctic-subarctic steppes with salt lakes" are particularly well developed in the interior area of Søndre Strømfjord, but in these regions, as well as in the Godthåbsfjord area, the fauna is predominantly lowarctic, although a few southern fauna elements also occur there.

The subarctic zone is in Greenland characterized by the dense scrubs and copses of *Betula pubescens tortuosa* (Fig. 1), sometimes as comparatively tall specimens, accompanied by *Sorbus groenlandica* and *Salix glauca*. The latter species, *i.e. Salix glauca*, is of much wider arctic distribution, but in the subarctic region forms copses of considerable height and density. Something similar can be said about *Juniperus communis nana*, which in gradually decreasing density and reduced growth is found northwards to Disko Bugt. *Alnus crispa* can also be enumerated among the subarctic species, but it is much more common and forms much higher and denser copses in the inner, continental lowarctic parts of Frederikshåb, Godthåb, and Sukkertoppen Districts than in the subarctic region proper, where it usually is almost absent.

This may be due to its inability to compete with *Salix glauca* and *Betula pubescens* in the south, or to the too moist climate there. Also a number of herbs should be included among the subarctic species; they are enumerated by BÖCHER (1938, p. 66) in what he calls "the subarctic cold-temperate types".

From a cosmopolitan, or circumpolar, point of view there are several vegetation types in the subarctic region. The Greenland zone corresponds very well with the oceanic *Betula* zone distributed from Labrador across the islands of the northern Atlantic Ocean to Scandinavia and eastern Russia to about the White Sea, as opposed to the more continental types characterized by various conifers in the greater part of Siberia and North America. According to the recent careful analysis of the subarctic region by BLÜTHGEN (1970, p. 26) this Atlantic part is called "the oceanic variety of the paraboreal subzone" and is said to comprise "the subpolar meadows with birch woods in Alaska, south-west Greenland, and Iceland, the Atlantic part of the Scandinavian mountain birch forest north of 68°N.; warmest month 10°C to 12°C, coldest 2°C to 0°C, low amplitude." In the Greenland subarctic, however, the temperature falls outside the limits given in this definition. In the Tunugdliarfik fjord, situated in Julianehåb District, in about the centre of the subarctic zone, the station Narssarssuaq has a mean temperature of the warmest month of 10.4°C, and of the coldest month of −6.3°C; amplitude 16.7°C. At Narssaq, nearer the mouth of the fjord, the mean temperature of the warmest month is 7.9°C, of the coldest month −4.4°C and the annual amplitude 12.3°C. Finally, on the island Simiutaq, just off the mouth of the fjord, the mean temperature of the warmest month is 6.2°C, of the coldest month −5.4°C and the annual amplitude 11.6°C. These figures correspond better to BLÜTHGEN's "northern belt of the continental variety of the paraboreal subzone" in which "the warmest month shows 8°C to 10°C, the coldest stays below −8°C and the amplitudes are large." To make the definitions still more uncertain and unsatisfactory the Greenland part of the subarctic zone in the map giving the subdivisions of this zone (fig. 10 in BLÜTHGEN 1970) is shown as belonging to the "pararctic subzone" which is said to be climatically charactized by a mean temperature between 4°C and 8°C in the warmest month, and below −8°C in the coldest month. However, the vegetation of the pararctic subzone is herbaceous tundra, not birch copses.

When comparing the temperature measurements of the Tunugdliarfik stations, given above, it appears distinctly that the interior station Narssarssuaq has a more continental climate than the more western ones, which are situated further towards the mouth of the fjord, and has a higher summer temperature and a lower winter temperature, and as a consequence of this a larger annual temperature amplitude. As

a matter of fact, the western limit of the subarctic zone is situated at about Narssaq and does not continue to the outer parts of the fjords. The comparatively great continentality of the inner fjord regions is further shown by the precipitation. Narssarssuaq has an annual precipitation of 696 mm, Narssaq of 712 mm and Simiutaq, which is a low island in the mouth of the fjord, 779 mm. Further north, however, the amount of precipitation is still larger. At Arsuk Fjord, which forms the northern limit of the continuous subarctic region in Greenland, the station Grønnedal has an annual precipitation of 1132 mm, and nearby Ivigtut 1128 mm, which is probably the highest precipitation found anywhere in the subarctic region.

As preciously mentioned, the northern limit of the subarctic zone in Greenland is difficult to determine, because a number of southern plant species penetrate northwards to very different positions. The boundary between the lowarctic and higharctic zone is much easier to fix. In West Greenland this boundary is found at the Melville Bugt, where a distinct floristic change takes place. Of the 101 species of vascular plants found within the region of Melville Bugt no less than 19 have their northern limit in this region (SØRENSEN 1943, p. 53), and include such characteristic members of the mixed dwarf-bush heath as *Betula nana*, *Phyllodoce coerulea*, and *Loiseleuria procumbens*. Even *Empetrum nigrum* approaches its northern limit here, as it is extremely rare north of the area.

BÖCHER, who more than anyone else has contributed to our knowledge of the distribution of the vascular plants in Greenland, separates a group of species which he calls "Subarctic cold-temperature types" (BÖCHER 1938, p. 266) and which more or less correspond to the designation subarctic as used in this paper. He enumerates 46 species in this group, of which a number, however, continue to Godthåbsfjord or to Angmagssalik District. Furthermore, BÖCHER has a group which he mentions as "Subarctic species with wide distribution northwards" (p. 263), comprising such widespread plants as *Arabis Holboelli* (northwards to Umanaq District), *Sedum rosea* and *Chamaenerion angustifolium* (both to Disko Bugt), *Alchemilla alpina* and *Thymus drucei* (both to Holsteinsborg District), and many more, altogether 109 species. In a more recent paper (BÖCHER 1963, p. 77) he adds to "boreal species" a number of plants with a still wider distribution in Greenland, *e.g. Mertensia maritima*, which even is found in many places in the higharctic region (cf. SØRENSEN 1943, p. 36). This shows that BÖCHER regards the subarctic concept not as a floristic term, but as a name for a special vegetation. However, when considering the term "subarctic" as the name of a floristic zone, as is done in this paper, the wide-spread species mentioned above cannot be regarded as subarctic or boreal. In zoogeography it is, in a similar way, necessary to distinguish between

regional faunas, based on faunal types, and the fauna zonation (cf. SALOMONSEN 1972, p. 4). From a zoogeographical view-point the subarctic zone must be regarded as a term in the faunistic zonation. To be true, the subarctic bird species, dealt with below, are of a wide boreal distribution, but they do not, or at least only slightly, penetrate into the lowarctic zone of the arctic region. There are, admittedly, a few species of Canadian and Siberian faunal types which in their breeding range are restricted to the subarctic zone and very well could be said to belong to a certain subarctic faunal type, or better subtype, but this problem does not concern any subarctic bird in Greenland.

Vertical Zonation

It is necessary to draw attention to the fact that the subarctic zone with its flora and fauna is developed only in the lowland while the huge mountainous part of S. W. Greenland, at altitudes higher than 100–300 m above sea-level, has a general lowarctic character. There are a number of species which further north are commonly distributed in the lowland, but which in the subarctic zone are found only in the mountains. This is the case with, *e.g.*, *Saxifraga oppositifolia* and *Cassiope tetragona* which form extensive growths in the northern part of the lowarctic region and in the higharctic region. Among invertebrates the higharctic butterfly *Colias hecla* can be mentioned. It is found in S. W. Greenland only in the higher mountains.

Among the birds all subarctic species mentioned below keep to the lowlands. The upper parts of the mountain slopes are here as further north in the lowarctic region inhabited only by two panarctic species, namely *Lagopus mutus* and *Plectrophenax nivalis*, of which the former commonly moves about in the mountains but rarely breeds at higher altitudes. When in the summer 1936 I climbed the mountain Trekanten (1027 m) in Upernavik District, I found *Plectrophenax nivalis* to be the only bird occurring right up to the barren stone-fields on the top (cf. SALOMONSEN 1950, p. 541). In the mountains of Angmagssalik District in East Greenland *Plectophenax nivalis* has been observed up to an altitude of 1530 m, and pairs were found up to 1270 m (GRIBBON 1964, p. 49).

Various investigations have shown, however, that a number of lowarctic birds may in some places continue rather high up in the mountains. All these records are enumerated in my book on Greenland birds (SALOMONSEN 1950). Especially I want to point out my investigation of the high plateau Nákajanga in interior Søndre Strømfjord where at an altitude of abgut 700 m I found during a visit on July 26–27, 1925, *Gavia stellata* (breeding), *Clangula hyemalis*, *Lagopus mutus* (breeding),

Anser albifrons (breeding), *Phalaropus lobatus*, *Corvus corax*, *Oenanthe oenanthe* (breeding), *Calcarius lapponicus* (breeding), *Plectrophenax nivalis* (breeding), *Carduelis flammea* (breeding). The term "breeding" inserted in brackets means in all cases that so late in the summer only juvenile birds with their parents were observed, but no egg-clutches.

On July 12, 1968, I scaled Lyngmarksfjeld in the southern part of Disko. This mountain rises to 975 m, but the upper part is covered by an ice-cap, while the ice-free mountain slopes reach 802 m. The fertile lowarctic vegetation in the form of heath and *Salix* copses was found to about 200 m, especially well-developed along water courses, but then rapidly decreased, and above an elevation of 300 m only fell-fields and scattered low trailing willows were developed on an underground of raw talus, patterned soil, stone stripes, or sliding ground due to solifluction. The bird-life was very meagre, and the small passeres (*Oenanthe oenanthe*, *Calcarius lapponicus*, *Carduelis flammea*) very soon disappeared, the greater part even below an altitude of 100 m. Above this height only a few specimens were exceptionally to be found. Tne only species which was to be found higher up the mountain was *Plectrophenax nivalis*, which was rather common to about 200 m and scattered to about 700 m. Apart from this species a flying *Carduelis flammea* was seen at 400 m, a flying *Larus hyperboreus* at 800 m, and one *Lagopus mutus* at 300 m.

In order to judge about the change in the life habits with altitude in the subarctic zone it is necessary to study the distribution of the plants. Böcher (1938, p. 308), who discusses the vertical zonation of plant life in Greenland, comments that "there are unfortunately no investigations of South Greenland to enable us to discuss the vertical zonation there."[2] More recently Böcher studied the highland flora of the middle part of West Greenland (Böcher 1963, p. 64–67), but no investigation of the subarctic parts of S. W. Greenland was carried out. On account of this I made an investigation of the vertical zonation in the summer of 1971 (June 19–21) in the subarctic lowland of Narssarssuaq and the mountains Mellemlandet bordering Narssarssuaq to the south.

The lowland plateau of Narssarssuaq mainly consists of salt marshes, sandy and clayey fields and flat sea-shore with numerous lagoons. It must be emphasized that there is no heath vegetation on this locality, but real heath vegetation is very local in the subarctic zone, and *Empetrum nigrum* is almost entirely lacking. The subarctic copses, mainly consisting of *Betula pubescens* and *Salix glauca*, covered the mountain slopes with a dense thicket and continued to an elevation of about 300 m above sea-level. At the same height or slightly lower down the herbaceous

[2]) However, Rosenvinge (1896, p. 85 & p. 215) investigated the vegetation of the mountain Qáqarssuaq (685 m) at Narssaq and of Arsuk Ø to an altitude of about 750 m.

floor vegetation gradually changed, and the main shift between subarctic lowland and lowarctic highland undoubtedly took place at this elevation. The characteristic heath plants *Betula nana glandulosa*, and *Vaccinium uliginosum* already began to appear at about 100 m altitude, and the vegetation in the mountains completely resembled the mixed dwarf-bush heath of the lowarctic zone further to the north. Slightly before the mountain top, at 680 m, clayey stretches with fell-fields, lichens and mosses replaced the heath and low willow copses and may, in a way, be regarded as a higharctic zone.

With the exception of the Graminea, which I did not examine, I found the following vascular plant species[3] in the lowland, up to 300m, but *not* higher up the slopes:

Dryas integrifolia	*Saxifraga aizoides*
Sedum rosea	*Lathyrus japonicus*
Chamaenerion latifolium	*Chamaenerion angustifolium*
Draba incana	*Arabis arenicola*
Betula pubescens	*Sorbus groenlandica*
Rumex acetosella	*Pinguicula vulgaris*
Viscaria alpina[4]	*Plantago maritima*
Stellaria humifusa	*Armeria scabra*[5]
Campanula gieseckiana	*Erigeron compositus*[6]
Antennaria hansii	*Antennaria affinis*[7]

The following species were found *both* in the lowland and in the mountains:

Botrychium lunaria	*Juniperus communis*
Thalictrum alpinum	*Potentilla crantzii*
Alchemilla vulgaris	*Alchemilla glomerulans*
Saxifraga caespitosa	*Papaver radicatum*
Draba aurea	*Angelica archangelica*
Salix herbacea	*Salix glauca*

[3]) Nomenclature after BÖCHER *et al.* 1966.

[4]) It was noteworthy that about 1% of the *Viscaria alpina* seen (10 specimens of about 1000 observed) belonged to var. *albiflora* or to intermediate stages between this form and the ordinary *alpina*. This comparatively great percentage of *albiflora*, which is rare in most places in Greenland, must be due to some man-made factor, probably some nutrient, which favours the appearance of this mutant at Narssarssuaq air-field. The var. *albiflora* has been collected at Narssarssuaq previously, by KORNERUP as well as by BÖCHER (cf. BÖCHER 1952, p. 21).

[5]) This species is not recorded further south than Godthåbsfjord by BÖCHER *et al.* 1966, p. 157.

[6]) Very rare in Julianehåb District.

[7]) Rare south of 66°N and previously not found in the subarctic zone.

Cerastium alpinum
Silene acaulis
Bartsia alpina
Taraxacum sp.[8]
Thymus drucei

The following species were found *only* in the mountains, usually above an altitude of 300 m:

Saxifraga oppositifolia
Rhododendron lapponicum
Diapensia lapponica
Pedicularis flammea
Betula glandulosa
Oxyria digyna.
Montia fontana
Arabis alpina
Polygonum viviparum
Draba norvegica
Vaccinium uliginosum

It should be added that *Arabis alpina* and *Oxyria digyna* began to appear already at 200 m above sea-level, and as said above, *Betula nana glandulosa* and *Vaccinium uliginosum* at 100 m.

The lists above, although worked out with much care, pretend by no means to be complete, but nevertheless give a good impression of the great differences in the flora of the subarctic and the lowarctic parts of the mountains.

Even the bird-life changes in accordance with the ecological alterations in the mountains. While *Oenanthe oenanthe* and *Carduelis flammea* are extremely common in the lowland, right up to the disappearance of the birch forest at about 300 m above sea-level, they practically cease to occur above this limit, although they did not completely disappear. On the other hand, *Plectrophenax nivalis* continues to the top of the mountains investigated (at an altitude of 680 m) and *Calcarius lapponicus* almost as far upwards. Not a single aquatic bird was observed in the lakes in the mountains, of which a dozen were examined. In the estuary of the river and at the shallow water areas of the fjord in the lowland there was a varied bird-life, which shall not be dealt with here, however.

Animal Husbandry in the Subarctic Zone

The subarctic zone is the region of animal husbandry in Greenland. The main livestock is sheep, of which there are about 50,000 head. The number of sheep fluctuates very much, for in catastrophic winters when the ground everywhere is covered by a deep layer of snow, a great number of sheep succumb when sufficient winter food has not been provided for them. Most serious was the winter 1966–67 when the number of sheep in Greenland drastically went down, from 47,000 head in 1966 to 22,000 in

[8]) I have not distinguished between the different apomictic species within the genus *Taraxacum*.

1967. There are also a few cattle in S. W. Greenland, and recently a small number of Yak Oxen (*Bos grunniens*) have been introduced by the Danish Veterinary College as an experiment in order to produce wool and meat. There are a few yaks in the area of Tasiussaq-Qagssiarssuk and formerly also at Eqaluit where they have now been slaughtered.

There are even a large number of horses in the subarctic region. They are only employed as mounts, used with eminent horsemanship. It is peculiar, however, that the number of horses appears to be much too high, considering their modest practical use. In Qagssiarssuk there are 80 horses and at the isolated farm at Qanisartut there are 12. At the Qordlortoq valley (Qordlortup itivnera) in the inner part of the Tunugdliarfik fjord a flock of 25–30 horses roam about wild in the country, destroying crops and doing damage to the fields. However, the inhabitants will not sell their horses nor reduce their numbers. There is either some superstition attached to the possession of horses, or they are by their owners regarded as symbols of strength and wealth.

The area of sheepfarming more or less corresponds with the subarctic region, continuing northwards without interruption almost to Arsuk Fjord. There are, however, a few sheep farms in Frederikshåb District, where the northernmost one is situated just south of Avigait Outpost. In Godthåb District a negligible sheepfarming takes place in the innermost Godthåbsfjord, at Kapisigdlit Outpost, while the sheepfarming station Qôrqut is now closed. It is noteworthy, however, that in the nearby uninhabited Ameralik Fjord sheep, escaped from Kapisigdlit, have been able to live quite wild in the fertile interior of the fjord and are hunted there regularly; in 1969 about ten were shot.

The sheep have a devastating effect on the subarctic birch and willow vegetation. All bushes and taller plants are eaten, to the effect that the landscape gradually assumes the same aspect as seen in other northern sheepfarming countries, such as Iceland and the Faroes, in form of large grass-covered rolling plains (Fig. 2), without bushes, except on very steep places inaccessible to the sheep.

Only at Narssarssuaq air-field, where sheep are not admitted, or in the only botanical reserve in Greenland, the Qíngua valley at Tasermiut fjord (Fig. 1), does the future of the birch copses appear to be secured.

However, the large and continuous grass steppes around Tunugdliarfik fjord and Igaliko Fjord were present much before the beginning of the recent period of sheep-farming which was initiated about 1920, and they were described already by ROSENVINGE (1896, p. 165) and also discussed by WARMING (1886, p. 16) who quotes botanists mentioning these grass fields already about the year 1800. This tends to show that the destruction of the birch copses dates further back, to the sheep-farming of the Norse settlement. This ancient husbandry ceased

Fig. 2. Large grass-covered rolling plains around Qagssiarssuk outpost, Narssaq Municipality, Julianehåb District. (Phot. 16th June 1971 by F. SALOMONSEN).

when the remnants of the Norse population became extinct or were absorbed by the gradually immigrating Eskimos, about the year 1500. This extreme protraction of the regeneration of the forests is borne out by our experience under similar conditions in subarctic Scandinavia, where overexploitation of the forest border "has left wounds which, at best, will be closed after many decades, probably even centuries, by a natural regeneration of the forests" (BLÜTHGEN 1970, p. 25). This corresponds with the fact that, according to BLÜTHGEN (*l.c.*) "the annual average yield of wood in the subarctic forests only in the most favourable sites exceeds 1 cm^3 per hectare." This extremely minute amount stated by BLÜTHGEN may be due to a mistake (or a misprint), but the primary production of vascular plants appears, at any rate, to be very modest in the Arctic. In lichen heaths in Norway as well as in northern tundras in Siberia it is annually below 40 g/m^2. The minimum, measured in a higharctic *Salix arctica* barren in northern Canada, was 3 g/m^2 (BLISS 1962, p. 137; WIELGOLASKI 1972, p. 30). Some new figures do not differ essentially. The annual net plant production calculated on the basis of full plant cover was on higharctic Devon Island about 60 g/m^2 on beach-ridges (SVOBODA 1973, p. 23), 13–28 g/m^2 on rock outcrops (BLISS &

KERIK 1973, p. 33), and 56 g/m² on lowalpine heath in Finnish Lappland (KÄRENLAMPI 1973, p. 111). It was generally stated by WEBBER (1974, p. 459) that the annual net productivity in the so-called "polar deserts" was less than 100 g/m², and 100–250 and 250–500 g/m² for higharctic and lowarctic tundra, respectively.

ROSENVINGE (1896, p. 142) draws the attention to the extensive use of birch wood as fuel by the Norse farmers in S. W. Greenland and is of the opinion that this may be the reason for the devastation of the forests. Still, he is more inclined to believe that the strong desiccating winds have made it impossible for the birch to obtain a strong-hold in areas where it is particularly exposed to the winds (ROSENVINGE 1896, p. 112).

There are still unspoiled birch copses in the subarctic region in Greenland, however, but botanists should hasten to get a few of these places protected from sheep-farming before it is too late. I should like to quote the botanist HUSTICH (1970, p. 237) who says that the subarctic zone "is very thinly populated. This is one reason why a noticeable, and in the long run dangerous, carelessness with nature is the mark of man's efforts in large parts of the Subarctic. One is seldom keen to save what one thinks one has more than enough of." This warning is especially relevant for the subarctic zone in Greenland.

SUBARCTIC BIRDS IN GREENLAND

There are very few subarctic birds in Greenland and all of them, except *Haliaetus albicilla*, are recent invaders which were not found in Greenland 50 years ago. In addition they are all very rare in Greenland. This paucity of subarctic birds is very natural when remembering that South Greenland jets out in the Atlantic Ocean and is very far removed from the nearest land masses. There is no possibility for southern species to push their breeding area gradually northwards in Greenland as they can in Canada or Siberia, since they must cross wide areas of open sea in order to reach Greenland. The present climatic amelioration has made it possible for a small number of subarctic birds to settle in Southwest Greenland, as will be shown below. To be sure, all Greenland subarctic birds belong to faunal types of very wide areas. There is in Greenland no breeding bird species of the genuine subarctic faunal type of which there are a number in North America and Siberia (cf. p. 8, above). There are even a few southern birds which breed in the lowarctic Angmagssalik District in Southeast Greenland, namely *Anthus pratensis* and *Motacilla alba*, of which at least the former is a recent invader which began to turn up in Greenland about the year 1900. But neitner of these two species can be regarded as subarctic. In Europe they are found from the temperate region right up to the lowarctic zone. In northern Scandinavia they are common in the low alpine zone and are scattered as breeding birds even in the highalpine zone. *Anthus pratensis* belongs to the European faunal type, *Motacilla alba* to the Palaearctic one, but when considering only the subspecies breeding in Greenland (nominate *M.a. alba*), the latter bird is also of European faunal type. They are, therefore, of a wide distribution in a north-south direction. The subarctic birds also belong to faunal types of wide distribution, but to the north they do not transgress the boundary to the lowarctic region, except for *Haliaetus albicilla*, which sparsely is found northwards to Holsteinsborg District. They are all immigrants from Europe, and not a single North American species has settled in the subarctic zone in Greenland.

Fulmarus glacialis auduboni Bonaparte

The Fulmar belongs to the Arctic faunal type and has almost a circumpolar distribution. It breeds from the North Canadian Islands and Greenland through the islands of the North Atlantic southwards to Great Britain, Brittany in northern France, and Norway, eastwards to the Kara Sea, and in the North Pacific from the Bering Strait southwards to the Pribilof Islands, the Aleutians and the Kurile Islands. The breeding places in Greenland are enumerated by SALOMONSEN (1950, p. 33) and are shown on Fig. 3. Except for the small breeding place in Orpigsôq fjord in Disko Bugt and the limited breeding places in Scoresby Sund (Cape Brewster, Raffles Island, Rathbone Island), all the remaining colonies are very large, numbering between 10,000 and 100,000 pairs. Furthermore, they are very stable and have no doubt all been occupied for centuries. Some of them have been known for about 200 years, *i.e.* since the time of OTTO FABRICIUS, who was a missionary in Greenland from 1768 to 1773. Knowing how conservative sea birds are, it must be assumed that these colonies have been in use since time immemorial. This fact is particularly emphasized here because the boreal Fulmars, distributed to the south of the arctic breeding places, have been involved in a spread of enormous proportions, unprecedented among birds. This remarkable population explosion is well documented, and has been carefully described and commented on particularly by FISHER (1951, 1952a, 1952b, 1966, and other papers). St. Kilda in Great Britain and Grimsey off North Iceland were the only known boreal breeding places until well into the eighteenth century. In the years previous to 1750 the Fulmar was found nesting in the Westmanna Islands south of Iceland, and from this period it spread all over the coasts of the boreal part of Europe, including the Faroes, Great Britain, Norway, and northern France, and the colonization is not yet finished, but has continued to this day. The immigration to the British Isles has been particularly closely followed. In 1878 the first breeding pairs, altogether 12, were discovered in the Shetland Islands. In 1899 there were 580 breeding pairs in the British Isles (excluding St. Kilda), in 1919 8,500 pairs, in 1949 68,000 (FISHER 1951, p. 455), and in 1959 97,000 (FISHER 1966, p. 34).

The most recent colonization has taken place in Norway, probably as an offshoot from the breeding places in the Shetland Islands. The Fulmar established a breeding colony on the island of Rundøy, south of Ålesund, at about 1920, but the proof of its breeding in form of eggs collected was not given until 1924. The number of pairs was then estimated at 50–100 (JOHNSEN 1924, p. 193). In 1947 there were 300–400 pairs, in 1954 about 500 pairs (BRUN 1971a, p. 35), and in 1971 600–700

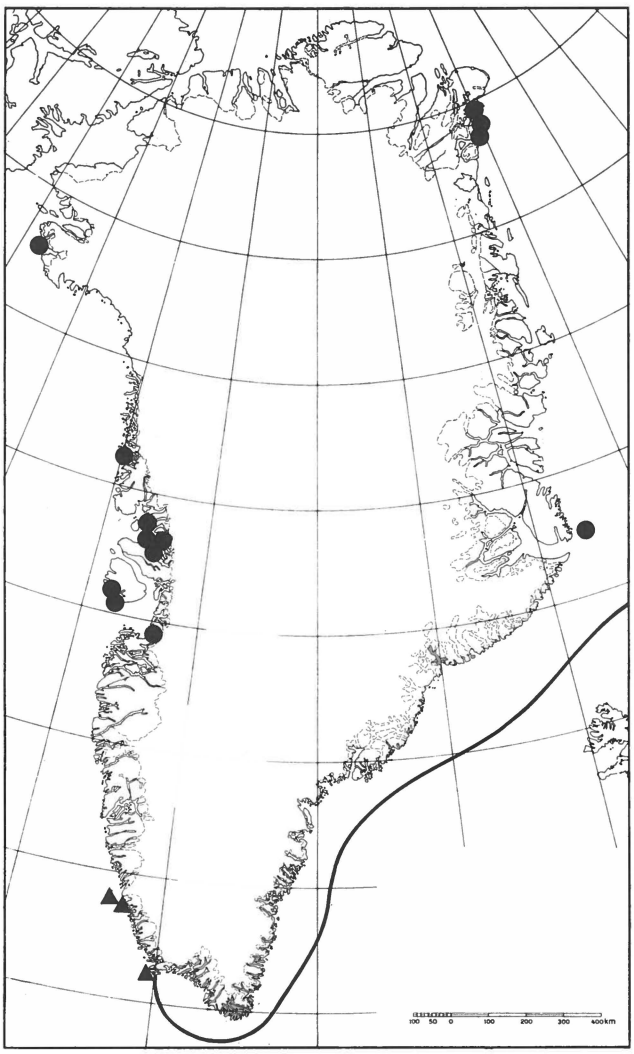


Fig. 3. Breeding-places of the Fulmar, *Fulmarus glacialis*, in Greenland. Solid circles represent old, well-established colonies of arctic Fulmars, solid triangles new, recently established boreal Fulmar colonies. The solid line shows the average boundary of the East Greenland ice (the "Storis") in the month of April in the period 1919–1942. Cf. p. 28.

pairs (Folkestad *et al.* 1972, p. 17). It spread from Rundøy not only to nearby Nerlandsøy to the south and to Vigra and Erkna (Haftorn 1971, p. 21) and Haramsøy to the north (Folkestad *et al.* 1972, p. 14), but to a number of other islands in western Norway from the county Sør-Trøndelag south to Hordaland. It is now known to bread on Einevarden in the northern part of Vågsøy (62°N, 5°E), Veststeinen (61°54′N, 4°52′E), Heglane (59°N, 5°23′E), Utsira (59°18′N, 4°55′E), and Lepsøy

(62°38′N, 6°08′E), in most places only with a few pairs (BRUN 1971a, p. 35), in 1971 altogether 173 pairs (BRUN 1971b, p. 225). Furthermore, it colonized the island Røst and neighbouring skerries in the southernmost part of the Lofoten Islands from 1940 onwards, and Værøy, somewhat further to the north, in 1964 (HAFTORN 1971, p. 21). Finally, two pairs were found breeding in 1968 and five pairs in 1969 on the island Bleiksøy at Andøya in Vesterålen, north of Lofoten (ELIASSEN 1970, p. 52).

This rapid spread and increàse in Norway is not the only recent colonization. From the British Isles the Fulmar has also immigrated to the south and was breeding in Brittany in 1960 (MILON 1960, p. 283; SALOMONSEN 1965, p. 347), but only in a few spots and with only 12–30 pairs. In 1968 it invaded Normandy (CHAPPUIS & LE MAHO 1971, p. 79), where it has now increased. In 1971–73 about 30–35 were observed at various places along the coast of Normandy (CHAPPUIS *et al.* 1974, p. 85), and in 1967 a few prospecting birds were observed on Heligoland (VAUK 1970, p. 14), where probably 1–3 pairs now breed (VAUK 1972, p. 22). In 1972 the Fulmar was observed on ledges on coast cliffs in southern Labrador (5 pairs) (NETTLESHIP & LOCK 1973, p. 314), and in 1973 six pairs were found breeding in southern Newfoundland (NETTLESHIP & MONTGOMERIE 1974, p. 16). The localities are marked on the map 2a in BROWN *et al.* 1975, p. 39).

As far as Iceland is concerned, there was only one Fulmar colony known in the country before the eighteenth century, in which period the great spread started. In 1949 a total of 155 colonies were known in Iceland (FISHER 1952a, p. 107). However, before 1835 the Fulmar had spread to a number of places along the south coast and a few places along the east coast, whereas now all coasts are densely inhabited by the Fulmar. The Faroes were colonized in the period 1816–1839, and before 1865 a great number of islands had been occupied. I stress these facts, because they have something to do with the controversial subject of the explanation for the population explosion.

FISHER (1952b, p. 433–453) described in a very convincing way the possible causes of the Fulmar's spread. In his careful and detailed investigation he suggests that the expansion of the Fulmar is a product of the increasing whaling and fishing industry in European and Atlantic waters in recent time, in so far as the offal and waste of this industry furnish the Fulmar with a surplus of food that formerly was nonexistent. Undoubtedly the modern fishing industry has furthered and accelerated the process by producing additional food for the Fulmar, but it has not given rise to the expansion and does not explain its origin. In the early days of the spread of the Fulmar, in the period 1750–1850, when it particularly increased in southern Iceland, almost all whaling took place in the very far north and was restricted to the catch of the Greenland

Whale (*Balaena mysticetus*). The whaling in the Spitsbergen seas and in the pack-ice off Northeast Greenland, north of a line from Jan Mayen to Scoresby Sund, diminished and finally ceased in this period, while it flourished in Baffin Bay and the Davis Strait from Holsteinsborg District northwards. But all these waters were far too remote to be utilized in the breeding time of the Fulmars inhabiting southern Iceland, which is situated about 700 km away. Moreover, in those years the Fulmar occupied the Faroes, which are still further away from the whaling areas. The modern, rational whaling methods, due to the invention of the SVEN FOYN harpoon, did not begin until 1865 and the long-ranging fish trawling in the Atlantic even later. I must admit that the American catch of the Sperm Whale (*Physeter catodon*) in the North Atlantic has not been considered. It started at the beginning of the 18th century and mostly took place in the Pacific or further south in the Atlantic. I do not believe that it influenced the feeding conditions of the Fulmar essentially. I am much more inclined to think that the spread of the Fulmar originated as a result of certain genetic changes, combined with certain selective advantages which I have described in a previous paper (SALOMONSEN 1965, p. 345–351), and which FISHER (1966, p. 76) has commented on. BROWN (1970, p. 49) agrees with me that production of offal at sea cannot have been the key factor.

As far as Greenland is concerned, I wish to quote what I have said (SALOMONSEN 1965, p. 347) about the status of the Fulmar: "The present large-scale trawling activity in the Davis Strait has not changed the breeding range of the Fulmar at all. The trawling started about 1920, simultaneously with the northward extension of cod due to the climatic amelioration, and has steadily increased to the present day when literally hundred of vessels participate. The fishing grounds stretch from Frederikshåb District northwards almost to Disko Bay, and the Fulmar is numerous everywhere on the fishing banks. Nevertheless, it has not settled anywhere on the coast which extends for almost 1,000 km (640 miles) along the fishing banks and possesses many cliffs suitable as breeding places. This demonstrates that an extensive fishing industry does not necessarily induce the Fulmar to any range expansions." This situation still holds true, and when the Fulmar now has begun to breed in some small colonies in the southern parts of West Greenland it is not due to an expansion of the genuine arctic Fulmar population of Greenland, but is an offshoot of the expanding boreal populations, no doubt originating from Iceland. I shall return to this point below (p. 30). In 1971 I found the following breeding places of the Fulmar, hitherto unknown:

(1) The islands Ydre Kitsigsut, in northern Julianehåb District, at 60°45′N, 48°25′W. These islands are situated in the open sea, about 10 km west of the large uninhabited island Nunarssuit, and are very

remote, about 70 km northwest of the nearest inhabited outpost, Qagssimiut, and about 50 km due south of the outpost Arsuk. Moreover, in summer the islands are surrounded by dense ice-fields of the East Greenland ice ("Storisen"), coming from the south, and are in certain periods almost unaccessible.

During a previous visit to Julianehåb District, in 1949, Mr. JON DAVIDSEN and Mr. RAME NIELSEN in Qagssimiut, told me that the Fulmar now bred in the Ydre Kitsigsut where on the island marked C on Fig. 41 there were about 25 pairs. It had not occupied other islands and was a recent invader. At that time there were no *Uria lomvia* breeding on the islands. In 1971 Mr. JULIUS JAKOBSEN in Arsuk told me that both *Uria lomvia* and the Fulmar were breeding on some of the islands and that there were altogether about 30–40 pairs of Fulmars. He was of the opinion that the Fulmar had occupied the islands about 1950, a few years before *Uria lomvia*. Since I was told already in 1949 that the Fulmar was breeding there, I should think that the islands were occupied about 1945.

It is quite out of the question that the Fulmar should have bred previously in this part of Greenland. Just in the area of Arsuk Fjord a number of keen ornithologists were living in the years 1886–93, namely O. HELMS, TH. N. KRABBE, and A. T. HAGERUP, but they do not with one word mention any breeding of the Fulmar here (cf. HELMS 1892, HELMS 1894, HAGERUP 1891). It is unthinkable that they should not have been informed by the Greenlanders in Arsuk if the Fulmar was breeding in this region.

I did not have the opportunity to visit the Ydre Kitsigsut islands until 1971. On July 3 I investigated the islands, coming from Arsuk, in a strong northern breeze. This wind had scattered the ice-floes and pack which for some time had made a visit impossible. The wind prevented us from landing on most of the islands and even the ice was a serious obstacle for navigation among the numerous islands. In addition, there was continuously a heavy fog which made orientation difficult, the cold was penetrating owing to the wind and the dense ice, and the boat took in much water. Nevertheless, we succeeded in investigating the breeding places of the Fulmar; these are further dealt with later, p. 165. The islands have no names, apart from the biggest one, which is called Umanaq, or by sailors "Thorstein Islænder." With an altitude of 116 m it constitutes a well-known and characteristic landmark. The islands were, therefore, designated with letters (cf. Fig. 41), and the Fulmars were breeding on the following islands:

On island B	11 pairs
On island C	40 pairs
On island D	18 pairs
On island E	5 pairs

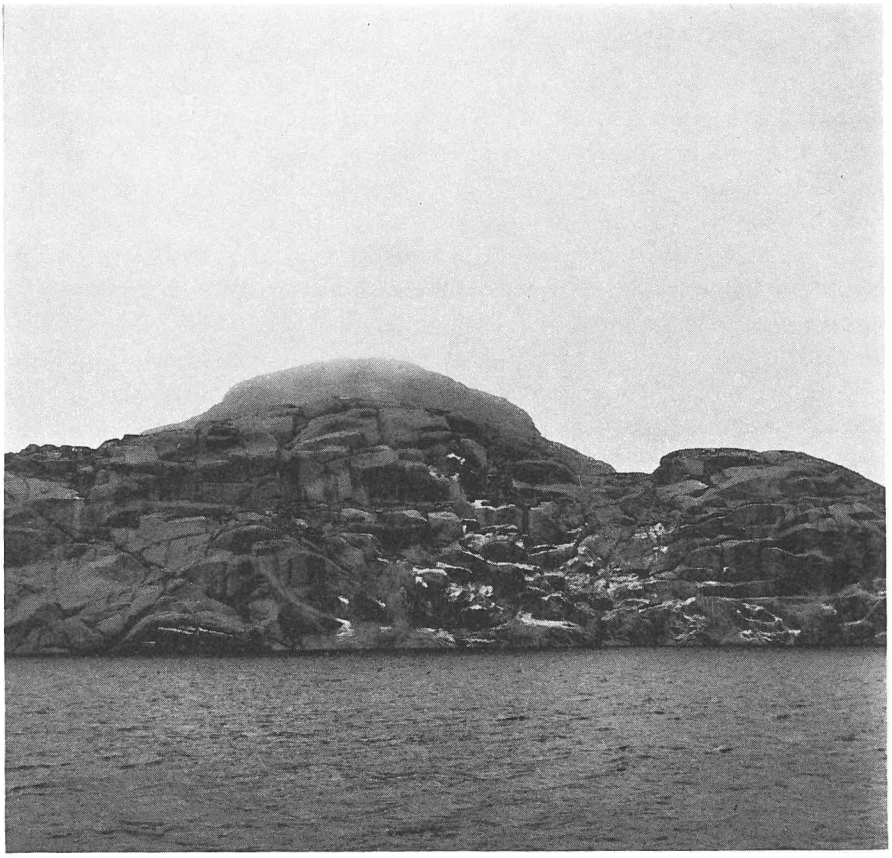


Fig. 4. The island Umanaq or "Thorstein Islænder" in the Ydre Kitsigsut islands, Julianehåb District, seen from south. In the centre of the picture is the top, of an altitude of 116 m, partly covered with fog. This is the island C on the map Fig. 41. The breeding-places for sea-birds, in front, are further shown in Fig. 42. (Phot. 3rd July 1971 by F. SALOMONSEN).

This means that there were altogether 74 pairs. Their breeding places were situated at small altitudes on the low islands, between 10 and 50 m above sea-level, and the ledges on which they were breeding were readily accessible (Fig. 4). The result is that each year when the ice situation makes it possible, the inhabitants of Arsuk and Qagssimiut raid the islands for eggs of both the Fulmar and the numerous *Uria lomvia*. The Ornithological Committee of Greenland has now asked the Greenland Provincial Council ("Landsrådet") to issue a legal protection for the Fulmar in the breeding time in Julianehåb and Frederikshåb Districts, but not in the northern districts of West Greenland where Fulmars are habitually objects of hunting and egg-collecting. This was granted in the new Greenland game-act, which came into force the 1st of January 1978.

(2) According to our motorman, JAKOB PETERSEN, and to Mr. KARL MØLLER, Avigait, the Fulmar breeds on two places on islands situated in the northern part of Frederikshåb District, off the great but unproductive glacier Frederikshåbs Isblink. They said that the Fulmar arrived as a breeding bird to these places about five years ago, *i.e.* about 1966, and the first year there were only 1–2 pairs on each place, but the next year there were "many."

I visited both these places on June 30, 1971. The first is the island Agpat, situated at 62°21′N, 50°09′W, just north of the islands Qegka, quite near the mainland which here, in front of the glacier, forms a huge desert of clay, partly flooded, without vegetation. The breeding place of the Fulmar (Fig. 5) was a perpendicular cliff, about 40 m high, facing West. When we approached it in a dory with outboard motor, the Fulmars probably were frightened by the noise and left, only one keeping to its nesting place. There were about 20 birds in the air, but I do not know how many pairs they represented. It appeared as if the eggs were collected, but it must have been a risky venture to visit the breeding places on the very narrow ledges on the perpendicular cliff. A more detailed description of the breeding place is given on p. 144.

(3) This breeding place was not far from Agpat, on the westernmost island in the island group Ikermiut, on 62°23′N, 50°16′W; cf. fig. 35. The breeding place was a steep promontory facing northwest, about 20 m high. Only two Fulmars were seen, soon leaving the ground when I approached by land. There are only a few pairs here, and according to JAKOB PETERSEN four eggs were collected here in 1970, this being the whole lot. A protection of the small breeding population is necessary if the colony shall be maintained and the Fulmar be able to increase and spread. Confer what is said above (p. 25) on protection. A closer description of the bird life on Ikermiut is given on p.141. Mr. MANASSE KNUDSEN, member of the local council of Avigait, told me in 1975 that the Fulmar had increased on Agpat, now numbering about 50 pairs, together with a few *Fratercula arctica*, which had now immigrated to this place. On the other hand, there were only two pairs of Fulmars on Ikermiut.

It is necessary to discuss the origin of these new colonies. It can be argued that they are offshoots of the northern arctic population and not of the southern boreal one. Both belong to the same subspecies (*auduboni;* cf. SALOMONSEN 1965, p. 352), and it will be very difficult to distinguish them morphologically. In my opinion there is no doubt, however, that they belong to the boreal population, for the following reasons:

When bearing in mind that the Fulmar is a pelagic seabird its occurrence in the southwestern part of Greenland forms a natural continuation of its breeding range in Iceland, and its occupation of S. W. Greenland has taken place simultaneously with its most recent

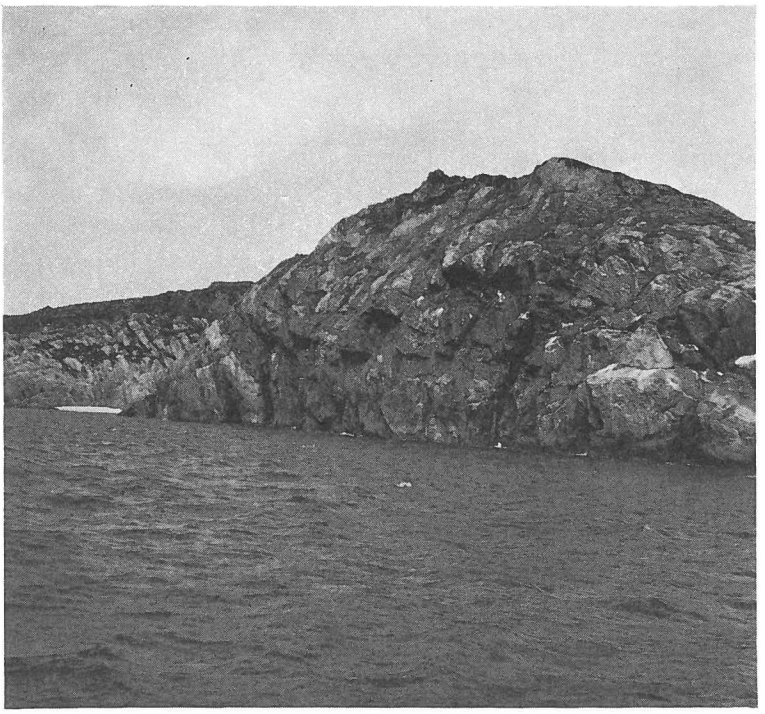


Fig. 5. The island Agpat in the northern part of Frederikshåb District, the south-western part, facing the breeding-place of the Fulmar, of an altitude of 40 m. (Phot. 30th June 1971 by F. SALOMONSEN).

spread in Norway, in Canada and elsewhere, probably as a result of overpopulation of the more southern breeding places. At the same time the new colonies are very small, just as new settlements of the boreal population use to be. The arctic colonies in the northern part of West Greenland, south to the island Disko, are all very big, with thousands of breeding pairs, situated on towering mountains, and there are no new small colonies erected in spite of the increasing fishery for more than fifty years. No colonies of Fulmars have been founded on the huge stretch of coast between Disko and Frederikshåb District, a distance of more than 800 km.

There is even a difference in ecology between the southern (boreal) and northern (arctic) populations, in so far as the attitude towards ice is concerned. The arctic Fulmars arrive in April at the breeding places. At their arrival the fjord-ice is firm and unbroken for a distance of 70–80 km out from the cliffs, but this does not prevent the birds from flying to and from the breeding place, although out to sea the Fulmar tends to avoid extensive ice-fields (SALOMONSEN 1950, p. 34).

In the boreal populations of Iceland and Great Britain the Fulmars

start to come back to their breeding cliffs in early November, and their number increase gradually until April when the population it at its highest and the amount of display and visiting becomes very great (FISHER 1952a, p. 337). They do not anywhere in their great breeding area experience the existence of ice, neither in summer at the breeding cliffs nor in winter out to sea. Now, it is noteworthy that the breeding places in Greenland are situated just north of the boundary of the Storis (the East Greenland ice) which in winter moves around Kap Farvel and in about April, when the greatest number of Fulmars arrive at the breeding places, has reached Nunarssuit Island where it is stopped for some time. In Fig. 3 is shown the average boundary of the ice in the month of April in the period 1919–1942, based on the maps of ice-conditions in the appendices to the Danish Nautical Meteorological Annuals. The breeding places on Ydre Kitsigsut are situated just north of the ice limit in April, and the two smaller and more recent colonies are found also in the so-called openwater region which is almost free of ice in winter and spring and stretches northwards along the coast to Egedesminde District. The pack-ice usually passes Kap Farvel in January and reaches Julianehåb a couple of weeks later and Nunarssuit in March or April. The waters north of Nunarssuit are quite free of pack-ice from August to March, and the amount of ice found there in summer is so slight that it generally does not influence shipping particularly, while the ice usually is very dense south of Nunarssuit and quite prevents the navigation to Julianehåb until August–September (BENDIXEN 1921, p. 380). South of Nunarssuit, and particularly south of Julianehåb, there are no breeding colonies of pelagic and offshore seabirds owing to the dense ice in summer (cf. Fig. 6). This means that the Fulmar could not settle anywhere south of Nunarssuit if it would avoid the ice to which the boreal populations are not adapted. It must be admitted that in recent years the ice situation has aggravated, and the East Greenland ice sometimes, as *e.g.* in 1970, blocks the entire coast northwards to the northern part of Godthåb District, but it does not pass Nunarssuit until June, *i.e.* about a month after the Fulmar has started egg-laying.

It may be mentioned here that the occurrence of the colour phases also tends to show that the Fulmar in Southwest Greenland belongs to the boreal population. This latter is characterized by possessing specimens of only the light phase, while in the arctic populations of Northwest Greenland the dark birds constitute 0.1 per cent of the breeding birds in Disko Bugt and Umanak District, and about 1.0 per cent of those in Upernavik and Thule Districts (SALOMONSEN 1965, p. 340). The difference is small, it is true, but it ought to be mentioned, nevertheless, that I observed only light birds at the breeding places in Southwest Greenland

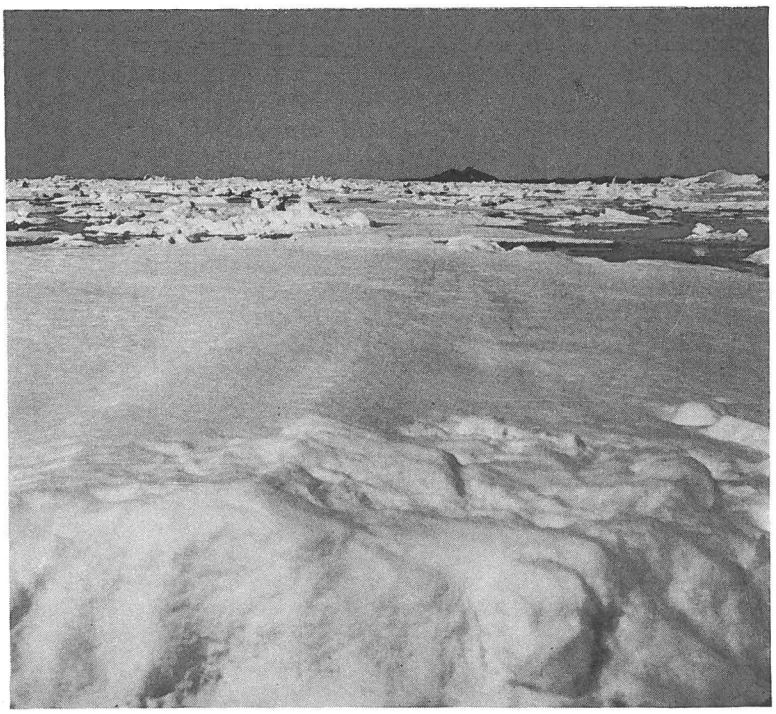


Fig. 6. The dense East Greenland ice (the "Storis") in summer at the Nordlige Kitsigsut islands off the coast of Nanortalik District, at 60°15′N. (Phot. 16th June 1949 by F. SALOMONSEN).

or in their immediate surroundings. Also my Greenland informers told me that only light birds were breeding there. In the waters off Frederikshåb District I saw twice a dark Fulmar, but that is not surprising since dark birds belonging to the breeding population of Baffin Island regularly and in some numbers occur on the fishing banks off the West Greenland coast (cf. SALOMONSEN 1965, p. 335; and this paper p. 179).

It must, finally, be mentioned that the waters off Southwest Greenland belong to the lowarctic part of the Atlantic, not to the boreal part, which does not approach the coasts of Greenland. A colonization of the southernmost fringe of the lowarctic zone by a boreal bird in a recent period may be related to the present climatic amelioration. Only in two other places has the expansion of the Fulmar crossed the boundary towards the lowarctic region, namely in southeastern Canada and in northern Iceland. This happened in Canada very recently, in 1972–73, but in Iceland much eartier, about the year 1900, after a few forerunners had appeared in northwestern Iceland in the latter half of the 19th century. The same development has taken place in two other boreal birds, the Gannet (*Morus bassanus*) and the Great Skua (*Ster-*

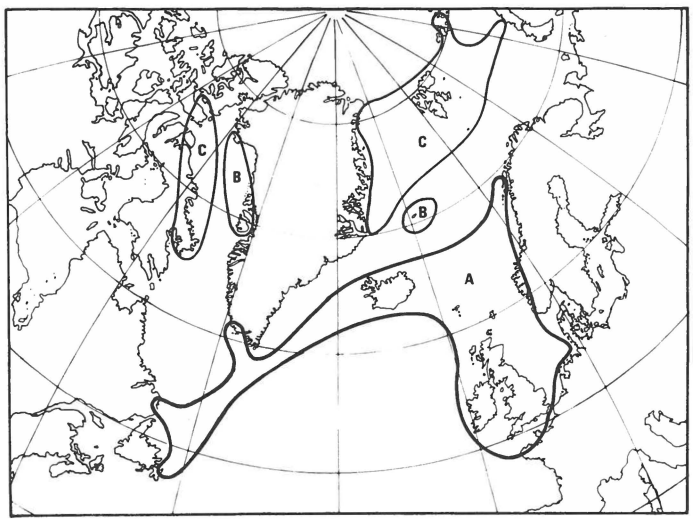


Fig. 7. The distribution of the Fulmar, *Fulmarus glacialis*. A: The expanding boreal population. B and C: The staple arctic populations. B: *F. g. auduboni*, mainly lowarctic; the boreal population A belongs to this subspecies. C: *F. g. glacialis*, mainly higharctic.

corarius skua), which both are expanding in this century and have settled in lowarctic northern Iceland, although in much more modest numbers than the Fulmar (cf. SALOMONSEN 1965, p. 350). It is very probably that the Southwest Greenland Fulmar population is an offshoot of the lowarctic North Iceland one. The breeding range of the boreal expanding population and of the other North Atlantic Fulmar groups is shown in Fig. 7.

Larus ridibundus Linnaeus

The Black-headed Gull belongs to the Palaearctic faunal type and is widely distributed in the northern parts of the Old World, breeding from Iceland, Great Britain and France through Central Europe and southern Scandinavia, Russia and Siberia to Mongolia, Manchuria and Kamchatka. Its main stronghold is in the cool temperate regions and until recently it did not occur in the subtropical parts of Europe.

Just like the Fulmar, the Black-headed Gull has carried out an enormous population increase and expansion in the North Atlantic area, but like the expanding Fulmar population it has remained within the boreal region and only in Iceland transgressed the boundary of the lowarctic zone. On the other hand, it is a terrestrial and inshore marine species and, therefore, not to be compared with pelagic species like the Fulmar. However, some other boreal inshore marine species, which in

recent years have also widened their breeding range, extend into the southern part of the lowarctic zone in the Kola Peninsula, North Russia, as is the case with *Larus argentatus*, *L. fuscus*, *L. canus*, and *Phalacrocorax aristotelis;* the latter breeds also at the lowarctic coasts of Iceland; cf. SALOMONSEN 1965, p. 333.

The Black-headed Gull started its range expansion later than the Fulmar, about 1850, and, therefore, its increase has usually been related to the amelioration of the Atlantic climate, which gradually began in this period, but essentially progressed after 1900; cf. SALOMONSEN 1948, p. 85; VOOUS 1960, p. 126. Therefore, the increase of the Black-headed Gull in northern Europe was considerably accelerated in the twentieth century.

In Denmark the Black-headed Gull began to increase as early as about 1820, particularly on the islands east of the Great Belt. In Sweden the first record dates back to 1798, and the species was known to breed sparingly in Scania in the year 1800 and was a common breeding bird there in 1835. In 1841 it invaded Gotland, about 1860 Öland, in 1890–1903 great parts of southern Sweden northwards to Uppland, and in 1916–1936 it shifted the northern boundary for its breeding range to Värmland-Västmanland and along the coast of the Baltic Sea to Norrbotten. Finally, it invaded Jämtland in 1940, and Dalarna in 1943. The periods of the strongest expansion and increase in Sweden were 1820–1840, 1870–1910, 1920–1930, and 1945–1960.

It immigrated to Finland about 1810, then disappeared and reappeared in great numbers 1860–1870 when it spread along the south and west coast northward to Hailuoto. In the period 1880–1900 it increased again considerably and colonized the Ahvenanmaa (Åland) Islands and other places. A still stronger increase took place 1920–1935 with colonization of the interior parts of the country, and finally in 1940–1955 when it spread over the entire boreal part of the country, northwards to Kemi and in the interior to Vilppula-Savonlinna (Nyslott), exceptionally to Haapavesi-Pielisjärvi.

In Norway the spread has been even stronger than in the other Scandinavian countries, and practically the entire coast of this longish country has been occupied in the short period since 1885. The first Norwegian record was from Stavanger in 1832, and the species began to breed in the country about 1885 on Jæren. It then made its way to the north in waves, with the most conspicuous increase in the 1880's, and espceially in the 1920's and the 1950's, occupying Hordaland 1887 (disappeared 1889, but reappeared 1941), Sør-Trøndelag 1920, Nord-Trøndelag (Steinkjer) 1921–1922, Oslo Fjord 1922, Lake Mjøsa 1930, Møre and Romsdal 1933, and Troms 1959. In recent years, since 1962, it has been found in scattered places in northernmost Norway, in the

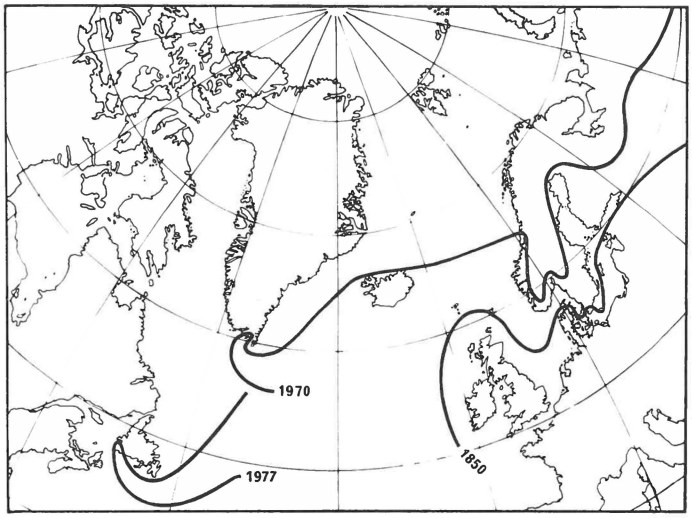


Fig. 8. The breeding-range of the Black-headed Gull, *Larus ridibundus*, in the European and North Atlantic area. The lines show the northern limit of the breeding area in 1850, when the expansion has just started, further that of 1970, when Greenland was reached, and finally that of 1977, when North America was colonized. Cf. also p. 39.

province of Finmark, but its continuous breeding range still does not transgress the Trøndelag area. It is noteworthy that the majority of new breeding records in the far North of Norway is characterized by numbering only one pair, not a colony of pairs. In more southern latitudes the Black-headed Gull invariably breeds in smaller or larger colonies.

The first record in the Faroe Islands was about 1800, and in 1848 it began to breed on the southernmost island, Suðuroy. About 1870 it had spread to the large islands in the central part of the archipelago, namely Streymoy and Eysturoy. Finally, on Iceland where the Black-headed Gull is now a rather common and widespread breeding bird, the first record is from 1906, when the species was recorded from several places as a winter visitor. In the following years it increased as a winter visitor, from December to April, and began to breed 1911 in the south-western part of the island, where the summer climate is mildest. From about 1927 it spread rather rapidly and even occupied the northern part of the country (Mývatn, Akureyri) and at the same time it increased in the winter time. In recent years it has increased still more.

The above description of the spread of the Black-headed Gull in the Scandinavian countries is based on numerous literature references and is summarized in SALOMONSEN 1963, p. 218–220. The northern limit of the breeding area in 1850, when the expansion had just started, and that of the present situation (in 1970) is shown in Fig. 8.

In the British Isles the population of the Black-headed Gull has

increased considerably in recent years. It amounted to 35.000 pairs in 1938 and to 50.000 in 1964, but it was apparently as big in the year 1800, having decreased during the 19th century owing to hunting and poaching (YEATMAN 1971, p. 192; CRAMP *et al.* 1974, p. 48). However, it is not certain that the population increase still continues in the British Isles (WITHERBY *et al.* 1945, p. 68).

It is noteworthy, however, that the Black-headed Gull in recent years has also expanded to the south in Europe and has occupied breeding areas in the subtropical, Mediterranean region. It began to breed in northern Italy in 1960, in the Ebro Delta in eastern Spain also in 1960, in Andalusia in southern Spain in 1966, and has increased enormously in the Camargue in southern France since 1930 (VON WESTERNHAGEN 1967, p. 65).

Simultaneously with this expansion the Black-headed Gull has changed its migration pattern and has increased as a resident bird in the North European countries where it was formerly only a summer visitor. At the same time it invaded the larger cities in winter where it was previously unknown. It was still extremely rare in Paris in 1876 (LEGENDRE 1928, p. 108), but is now very common there (YEATMAN 1971, p. 209). It began to spend the winter in Copenhagen in 1887 (SALOMONSEN 1963, p. 220), in Berlin in 1870, in Prague about 1920 (MAKATSCH 1952, p. 61), in London 1894 (BANNERMAN 1962, p. 250), and even as far north as in Bodø in Nordland, Norway (at 67°25′N) in 1970 (LUND 1971, p. 277). At the same time the Black-headed Gull has extended its migration to the south and in recent years, after 1970, it occurs as a regular winter-visitor in Kenya in tropical Africa, where it had never been met with previously (STEINBACHER 1977, p. 65).

It is interesting to notice that while the Black-headed Gull is vigorously expanding its range, it appears to be decreasing in numbers in the central parts of its breeding range in Europe. In Denmark it has decreased about 50 percent in the period 1950–1960, which is due, probably, to competition with the bigger *Larus argentatus*, increasing in number in these years, as well as to destruction of its habitat (ISENMANN 1976, p. 352; MØLLER 1978, p. 31). MAKATSCH (1952, p. 11) gives a number of examples which show that it has decreased in Germany in the last decades, and CREUTZ (1965, p. 262), who has carried out a very careful census in Eastern Germany, is certain, at any rate, that the population in that country has not increased. Egg-collecting and destruction of the natural habitats of the birds, especially the swamps and lakes, is given as the main reason for the decrease. This suggests that the expansion of the species is not due to population pressure from the central parts (Germany, England) of the distribution, but probably has something to do with a climatic change. On the other hand, it cannot be denied that the

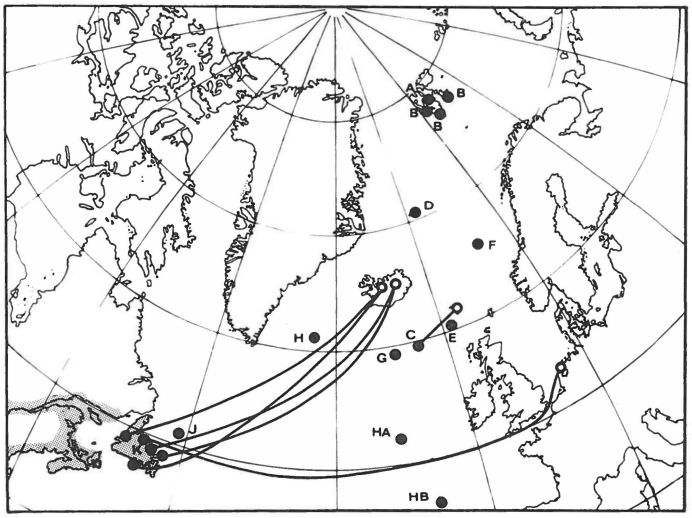


Fig. 9. North Atlantic records of the Black-headed Gull, *Larus ridibundus*, shown by solid circles and letter-designations described in the text, p. 00–00. In the case of ringing recoveries the ringing locality is shown by an open circle connected with a line to the place of recovery. The shaded area represents the region in which *Larus ridibundus* occurs in North America as a regular winter-visitor.

expansion appears somehow to be connected with the greater amounts of garbage available to the gulls in recent years. Their occurrence in the European cities must, at least, be due to their role as scavengers.

An earlier analysis of the food of the Black-headed Gull, based on stomach contents of 3,500 specimens (SPÄRCK 1951, p. 588), showed that the main food of the Black-headed Gull in Denmark consisted of insects (55 percent), while offal amounted to about 20 per cent. In more northern latitudes the percentage of garbage must undoubtedly be greater, but no food analysis has been made in northern countries, to the best of my knowledge. It is noteworthy, however, that in Greenland the Black-headed Gull always occurs and even breeds close to human habitations with extensive refuse dumps.

I do not agree with ERSKINE (1963, p. 336) when he says: "Black-headed Gulls are rarely if ever seen at dumps and other places where garbage and offal attract scavengers. The small gulls probably favor small food items, and are unable to compete effectively with larger gulls at dumps and fish piers." As said already, the appearance of the Black-headed Gulls as scavengers at dumps and similar places in the European cities is a well-known fact. It is quite true that in harbours with fish-waste they are ineffective competitors of the larger gulls, but in places in northern Europe where these species are less common, the Black-headed Gull also appears at fishing piers. In addition, they are more confident

in their conduct towards man, less shy than the larger gulls, and this behaviour is of competitive value in places where many people are present.

The increase in Europe of the greater species of *Larus* is usually explained as a result of the abundance of fish-waste and offal which is provided in modern civilized countries and which is available as food for the gulls. However, HARRIS (1970, p. 332) has shown that the number of *Larus argentatus* and *L. fuscus* continue to increase in recent years in spite of the decreasing amount of garbage due to improved waste disposal. This appears to show that also other factors than food are responsible for the increase and expansion of these gulls, and the same is no doubt also the case with the Black-headed Gull.

There is a lively traffic of Black-headed Gulls over the pelagic parts of the North Atlantic Ocean, which, naturally, is to be expected of a species in active expansion in these regions. The following observations, recoveries of ringed birds or other records, have been made in recent years on the Atlantic Ocean proper or in areas north and west of the European breeding area. The North Atlantic records are plotted in Fig. 9, the Greenland records in Fig. 10, and each of them is provided with the letter with which they are described below.

A. One adult specimen observed at Longyear City, West Spitsbergen, 27th June 1961 (HALKIER 1961, p. 195).

B. On 19th July 1964 an adult specimen was observed at Kapp Borthen, West Spitsbergen (OGILVIE & TAYLOR 1967, p. 307). In the summer of 1969 two specimens were observed on Spitsbergen, one at Kapp Linné, West Spitsbergen, another at Edgeøya (NORDERHAUK 1970, p. 108). A and B are the only records of the Black-headed Gull known from Spitsbergen.

C. The following specimen was ringed in the Faroes and recovered in the Atlantic, according to PREUSS 1971:
C. 642561 pull. 27th June 1963 Mikladali, Faroe Islands.
() 19th May 1964 Hutton Bank, Atlantic Ocean (59°N, 16°30′W).

D. One unsexed, first winter bird was obtained on Jan Mayen in the early spring of 1929 (HOLGERSEN 1953, p. 5). HOLGERSEN adds that it is no doubt a bird bred in Iceland in 1928.

E. An adult specimen was observed on 16th September 1958 south of the Faroe Islands, at 60°30′N, 9°W, flying in a southeaster direction (DYCK 1965, p. 36). It was probably of Icelandic origin.

F. A number of ornithological observations have been made from

various weather-ships which for meteorological reasons, especially for weather-forecasts, have been stationed in the North Atlantic. At the Ocean Weather Station "M", stationed at 66°N, 2°E, a number of Black-headed Gulls have been observed, most of them in the spring migration period in April. On 24th April 1951 one bird was observed, on 12th April 1953 a flock of 15 specimens, on 26th April 1955 two birds, on 26th June 1956 two birds, and on 19th April 1960 one bird (HJELMTVEIT 1969, p. 15).

G. Also on the British weather-ships various ornithological observations have been made in the period 1951–1962, published in a number of papers in "Dansk Ornithologisk Forenings Tidsskrift", "The Sea Swallow" and "Marine Observer". A great number of Black-neaded Gulls were observed in localities mapped as G, H, HA and HB, respectively, on Fig. 9. On the weather-ship "India" stationed at 59°N, 19°W (mapped down as G), during an observation period between 12th May and 6th June 1957, an adult Black-headed Gull was observed on 13th May, another on 23rd May and an immature specimen on 22nd May (MCLEAN & WILLIAMSON 1961, p. 209). Further, the following specimens of Black-headed Gulls have been observed at "India", according to TUCK 1967, table A; TUCK 1968, table A; and ANON. 1971, table A:

	Observation period
1 specimen	11th February–6 March 1966
2 adult birds	1st–22nd April 1966
1 specimen	19th May–9th June 1966
3 adult birds	20th Aug.–11th Sep. 1966
1 specimen	27th Sep.–19th Oct. 1966
21 specimens, among which	
2 immature birds	15th April–8th May 1967
47 specimens, among which	
36 immature birds	10th May–2nd June 1967
1 specimen	28th Nov.–13th Dec. 1967
2 specimens	7th–29th August 1969
2 specimens	22nd Sep.–16th Oct. 1969

It is distinctly to be seen that a much greater number of Black-headed Gulls were observed in the spring of 1967 than in that of the previous year. There are no spring observations from 1968 and 1969.

H. On the weather-ship "Alpha", stationed at 62°N, 33°W, during an observation period between 23rd April and 16th May 1962, an immature Black-headed Gull was observed on 29th April (ROGERS

& WILLIAMSON 1963, p. 229). During an observation period between 12th May and 3rd June 1966 six adult specimens were observed (TUCK 1967, table A), in the period 5th–28th May 1967 two specimens were observed (TUCK 1968, table A), and in the period 11th June–6th July 1969 15 specimens, nine of which were immature birds, were observed (ANON. 1971, table A).

HA. On the weather-ship "Juliet", stationed at 52°30'N, 20°W, during an observation period between 28th March and 24th April 1966 10 Black-headed Gulls, five of which were immature birds, were observed, in the period 3rd–25th July 1966 two were observed, in the period 2nd–23rd October 1966 one was observed (TUCK 1967, table A), and in the period 26th April–19th May 1969 five were observed (ANON. 1971, table A).

HB. Although the weather-station "Kilo", at 45°N, 16°W, appears to be stationed somewhat further south than appropriate for the purpose of this investigation, the observations of Black-headed Gulls at this station shall be briefly mentioned. In the period 27th December 1965–20th January 1966 five specimens, two of which were immature birds, were observed (TUCK 1967, table A), and in the period 4th–30th October 1967 one specimen was observed (TUCK 1968, table A). In the spring of 1958 no Black-headed Gulls were observed (MCLEAN & WILLIAMSON 1959, p. 177).

I. During a trip of the research trawler A. T. CAMERON an adult Black-headed Gull in breeding plumage was observed on 12th May 1970 at 51°27'N, 51°24'W (R. G. B. BROWN, *in litt.*).

K. A number of Black-headed Gulls have crossed the Atlantic Ocean and have reached Newfoundland. Altogether five birds ringed in Europe have been recovered in Newfoundland, one from Holland as early as in 1933, and no less than four from Iceland in the years 1943–1959. The ringing data are given by TUCK (1971, p. 203), and the records are shown on Fig. 9. TUCK (1971, p. 190) adds that the Black-headed Gull is now a familiar part of the winter avifauna in Newfoundland and that it has been recorded there in every month of the year. According to ERSKINE (1963, p. 334) the first Black-headed Gull in North America was identified in 1930[1] and since that year the number has gradually risen, particularly much after 1945–1950, to the effect that the total wintering population in North America now (*i.e.* in 1962) is certainly not less than 300 individuals and probably not more than 3000. The place of origin of this large

[1]) However, ringed European Black-headed Gulls were recovered as early as 1911 on the island of Barbados and 1912 in Mexico (COOKE 1945, p. 127).

number of Black-hedaed Gulls recently occurring in North America is not known with certainty, but ERSKINE (*l.c.*, p. 336) points to Iceland as the most probable source. The large number of ringed Iceland birds recovered in Newfoundland bear out this assumption. ERSKINE, further, draws attention to the fact that weather patterns would favour migration from Iceland to Newfoundland. When a high-pressure area dominates the eastern Canadian Arctic, with an intense low in the central Atlantic south of Iceland, the resulting air-flow from the northeast would aid migration from Iceland towards west. This pattern is quite typical for the situation after the passage of major cold fronts in northeastern Canada.

Black-headed Gulls now occur annually on the eastern coasts of North America from Newfoundland and Nova Scotia southwards to New York and the Delaware River and westwards via the St. Lawrence valley to the Great Lakes, but they are much more common in Canada than in the United States. The winter distribution is outlined in Fig. 9 as the shaded area.

All records of the Black-headed Gull in the North Atlantic region until 1970 have been enumerated above and have been outlined in Fig. 9. Summarizing it can be said that in almost all years between 1951 and 1970 one or more observations have been made in the North Atlantic north of 59° n.lat., the greater part in the migration period in April–May, but also some in the summer. In the same period the Black-headed Gull has increased considerably as a winter visitor in S. E. Canada. The occurrence in the North Atlantic is a recent phenomenon and appears to show that the Black-headed Gull in recent years during the spring migration is expanding far and wide over the ocean, no doubt in search for new breeding places. It is noteworthy that WYNNE-EDWARDS (1935) in his work on the distribution of birds in the North Atlantic Ocean does not mention the Black-headed Gull at all, as this species had not occurred in the North Atlantic as early as in 1935. I may add that I have not considered the bird observations made on numerous voyages between England and Halifax-New York (50°–45° n.lat.), as these latitudes appear to be situated too far to the south for the purpose of this study. But as far as I know, no records of the Black-headed Gull have been published from such voyages.

The recent expansion of the Black-headed Gull in the northern Atlantic has also reached Greenland, from which country there are a number of observations in recent years. Now it has even started to breed in Greenland, restricted to the subarctic zone of S. W. Greenland, in this way sending offshoots of the European population to the Nearctic region, in the same way as the Fulmar has done. This development has

been expected for some time. In 1951 GUDMUNDSSON said about the recovery in Greenland and North America of Black-headed Gulls ringed in Iceland: "The unexpected recoveries in S. W. Greenland and Newfoundland indicate that the Black-headed Gull will not stop at Iceland but will penetrate farther westwards and perhaps establish itself in Greenland and N. E. America" (GUDMUNDSSON 1951, p. 507). A few years later VOOUS (1960, p. 126) was of the opinion "that a colonization of North America is not impossible." In the same way ERSKINE (1963, p. 338) said that "the possibility of Black-headed Gulls establishing themselves as breeding birds in the Northeast of North America seems quite good." Finally, TUCK (1971, p. 190) briefly stated that "reports of breeding in the New World are anticipated." However, now the Black-headed Gull has begun to breed in North America. In 1977 two or three pairs were breeding on the west-coast of Newfoundland (VICKERY 1977, p. 1112; FINCH 1978, p. 312); cf. also Fig. 8.

All records of Black-headed Gulls in Greenland are enumerated on the map Fig. 10, where they have been provided with the letter with which they are described below. According to HØRRING & SALOMONSEN (1941, p. 46) the following Greenland records were known up to 1940:

A. Fiskenæsset outpost, Godthåb District, 29th January 1917, ♀ ad.

B. Frederiksdal outpost, Nanortalik District, autumn of 1929, an immature specimen. Probably shot in the beginning of October, according to OLDENDOW (1933, p. 75).

C. Fiskenæsset outpost, Godthåb District, 2nd February 1917, ♀ ad.

D. Tuapait, Nanortalik District, 6th November 1933, in first winter plumage.

E. Fiskenæsset outpost, Godthåb District, summer of 1932, an immature specimen.

These records show that the Black-headed Gull was unknown in Greenland until 1917. However, there is a rather uncertain record which is much older. KOLTHOFF (1903, p. 69) states that he observed an adult bird at the ice-border off the southeastern coast of Greenland on 14th June 1883, but for various reasons this record must be regarded as doubtful; cf. SALOMONSEN 1963, p. 219.

However, the records mentioned above show an interesting phenomenon. As described already in this paper (p. 28), the East Greenland Ice ("Storisen") blocks the coast of southernmost West Greenland, *i.e.* Nanortalik and Julianehåb Districts, from about New Year to August. It is noteworthy that the Black-headed Gull, which is a boreal species usually not capable of finding food in large ice-fields, during its visits to

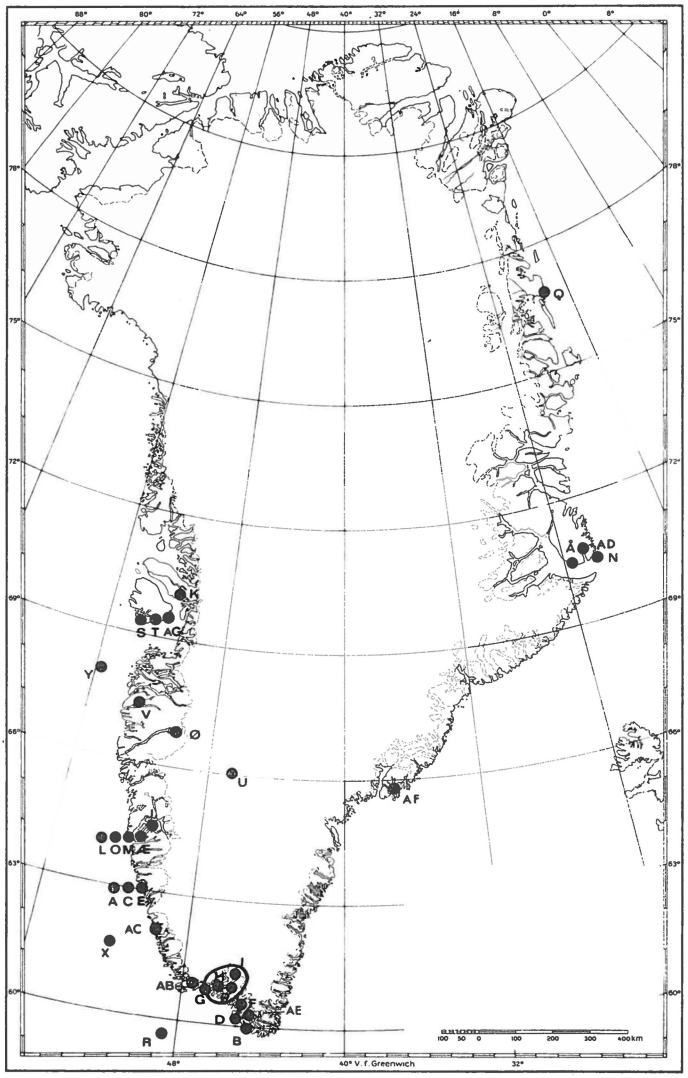


Fig. 10. The Greenland records of the Black-headed Gull, *Larus ridibundus*, shown by solid circles and letter-designations described in the text p. 39–47. The boundaries of the breeding area in S. W. Greenland is indicated by a circular line.

Greenland apparently avoids the dense ice areas and does not approach land until it has reached beyond the Storis, *i.e.*, in Frederikshåb and Godthåb Districts in the period January–August. The specimens marked A, C, and E have all been secured at Fiskenæsset in the southern part of Godthåb District in January, February, and "summer", respectively. On the other hand, the specimens B and D, which both have been obtained in Nanortalik District, are from November and "autumn" (probably

October), respectively, *i.e.* the period during which the coasts of this district are free of ice.

It is noteworthy that the European Golden Plover (*Pluvialis apricaria altifrons*) on its frequent visits to Greenland from Iceland as a fairly regular annual visitor in the same way as the Black-headed Gull avoids the ice-covered coasts of the southern West Greenland during its spring migration. I said about these visitors, from April–May, that "there is no doubt that these birds have tried to avoid the dense ice-fields surrounding the southern parts of Julianehåb District, and have approached the land slightly more to the north, where the ice is more scattered, or where in certain years there is no ice at all" (SALOMONSEN 1950, p. 194).

A number of new, mostly unpublished records from Greenland can be mentioned from recent years:

F. There are no less than four recoveries in S. W. Greenland of Black-headed Gulls ringed as nestlings in Iceland. The first was a bird ringed near Mývatn in northern Iceland in 1947 as nestling and shot on 10th December 1947 at Sletten outpost, Julianehåb District (GUDMUNDSSON 1953, p. 35). It had the ring number Reykjavik 5–3226, and it was shot by KLEMENS JOHANSEN, Mr. L. HAGENSEN, chief of sales department in Julianehåb, sent the foot with the ring to the Zoological Museum in Copenhagen. The tarsus measured 43 mm, the middle-toe with claw 38 mm.

G. A bird ringed as nestling at Hörgárdalur, Iceland, in 1963 was recovered near Narssaq, Julianehåb District in 1965, but the exact date is unknown. It has neither been told how it succumbed (SALOMONSEN 1971, p. 17).

H. A specimen ringed as nestling at Bessastadir in Iceland in 1969 was shot at Narssaq, Julianehåb District, the 22nd October 1969 (SALOMONSEN 1971, p. 49). The specimen was sent to the Zoological Museum in Copenhagen by Mr. HANS JØRN LAURSEN in Narssaq. He informed me that it was shot by Mr. NAMAN DAVIDSEN at a promontory called Nûgârmiut, situated about 2 km from Narssaq. The specimen was in freshly moulted first winter-plumage, with the small wing coverts and inner secondaries brownish. It was a ♀, with a weight of 230 g and a wing length of 292 mm. It is kept as a skin in the Zoological Museum.

I. A specimen ringed as nestling at Skipalon in Iceland in 1963 was shot at Narsarssuaq, Julianehåb District, on the 3rd June 1971. This recovery has not previously been published and will be further dealt with below, p. 49.

It appears that two of these ringed specimens (Nos F and H) were recovered in Julianehåb District in their first autumn, when the district is free of ice (cf. above p. 28), and the same probably applies to No. G. The last specimen (No I) was shot not far from the breeding place in the breeding time.

J. In the so-called OLDENDOW collection of birds in the seminary of Godthåb there is a specimen of the Black-headed Gull, examined by me during my visit to Godthåb in 1946. It was shot at Qôrnoq, Godthåbsfjord, the 8th December 1933, and was a male in first winter plumage. The wing measured 295 mm. It was skinned by JULIUS OLSEN, of whom the specimen was bought to the seminary. This record has not been published previously.

K. A specimen was shot on the 19th May 1952 at Sarqaq outpost in Disko Bugt by ABRAHAM JENSEN and sent to the Zoological Museum in Copenhagen by HANNIBAL FENCKER, manager of the outpost. It was a one-year old bird, with the head partycoloured blackish and white, and with the small wing coverts and the inner secondaries brown, the whole plumage being very worn. The wing measured 300 mm. It is kept as a skin in the Zoological Museum.

L. A mounted specimen is kept in the seminary of Godthåb, shot on the 3rd December 1955 near Godthåb. It is a ♀ in the first winter-plumage, with the small wing coverts brownish, and was examined by me during a visit to Godthåb in 1960.

M. Mr. IB TRAP LIND, taxidermist at the Zoological Museum in Copenhagen, who spent the year 1958 in Godthåb, informs me that a juvenile Black-headed Gull was shot at Godthåb on the 4th August 1958. It was used as food and, therefore, could not be skinned.

N. About 10 specimens of the Black-headed Gull were observed at Kap Tobin outpost, about 7 km from Scoresbysund, from early May to early June 1960. The gulls were often seen at the dump, on the heaches or in the open sea. A specimen shot on the 2nd May 1960 was by Mr. OVE BUSK POULSEN, Kap Tobin, sent to the Zoological Museum in Copenhagen. It was an adult ♀ in full summer plumage and with follicles about 2 mm in diameter in the ovary. This comparatively large follicle size showed that the bird was capable of breeding. The wing measured 300 mm. It is now kept as a skin in the Zoological Museum. It is noteworthy that the Greenlanders in Kap Tobin who were shown the specimen did not know the bird, which they had never seen before, while some of the Danes present believed that they had seen it at Kap Tobin a couple of years previously.

O. A specimen was shot near Godthåb on the 11th November 1963 and presented to the Zoological Museum in Copenhagen by Mr. JENS KREUTZMANN, who had skinned it. It was an adult male in winter plumage. The wing measured 299 mm. It is now kept in the Zoological Museum.

P. Mr. LARS MOTZFELDT, catechist at Qagssiarssuk, Julianehåb District, tells me (*in litt.*) that he observed a Black-headed Gull near Narssarssuaq air-field in the summer of 1961. It was together with a flock of Kittiwakes. In the summer of 1964 he observed, at the mouth of the Narssarssuaq river, three Black-headed Gulls, accompanied by some Glaucous Gulls or Iceland Gulls. On the 7th August 1968 Mr. MIKAEL IVERSEN shot a juvenile Black-headed Gull at Qagssiarssuk, which is situated very near to Narssarssuaq air-field. The specimen was sent to the Zoological Museum in Copenhagen by LARS MOTZFELDT, but it was too decayed to be skinned.

Q. Mr. HANS MELTOFTE, who spent two years (from April 1969 to April 1971) at the weather-station Danmarkshavn in Germania Land, N. E. Greenland, reports that he observed a Black-headed Gull at the entrance of a small river not far from the weather-station on the 3rd July 1969 and again on the 5th July (MELTOFTE 1975, p. 50).

R. An adult specimen of a Black-headed Gull in summer-plumage was observed on the 25th May 1969 off the ice-border south-west of Nanortalik, on 59°54′N, 48°55′W, by Mr. KURT LAMBERT. The gull followed the ship together with various other species of gulls (LAMBERT 1972, p. 72).

It has been shown above that there are several observations of the Black-headed Gull from 1968–1969, and in the following years the number of observations increase.

S. AAGE MEYER, director of a shrimp cannery in Godhavn, possesses in his bird collection a specimen of a Black-headed Gull which I examined during my visit to Godhavn in the summer of 1973. The specimen was an adult bird of unknown sex, shot at Diskofjord outpost about the 1st June 1971 by JAKOB JEREMIASSEN. The wing measured 297 mm.

T. Mrs. HANNE MILAN PETERSEN, working as a zoologist at the Arctic Station in Godhavn, observed a specimen of a Black-headed Gull in Godhavn in the last days of April 1971. It was not very shy and was searching for food at a dump near a road. Further, Mrs. MILAN PETERSEN tells me (*in litt.*) that she again saw a specimen of the

Black-headed Gull on the 5th September 1971 in a dump near a road in Godhavn, not far from the Arctic Station. The head of the Gull was partly blackish, partly white, showing that it was in the postnuptial moult.

U. During my sojourn at the American base Dye II on the Ice-cap, belonging to the DEW Line, at 66°05'N, 47°06'W (cf. p. 195), Mr. H. E. HUNTON told me that two individuals of the Black-headed Gull were observed at the base in the midst of April 1971. The observer, who is not an ornithologist, told me that the two birds were medium-sized gulls with blackish head. They were seen only one day and then disappeared.

V. Mr. P. GROSMANN, leader of the hunting club in Holsteinsborg, tells me (*in litt.*) that when on a trip to Ikertôq fjord, south of Holsteinsborg, on the 2nd June 1972 he observed two small gulls at some freshwater lakes about 70 km from the entrance of the fjord. The gulls were the size of Kittiwakes, and similar to this species in shape and colouration, but had blackish head. They flew about crying as if they were breeding there. These gulls in my opinion must undoubtedly have been Black-headed Gulls.

X. Mr. HENNING THING tells me that he on return from a zoological study in Greenland on board a southgoing steamer observed a Black-headed Gull on the 13th September 1972, when the ship passed Frederikshåb. The bird followed the ship for some time in company with several Kittiwakes.

Y. Mr. PETER MILAN PETERSEN tells me that he on the 29th August 1972 when on board a steamer observed about 20 sepcimens of Black-headed Gulls midway between Egedesminde and Holsteinsborg. The gulls followed the ship for about half an hour.

Æ. Mr. ERIK HANSEN, fishery biologist in Godthåb, reported (*in litt.*) that three specimens of the Black-headed Gull were shot near Godthåb in June 1972 by a Greenlander who told him that he had never seen this species before. The gulls were sold for food and not preserved. Even in 1973 the species was observed at Godthåb. On the 3rd August 1973 STEFAN PIHL and SØREN HELLES PEDERSEN, both members of the Greenland Ornithological Society, observed an adult specimen of the Black-headed Gull flying slowly along the coast. STEFAN PIHL saw again an adult one the 8th August and an immature one as late as the 22nd October 1973 at Godthåb, and he also observed an immature specimen near Julianehåb on the 25th October 1973. Two specimens in first winter-plumage were shot at

Godthåb on the 7th January 1974, according to Mr. ERIK HANSEN (*in litt.*), while Mr. THORKIL DUCH (*in litt.*) states that one was shot there on the 3rd January 1974 and three on the 5th January 1974, all four specimens being in the first winter-plumage. As recently as this year (1978) Black-headed Gulls have been recorded from Godthåb District. According to information from the museum curator JENS ROSING an adult specimen with black head was shot on the 5th May 1978 near Godthåb and was bought by the Greenland Museum (Landsmuseet) in Godthåb, intending to exhibit it. The specimen was shown to me by JENS ROSING; its wing measured 280 mm. It was in all respect an adult bird, and appeared to be a female, with the ovary measuring 15 mm. On the 23rd May 1978 ERIK HANSEN observed two adult specimens of the Black-headed Gull in the Amitsuarssuk branch of the Godthåbsfjord. They were swimming on the water when ERIK HANSEN arrived with the fishery research vessel "Adolph Jensen". When anchoring the ship the birds were scared and rose and could then be very well observed with the field-glasses. They left the fjord and were not seen later, although the ship stayed in the fjord for the next 24 hours.

Ø. Mr. JAMES HARRIS, member of an American expedition under the leadership of dr. WILLIAM MATTOX, working in the interior of the Søndre Strømfjord area, observed an adult Black-headed Gull on the 7th July 1972 at the gull colony in the Tatsip atâ branch of the fjord, at 66°52′N, 51°07′W. It flew around together with several *Larus glaucoides* and a few *L. hyperboreus* breeding in the gullery. The next summer two adult Black-headed Gulls were observed in the Umîvît branch of Søndre Strømfjord, near another gullery, situated at about 66°54′N, 50°58′W, not far from the Tatsip atâ branch. The birds were observed on the 10th June 1973 and again on the 7th July 1973, by STEEN MALMQUIST, manager in the Royal Greenland Trade Department. I visited the locality together with Mr. MALMQUIST on the 22nd July 1973 and observed one Black-headed Gull, soaring high up in the air, above a great number of *Larus glaucoides* from the gull-colony, which were startled by the noise of our motor-boat. This bird must have belonged to the pair observed earlier this summer by STEEN MALMQUIST. It must have stayed on this locality during the entire summer, socially attached to the breeding *Larus glaucoides*, just like the bird observed in 1972 at the gull-colony of Tatsip atâ, but the pair seen at Umîvît probably made no attempt to breed. An adult bird was observed on the 22nd July 1973 at Umivit bird-cliff by Mr. STEFAN PIHL (PIHL 1976, p. 105). A pair of Black-headed Gull was observed in the last days

of June 1974 also at Umivit by Mr. STEEN MALMQUIST. At the same locality a pair was observed on 22nd June 1975 by Mr. MALMQUIST, who in July 1975 observed even four specimens of the Black-headed Gull.

Å. Dr. JACOBUS DE KORTE, from the Zoological Museum in Amsterdam, Holland, has kindly informed me that in 1973 during an ornithological expedition to Scoresby Sund, he twice observed a specimen of the Black-headed Gull at different localities in the fjord in the first part of August. One of the observations made was near Sydkap in the interior part of the fjord. Cf. also DE KORTE 1973, p. 8.

AB. Mr. POUL HALD-MORTENSEN, leader of the Danish Ornithological Society Expedition to Julianehåb District in 1973, informs me that on the 1st July 1973 he observed eight Black-headed Gulls at the bottom of the Sermitsialik fjord, near the rim of the glacier, about 60°58′N, 47°03′W, somewhat north of Qagssimiut outpost.

AC. Mr. DAVID BOERTMANN, the leader of an ornithological excursion in West Greenland in 1974, reports (*in litt.*) that he observed an immature, one year old Black-headed Gull on the 26th June 1974 near Frederikshåb city.

AD. Dr. JACOBUS DE KORTE observed a specimen of the Black-headed Gull on the 16th June 1974 near Kap Stewart, Scoresby Sund (DE KORTE 1974, p. 7). In 1975 he met with the Black-headed Gull again. An adult specimen in summer-plumage was observed on the 22nd July 1975 and two adult specimens in summer-plumage on the 24th July 1975 at the head of Hurry Inlet, Scoresby Sund (DE KORTE & BOSMAN 1975, p. 9).

AE. Mr. STEFAN PIHL, in 1974–75 serving as a teacher in Sydprøven outpost, Nanortalik District, observed a number of Black-headed Gulls in the vicinity of Sydprøven. An immature, one year old specimen was observed on the 24th August 1974, 12th September 1974 and 14th October 1974, possibly the same bird. An adult specimen was observed in winter, on the 26th–27th January 1975, foraging on the dump of Sydprøven in company with *Larus glaucoides* and *L. marinus*. Two adult specimens were observed near Qagdlumiut in the Lichtenau Fjord on the 8th June 1975, possibly a pair on their way to a breeding-place (PIHL 1976, p. 105).

AF. Mr. STIG JÜRGENSEN, superintendent in Angmagssalik, informs me (*in litt.*) that an adult Black-headed Gull was shot on the 23rd May 1975 at Angmagssalik city in S. E. Greenland.

AG. An adult specimen of Black-headed Gull was obtained in the beginning of May 1975 at the sea close to Godhavn city by PAVIA VILLUMSEN. The specimen was by director AAGE MEYER presented to the Zoological Museum, where it is kept as a skin. Director MEYER has informed me that in the midst of May 1975 he observed another adult individual of the Black-headed Gull near Fortunebay, Disko[1].

On account of what has been said above, it is quite certain that in recent years the Black-headed Gull has appeared much more commonly along the coasts of S. W. Greenland than in the previous years and that it even has extended its wanderings to N. E. Greenland and to the ice-cap. The number of observations is particularly great in 1971–1975. It was natural to suppose that the species would some day start to breed in the country. The many records of birds observed or shot in the area of the Tunugdliarfik fjord in the subarctic part of S. W. Greenland imply that it started to breed in this region some years ago, perhaps already about 1964, according to the observations of LARS MOTZFELDT, quoted above. However, we know with certainty that it was breeding in 1969 at least in two places. LARS MOTZFELDT with whom I have exchanged a number of letters concerning the Black-headed Gull in Greenland, tells me that in 1969 a pair of this species was breeding in the bay Tasiussaq in Nordre Sermilik, on a small island shown in Fig. 11. According to the sheep-farmer HANSÊRAQ FREDERIKSEN, Tasiussaq, the Black-headed Gulls appeared again in 1970 when they occurred in much greater numbers. They arrived on 10th May 1970, and about 10 or 12 pairs were breeding on the same island in the fjord as in 1969. Mr. NIELS HENRIK LYNGE informed me that he, when visiting HANSÊRAQ FREDERIKSEN, observed a flock of 22 specimens in Tasiussaq on 1st August 1970. HANSÊRAQ's son, ENOQAQ FREDERIKSEN, also a sheep-farmer, tells me that in 1970 he found a single nest with eggs on another island situated in the southern part of Tasiussaq, and subsequently he observed the nestlings. HANSERAQ also told me that the sheep-farmers at Tasiussaq would not shoot the Black-headed Gulls because they were certain that the gulls would increase in the subsequent years if they were left in peace.

In 1971 the gulls arrived in some number to Tasiussaq as early as

[1]) It should be added, for the sake of completeness, that G. ANDERSON (1973) during the British "Greenland (Cape Farewell) Expedition" in the summer of 1972 observed the Black-headed Gull several times and stated it to be "very common along the West coast" of Greenland. Since ANDERSON's list of the bird observations is extremely erroneous, I must be permitted to leave his records out of account. Moreover, P. ELLIS (1973, p. 114), the ornithologist on another British expedition, which in 1972 camped in the same fjord in S.W. Greenland as ANDERSON's party, did not encounter the Black-headed Gull at all.

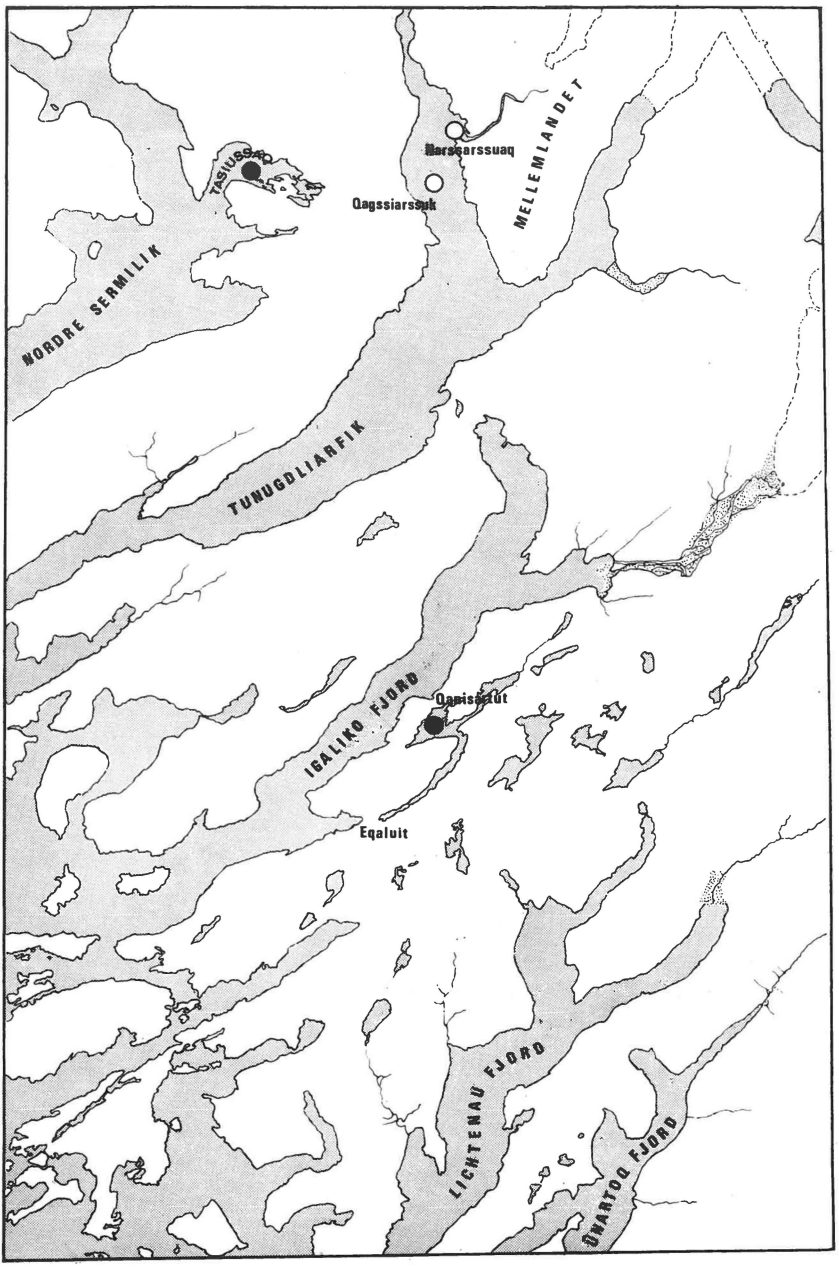


Fig. 11. Map of the inner parts of Julianehåb District (60°30′–61°15′N, 45°–46°W), giving breeding-places (solid circles) and observations (open circles) of the Black-headed Gull, *Larus ridibundus*, in 1971.

20th April and settled on the same island as in 1969 and 1970. However, in the last part of April a great amount of ice pushed forward from the glacier in Sermilik, and Tasiussaq bay became densely covered with ice. As a result the Black-headed Gulls disappeared. This was the situation when on 15th June I went to Tasiussaq for a ride, coming from Qagssiarssuk, accompanied by LARS MOTZFELDT. In a small motorboat we tried to visit the breeding place, but the bay was still so densely packed with ice that it was inpracticable to approach the island more closely than about 300 m. However, it was quite obvious that there were no gulls.

In the following days I got a great deal of information on observations of the Black-headed Gull in these areas. Mr. EDDY PEDERSEN and Mr. KURT PETERSEN at Narssarssuaq air-field, both keen sportsmen, told me that on a hunting trip on 3rd June 1971 they observed 15–16 specimens of Black-headed Gulls at the outlet of the Narssarssuaq river. They shot three specimens which were all presented to an anonymous old woman at Qagssiarssuk for food. I succeeded in discovering this woman who told me that the remnants of the gulls, including the wings, were thrown away on the dump. Several persons then helped me to search for these remnants and we succeeded in finding one wing which definitely belonged to the Black-headed Gull. One of the three specimens shot had been ringed in Iceland and had the number "Museum Reykjavik 613933". It had been ringed at Skipalon in northern Iceland (65°47′N, 18°12′W) on 14th June 1963 as nestling, *i.e.* being now 8 years old. This specimen is mentioned above (p. 41) as No. I.

Mr. KURT PETERSEN also told me that in the summer of 1970 there had been four to five Black-headed Gulls at Narssarssuaq, thus much fewer than in 1971. Mr. NIELS PAVIASEN, a sheep-farmer, whose farm is situated on the eastern side of Tunugdliarfik not far from Narssarssuaq, told me that on several occasions in May 1971 he had observed Black-headed Gulls pass along the fjord in small flocks. They disappeared in early June, but he had seen one again on 17th June. Mr. FRANKLIN HØEGH OLSEN, manager of the outpost Qagssiarssuk, informed me that several times in the spring of 1971 he had observed Black-headed Gulls pass the outpost along the fjord, usually single individuals, but once even a flock. Several other inhabitants of Qagssiarssuk had seen the Black-headed Gull in 1971, but it is not necessary to go further into details. The fact remains that the Black-headed Gull must have been a common visitor to Tunugdliarfik in the spring, particularly in May and early June, when the gulls had left the breeding place in Tasiussaq owing to the appearance of dense ice-masses.

I had the privilege myself to make some observations of the Black-headed Gull at Narssarssuaq in 1971. On 19th June I observed eight specimens, all adult birds in summer plumage, at the mouth of the broad

Narssarssuaq river. They uttered their well-known call notes almost constantly and were continuously flying about, probably catching insects in the air, which were carried upwards by the warm air that day. They sometimes settled on a very low sandy shoal, washed over by the waves, and here up to six birds commonly carried out bathing with much splashing. Subsequently, the gulls were resting on a small ice-floe, just as it can be seen during the winter in Europe. They were scared up from this place by two *Larus hyperboreus* passing by in the air and making a turn towards the smaller gulls. On the other hand, a *Stercorarius parasiticus*, passing the Black-headed Gulls, was attacked by four or five of the gulls and slowly cleared out. The gulls remained here the whole day and did not show any disposition to breed.

On 21st June I studied the southern part of the coast at Narssarssuaq and observed a flock of 15 Black-headed Gulls which swarmed over Tunugliarfik, about 300–500 m from the coast (Fig. 11). They were all adult birds in summer plumage and were constantly uttering their call notes. These gulls observed at the fjord no doubt constituted the main bulk of the breeding colony of Tasiussaq, which, as said above, was driven away by the ice and now probably awaited an amelioration of the climate. I did not follow, personally, what happened later in the summer, but LARS MOTZFELDT, during a visit to Copenhagen in the autumn of 1972, informed me that the Black-headed Gulls returned to the breeding place at Tasiussaq at the end of June when the ice gradually disappeared from the bay, and they then succeeded in breeding. A small colony was breeding on the same island in 1972, according to information from HANSÊRAQ FREDERIKSEN. Also in 1973 the Black-headed Gull was observed in these areas, according to POUL HALD-MORTENSEN. On 28th June 1973 he observed three to four specimens on Tunugdliarfik near Narssarssuaq. He also observed some Black-headed Gulls slightly further north, as mentioned already in the note AB on p. 46. Even in 1974 and 1975 the Black-headed Gulls returned to Tasiussaq. Mr. JOHANNES FREDERIKSEN, draughtman and keen ornithologist, informs me (*in litt.*) that he observed two specimens of the Black-headed Gull, probably a pair, on the 1st August 1974 at Tasiussaq. An adult specimen was, further, observed on the 15th August 1975 at Tasiussaq by VIGGO ASMUSSEN, teacher in the school of nearby Qagsiarssuk.

I spent the days 22nd–24th June 1971 at Qanisartût at Igaliko Fjord. This is a sheep-farm owned by HENNING LUND whose son, studying in Copenhagen, had previously told me about some peculiar small gulls with black heads breeding at Qanisartût in 1969 and observed also in 1970. In 1969 a single pair bred on a small island in the big lake Tasersuaq, about 13 km long, situated just south of Qanisartût (Fig. 11). In 1970 about 12 birds were observed in the last days of April, but in this period the lake was covered with ice, and the gulls, therefore, roamed

Fig. 12. The lake Taserssuaq, near Qanisartût, Igaliko Fjord, with the island on which the Black-headed Gull, *Larus ridibundus*, was breeding in 1971. (Phot. 24th June 1971 by F. Salomonsen).

around and several times were also observed by the inhabitants of Søndre Igaliko, about 20 km further north in the fjord. In the beginning of May when the ice on the lake began to thaw, the gulls were present at the lake constantly and remained here for about a month before they left. They did not breed here this year.

These gulls turned out to be Black-headed Gulls. When I visited Qanisartût in 1971, a single pair was breeding on a small island in Taserssuaq, just as in 1969. I visited the breeding place on 24th June. The island was longish and only about 50 m long (Fig. 12). At some distance we could see one of the birds sitting on the nest, which was situated on the south coast of the island, while the other bird was floating on the water just in front of the nest. When we approached the two birds rose, uttering the well-known alarm cry in the air. The nest was situated on the stony coast at an altitude of about 2 m and contained two newly hatched young and one egg, ready to hatch, already with a small opening made by the bill of the young (Fig. 13). The nest, placed under a bush of birch, was amazingly small and rather poorly built, consisting of a few straws and thin twigs. It was almost hidden in the vegetation which around the nesting site consisted of *Juniperus communis*, *Alchemilla alpina*, *Polygonum viviparum*, and *Potentilla crantzii*.

The island was densely overgrown with high bushes of *Betula pubescens*, *Sorbus groenlandica*, and *Salix glauca*, and with a profuse herbaceous growth of *Thalictrum alpinum*, *Potentilla crantzii*, *Chamanerion angustifolium*, *Taraxacum sp.*, *Silene acaulis*, *Polygonum viviparum*, *Alchemilla alpina*, *Bartsia alpina*, *Draba incana*, *Veronica fruticans*, and *Hieracium alpinum*, with scattered trailing specimens of *Juniperus communis*.

It was noteworthy that four nests of *Mergus serrator* were found on the island, all placed along the south coast, where the snow melts earlier than on the other coasts and where the radiation of the sun is the strongest. All the nests were built among the boulders, densely covered above by bushes of birch. Two of these nests were old ones from the preceding year, the third was newly built but without eggs, while the brooding female was startled and flew away from the fourth nest, which contained four eggs.

The Black-headed Gull was breeding extraordinarily late both at Tasiussaq and at Qanisartût. At the latter place the young were newborn at my visit on 24th June, which implies that egg-laying must have taken place about the 1st June. In Scandinavia the time for egg-laying varies from mid April to mid May. Another interesting point is the fact that at Qanisartût the Black-headed Gull was not breeding colonially, but solitarily, just as it does in Finmarken in Norway (cf. p. 32).

I am somewhat in doubt whether the single pair of Black-headed Gull succeeded in rearing the young. Some hundred metres from the island a pair of *Larus marinus* was breeding on a small cliff in the lake and had large young during my visit. These predators may very well have succeeded in finding and robbing the young of the Black-headed Gull, although the nest site was very well hidden below a dense birch.

In 1972 no Black-headed Gulls were breeding at Qanisartût, according to information by HENNING LUND. However, in 1973 during a visit to Qanisartût on the 22nd July POUL HALD-MORTENSEN found four nests of the Black-headed Gull, evidently used in the summer of 1973, but now abandoned. The nests were placed on the same island in Tasersuaq on which the Black-headed Gull bred in 1969 and 1971. Mr. H. C. PETERSEN, former headmaster of Knud Rasmussen's Highschool in Holsteinsborg, told me on the 10th July 1978 that the Black-headed Gull in the latest years had begun to spread to other localities in the vicinity of Qanisartût, according to information he had recently received from HENNING LUND. Furthermore, in 1978 a pair of the Black-headed Gull was breeding on one of the islands in the Qagssissagdlit group, about 18 km south of Godthåb. The nest was placed in a colony of the Arctic Tern and in the beginning of July contained two young. The birds were observed and the nest found by STEFFEN MØLLER, Godthåb, according to information by ERIK HANSEN, Godthåb.

Fig. 13. The clutch of the Black-headed Gull, *Larus ridibundus*, with one egg and two newly hatched young, on the island in Taserssuaq, Igaliko Fjord; cf. Fig. 12. (Phot. 24th June 1971 by F. SALOMONSEN).

During my trip in Julianehåb District in 1971 a great many people could inform me about the Black-headed Gull, and a name for this spectacular bird in the Greenland language was by most people regarded as a necessity or a practical convenience. All agreed on the name *nasalik*, meaning "the hooded one," which, therefore, is introduced here. The designation *naujat ilât* has been proposed formerly in a Danish-Greenland vocabulary (BUGGE *et al.*, 1960, p. 237), but it is an artificial desk name, quite unknown to the inhabitants.

As in the case of the Fulmar, The Ornithological Comittee of Greenland has asked the Greenland Parliament to issue a legal protection for the Black-headed Gull in Julianehåb District in order to facilitate its colonization and spread in southern Greenland. In the new Greenland game-act, which came into force the 1st January 1978, the Black-headed Gull is fully protected.

Turdus iliacus coburni Sharpe

The Redwig belongs to the Siberian faunal type, breeding in Europe from Iceland and the Faroe Islands, rarely Scotland, and Scandinavia and northern Russia south to Poland and eastern Germany, exceptionally westwards to eastern France as a boreomontane element, further eastwards through northern Siberia to Lena and Kolyma Rivers, south to Lake Baikal. It is usually migratory, wintering in Central and Southern Europe and eastwards to Iran and Turkestan. There are two geographical subspecies, both of which have been met with in Greenland. The form *T. i. coburni* Sharpe breeds in Iceland and irregularly in the Faroe Islands, and the nominate *T. i. iliacus* Linneaeus in the remaining range. *T. i. coburni* is darker and warmer brown on the upper-parts than the nominate *iliacus*, and has darker and larger spots on the under-parts and darker red on the flanks. It is also much larger, the wing-length of the two forms measuring, according to SALOMONSEN (1935, p. 151):

Ti. i. iliacus: 14 ♂♂ 115–121 mm, 27 ♀♀ 112–120 mm (Scandinavian specimens)

T. i. coburni: 23 ♂♂ 120–131 mm, 13 ♀♀ 119–126 mm (Iceland specimens)

The Greenland records of the Redwing have been enumerated by HØRRING and SALOMONSEN (1941, p. 71 and p. 83). Of the two forms *T. i. coburni* is by far the commoner. It appears to be an irregular passage and winter visitor, most often encountered in October, but sometimes also in January-February or in the spring. A total of 12 records of *coburni* are mentioned, the greater part from Julianehåb and Nanortalik Districts in the southernmost part of the West Coast, but there is one record from Frederikshåb District, slightly farther to the north, and three from Angmagssalik in S. E. Greenland. The Redwing's occurrence in Greenland is restricted to the periods of climatic amelioration. There are two records from 1845, which year was situated in a mild period, the remaining records are from the period 1904–1934.

Only one record is known of a nominate *iliacus*, an immature specimen from Scoresby Sound City, obtained on 6th October 1934. However, a specimen obtained on 25th January 1926 at Nûk near Augpilatoq in the southern Nanortalik District, not far from Cape Farewell, also belongs to *T. i. iliacus*. It was included among the *coburni* by HØRRING & SALOMONSEN (1941, p. 72), but not examined personally by them. However, I have more recently examined the specimen which belongs to the OLDENDOW collection in the seminary of Godthåb. It was an adult male with the typical pale colouration of nominate *iliacus*, and it had a wing-length of only 118 mm.

More recently some Redwings have been observed on the British weather-ships, stationed in Greenland waters, no doubt specimens of the Iceland form *coburni*, migrating to Greenland. On the weather-ship "Weather Observer" placed at the station "Alpha" in the Denmark Strait (62°N, 33°W), two birds came aboard in the morning of 15th April 1959 and disappeared the same afternoon (McLean & Williamson 1960, p. 70). Also at the locality "Alpha" a Redwing came aboard on 24th April 1962 and disappeared on 28th April, and another bird was observed on 30th April (Rogers & Williamson 1963, p. 229). Further, three Redwings were observed on "Alpha" on the 3rd May 1967, and one of them stayed on the ship until 6th May (Tuck 1968, p. 16). One specimen was observed on 23rd April 1958 somewhere in the Denmark Strait, and one on 1st April 1959 in the Denmark Strait at 71°47'N, 11°17'W during Norwegian expeditions (Berland 1961, p. 17). All these spring migrants must have come from Iceland or from Norway, but no racial distinction was made in any of these instances.

A number of Redwings have reached Greenland in recent years. A total of five specimens have been sent to the Zoological Museum in Copenhagen, but none of them have been sexed. The wing-lengths of these specimens are 118, 119, 121, 121 and 125 mm, which shows that they are rather large birds, notwithstanding the sex, and that they undoubtedly belong to the Iceland form *coburni;* cf. measurements given above, p. 54. Of these five specimens three have a fresh and usuable plumage, which is dark, typical of *coburni.* The two remaining specimens are mummified and somewhat discoloured, but the dark and large spots on the under-parts are distinct, and these specimens, likewise, must belong to *coburni.*

The following details can be given about the five Greenland specimens:

(1) A specimen was found dead near Qagssiarssuk outpost, Julianehåb District, the 12th January 1943 and by J. Troelsen presented to the Zoological Museum. The bird was mummified, but the plumage not discoloured, unsexed; wing-length 118 mm.

(2) A specimen was collected near Narssaq City, Julianehåb District, in 1947 and presented to the Zoological Museum by Kristen Poulsen, catechist in Narssaq. The bird was mummified, unsexed, somewhat discoloured; wing-length 119 mm.

(3) During my stay in Narssaq, Julianehåb District, in 1949 a Redwign was delievered to me by the catechist Kristen Poulsen, who told me that the bird was found dead in the latter part of April 1949 near Narssaq by Karoline Onisimussen. The bird was mummified, unsexed, discoloured; wing-length 121 mm.

(4) A specimen was shot at Narssaq outpost (nov abandoned), Godthåb District, on the 2nd November 1952. The bird was sent to the seminary of Godthåb, where it was skinned by JULIUS OLSEN. During my sojourn in Godthåb in 1954 I received the skin for the Zoological Museum in exchange for other birds. The wing-length of the unsexed specimen is 125 mm.

(5) Mr. BØRGE JØRGENSEN, Fiskenæsset outpost in Godthåb District, on the 3rd January 1956 caught a very exhausted specimen at the outpost and kept it for some time in a cage. It died after some weeks and was sent to the Zoological Museum in Copenhagen in the summer of 1956. It was mummified, discoloured, unsexed; wing-length 121 mm.

To these specimens, obtained in Greenland in 1943–1956 and sent to the Zoological Museum in Copenhagen, should be added a number of observations of the Redwing from more recent years, namely-from the period of 1973–1977. The following details can be given about these records:

(6) A specimen of the Redwing was observed on the 22nd–26the December 1973 at Sydprøven outpost, Nanortalik District, by STEFAN PIHL, teacher in Sydprøven (PIHL 1976, p. 105).

(7) STIG JÜRGENSEN, superintendent in Angmagssalik, in S. E. Greenland, has informed me (*in litt.*) that he has observed the Redwing as an älmost regular visitor in recent years. He has seen the following birds; all observations have been made in Angmagssalik proper:

13th November 1974, one Redwing. He states that its plumage was very dark (*coburni*?).
22nd April 1975, one Redwing, which was singing.
26th April 1976, one Redwing,
26th November 1976, three Redwings. A couple of days previously a number of Fieldfares were observed, but Mr. JÜRGENSEN expressly states that the three specimens from the 26th November were Redwings.
20th May 1977, one Redwing.
20th October 1977, two Redwings.

(8) POUL BJERGE, Uperniviarssuk, Julianehåb District, informs me (*in litt.*) that on the 28th October 1977 a specimen of Redwing was found dead near his house at Uperniviarssuk. He sent me several photographs of the bird and it was therefore easy to identify it.

(9) DAVID BOERTMANN, leader of an ornithological excursion in Greenland in the summer of 1975, reports that participants in the excursion "probably" heard a specimen of the Redwing on the 21st July 1975 near Holsteinsborg Church, situated in the centre of the city. This record appears to be dubious (ANON. 1975). However, he heard and saw a Redwing in Bredefjord, Julianehåb District 22nd June 1972 (BOERTMANN 1979, p. 175).

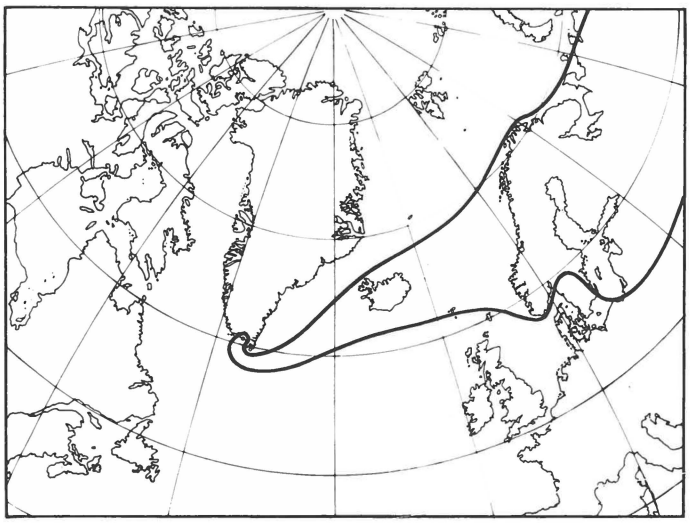


Fig. 14. The present distribution of the Redwing, *Turdus iliacus*, in the European and North Atlantic area.

It should finally be mentioned that the Redwing (of the nominate form) in October-November 1976 invaded Greenland in large numbers, but further particulars are at present not yet known, and the subject will therefore be dealt with elsewhere at a future date. However, as enumerated above, three specimens of Redwing were observed in October-November 1976 in Angmagssalik, and they are probably to be regarded as offshoots of the invasion.

It is noteworthy that in the last years the Redwing has increased its breeding area in Europe and has moved more to the west and south. In Sweden the southern limit of its breeding area formerly was about Värmland-Dalarna-Hälsingland, but from the period 1943–1947 it began an expansion to the south, increasing in the 1950's (Salomonsen 1963, p. 324), and is now more or less wide-spread in the southern parts of the country. It has even spread westwards across the Øresund and was found breeding in 1967 and 1968 on the island of Zealand in Denmark (Dybbro & Kruse 1968, p. 149; Dybbro 1970, p. 90). In Great Britain it was previously unknown as a breeding bird, or was breeding only exceptionally, but since 1953 it has probably nested every year in Scotland; in 1968 no less than 25 pairs were known to nest (Snow 1971, p. 223).

In about the same period the Redwing has immigrated to Greenland where it is extremely rare, however, and only a few times has been found breeding in the subarctic area (Fig. 14). I have, personally, never met with the species in Greenland.

Of the five specimens collected in Greenland in 1943–1956, mentioned above (p. 55), three were obtained in the subarctic part of West Green-

land, at the shores of Tunugdliarfik, *i.e.* at Narssaq or at Qagssiarssuk, in the same area in which the Fieldfare is known to breed. In 1949 when I investigated. Julianehåb District KRISTEN POULSEN told me that the Redwing was "very common" in the hinterland of Narssaq, in the inner parts of the country surrounding Tunugdliarfik, and was well-known by the inhabitants of Qagssiarssuk, who had seen it for about a dozen years. It had received the name *narssarmiutarssuaq*, while the Fieldfare was called *orpingmiutarssuaq*. I was sceptical of these remarks, and since my investigations in Julianehåb District in 1949 had convinced me that the inhabitants knew only of the Fieldfare, which I observed myself rather frequently, I felt sure that POULSEN and his informants had somehow mixed up the two species of thrushes.

However, in the previous year the Redwing was definitely identified as breeding in Greenland by the biologist Dr. CHRISTIAN VIBE, who is very well acquainted with Greenland and European birds. During a ride from Søndre Igaliko to the country north of the Amitsuarssuk branch of the Lichtenau Fjord, on the 18th July 1948 he observed a Redwing several times. It was flying with insects or worms in its bill, a certain proof that it was feeding nestlings. The locality was about 60°52′N, 45°05′W. When VIBE in various publications (VIBE 1950, p. 201; 1970, p. 391) maintains that the Redwing breeds in Greenland it is based on this single observation.

A Danish ornithologist, BENNY GÉNSBØL, observed a pair of Redwing breeding at Narssarssuaq airfield in the summer of 1967. "The birds arrived at the breeding place at Narssarssuaq in the beginning of June and were feeding young in early August. Such a late arrival is probably not normal. April or early May should have been expected according to the habits of the Redwing in Iceland"[1] (GÉNSBØL 1969, p. 181). Even the birds observed by VIBE in 1948 were feeding young almost as late in the summer as GÉNSBØL's birds.

This meager information is all we know about the breeding of the Redwing in Greenland. There is, however, no doubt about the fact that a small number of Redwings breed in the subarctic birch forests of S. W. Greenland. Like that of the Fieldfare this population constitutes an off-shoot of the European taiga fauna (Fig. 14), but while the Fieldfare immigrated from Scandinavia, the Redwing probably came from Iceland. The Redwing may have been an irregular breeding bird in Greenland for some years. However, if there was a regular, although very small, breeding population, it was undoubtedly almost totally wiped out during the cold and snowy winter 1966–67 (cf. p. 15). The fact that it was eound breeding in 1967 shows that the breeding population was not entirely eliminated.

[1]) Original Danish; translated by me.

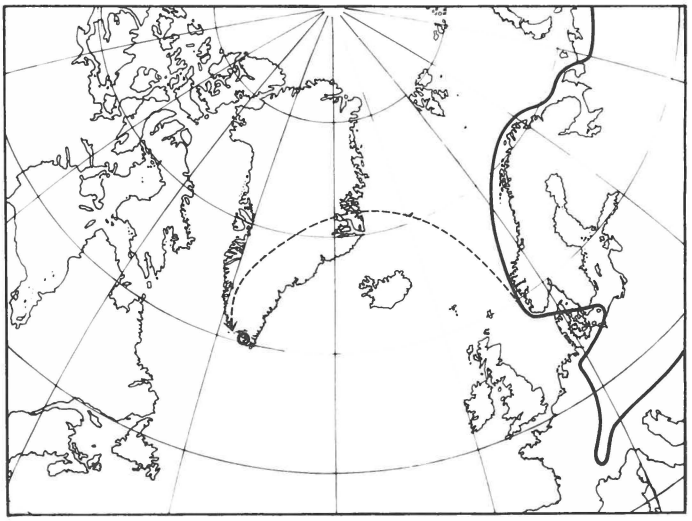


Fig. 15. The present distribution of the Fieldfare, *Turdus pilaris*, in the European and North Atlantic area. The broken line (with arrow-head) indicates the immigration route of the European population to Greenland in 1937.

Turdus pilaris Linnaeus

The Fieldfare, like the Redwing, belongs to the Siberian faunal type. Its breeding area extends from Scandinavia and Russia eastwards through Siberia to the rivers Lena and Aldan, southward in Europe to Germany, Hungary and eastern France, where in many places it is a boreomontane breeding bird, and southward in the Soviet Republic to the Ukraine, Altai and Western Transbaikalia. It is usually migratory, wintering south to the Mediterranean Sea, and to Iran and Turkestan.

The Fieldfare has extended its breeding range in Europe in recent years during the present period of climatic amelioration. It has expanded to a much greater extent than the Redwing and has spread in southern Sweden since about 1920, has invaded Denmark about 1960 and has even bred a few times on the islands north of Scotland since 1967. At the same time it has expanded in a southwestern direction, to Western Germany, Switzerland (since 1923), eastern France (since 1955), Hungary, Italy (since 1967), Romania (since 1966), and Belgium (since 1967) (Yeatman 1971, p. 268).

The range espansion was even extended to Greenland, and it aroused much interest when it appeared that the Fieldfare in 1937 had spread to the southwestern part of the country and that in the following years it became a well-established breeding bird in the subarctic areas of Julianehåb District. The Fieldfare is thus another instance of a European bird which has expanded to Greenland. I have described this expansion

in detail (SALOMONSEN 1951, p. 515) and shall not repeat it here. I wish only to stress the point that the Fieldfare in Greenland has arrived from Scandinavia (Fig. 15) while the Fulmar, Black-headed Gull and the Redwing obviously all are of Icelandic origin. The Fieldfare is resident in southern Greenland, contrary to its ordinary behaviour in the Old World where it is usually migratory.

Without being a resident in Greenland it would no doubt have been impossible for the Fieldfare, as a newcomer, to establish itself permanently there. If it had tried to migrate, after the first successful breeding-year so far from its normal distributional area, the entire population would no doubt have perished. A certain number have probably started migration and have succumbed in the sea. In this way selection has formed a population in which the urge for migration has been lost or at least has been considerably inhibited (SALOMONSEN 1951, p. 524). Therefore, the Fieldfare in its Greenland period (since 1937) has been observed in North America only as a rare exception, while before this period it never had been recorded from North America. There is a record from Foxe Basin as early as 1939 (SALOMONSEN 1951, p. 517), from Ottawa in 1967, from Delaware in 1969, from New York on the 3rd February 1973 and from St. John's, Newfoundland in early January 1973 (THRELFALL *et al.* 1973, p. 311). Finally, Dr. DAVID SERGEANT, member of the International Council for Bird Preservation in Canada, informs me (*in litt.*) that a Fieldfare spent the complete winter, from early January to late March 1976, at Rigaud, Quebec (about 45°30'N lat., 75° W long.). I am quite sure that these winter-visitors to eastern North America must have originated in Greenland.

On the map p. 523 in my paper, mentioned above (SALOMONSEN 1951), I have given the breeding distribution of the Fieldfare in the subarctic part of Southwest Greenland. The map is not quite correct, however, as it appears that the Fieldfare does not breed in the hinterland of Qagssimiut (the westernmost part of the range shown on the map), although it had been observed there by Greenlanders, as mentioned in my paper on p. 524. However, THORKILD LUND, the teacher in Qagssimiut, who knows the Fieldfare very well from Denmark, investigated this part of the country in the summer of 1965 and tells me that he did not find this species at all, and that the few sheep-farmers who have settled there do not know it at all. Only one of these had observed a Fieldfare at Kûgssuánguaq, a locality about 20 km northeast of Qagssimiut. LUND did not find it there himself, although the habitat appeared to be very suitable to the Fieldfare, with dense and high copses of willows covering large areas.

In the period since my 1951-publication of the immigration of the Fieldfare to Greenland I have received much information on the appe-

arance and breeding of this species in Greenland and can also add some notes from my own investigations. It appears thar the Fieldfare gradually increased in number until 1966 and also extended its breeding range much further to the south, *e.g.* to the Qíngua valley at the Tasermiut fjord, where numerous Fieldfares were observed until 1966; cf. below, p. 62. As already mentioned (p. 15), the winter 1966–67 was exceptionally severe, and virtually the entire southern Greenland was covered by a deep layer of snow. This was a catastrophic situation for the Fieldfare, which habitually feeds on insects and larvae in the ground or on berries of the heath plants which in that winter were entirely hidden below the snow. The result was a drastic decline in the number of the Fieldfare, which could not escape the severe conditions by migrating to the more mitigated areas further south as could the Scandinavian and North Russian populations. In the subsequent years the Fieldfare was not observed at all, and it was feared that it was completely wiped out in Greenland. However, we know now that a small population has been left which probably will increase in the following years if a new climatic disaster does not occur.

I can now add the following information to the notes given in my paper published in 1951:

In the bird-collection of the seminary in Godthåb there is a skin of a Fieldfare, ♂, shot near Godthåb the 24th November 1947. I have examined it during a visit to Godthåb some years ago. This specimen might have been a straggler from the population of Julianehåb District, or it might have originated from a breeding place more close to Godthåb. It is of interest in this respect that in conversations with me it has often been maintained that the Fieldfare was breeding in the innermost parts of Ameralik Fjord, not very far south of the Godthåbsfjord. The country in the inner parts of the fjord area, about 80–90 km from the sea coasts, is extensively covered with forests of *Salix glauca* and *Alnus crispa*, of a height of up to 3 m, and with a pleasant dry and continental climate in summer. In 1960, during a visit to Godthåb I was told by KARL HEILMANN that the Fieldfare had bred in many years in the inner parts of Ameralik Fjord. It should be remembered that during the invasion of the Fieldfare to Greenland in January 1937 a number of specimens were shot in the inner parts of Godthåbsfjord (Qôrnoq, Kapisigdlit), and the skins are still kept in the seminary of Godthåb where I have examined them. The Fieldfare was also observed in the Ameralik Fjord, the bottom of which is situated not very far from Kapisigdlit in Godthåbsfjord (cf. SALOMONSEN 1951, p. 517). It is possible that part of the invading flocks have remained in the inner parts of Godthåb District without following the main flock to the south and that they have been able to keep a small breeding population there. As recently as in 1970 members

of the Ornithological Society in Godthåb told me that they had observed the Fieldfare enar Kapisigdlit that summer, and the Danish teacher BØRGE SIBBERN in Godthåb had seen it both at Kapisigdlit and in the Ameralik Fjord. I visited the bottom of Ameralik Fjord in the summer of 1970 and walked around for many hours ln the magnificent forested landscape there, but without hearing or seeing any Fieldfares.

Dr. S. A. HORSTED, from the Greenland fishery research, informed me that he observed a Fieldfare the 23rd August 1966 at the bottom of the Igaliko Fjord, on the southern coast, not far from the hamlet Iterdlak. Mr. BJERG THOMSEN, game consultant, told me that he observed about 20 individuals of the Fieldfare at Narssarssuaq airfield on the 11th July 1966, which were probably several pairs with their fledged young. On the 15th July 1966 he noticed several Fieldfares ln the tall birch forests at the bottom of Tunugdliarfik.

Also GRAVESEN (1973, p. 140) observed about 10–20 Fieldfares in 1966 at Narssarssuaq airfield. On the other hand, J. DYCK (1965, p. 36) who visited Narssarssuaq in 1958 did not see the Fieldfare there at all.

POUL BJERGE, leader of the agricultural research station Upperniviarssuk in Julianehåb District, informed me that before 1966 he had several times observed the Fieldfare at the Qíngua valley sanctuary, Tasermiut fjord, northeast of Nanortalik. In 1966 GRAVESEN (1973, p. 140) observed about 100 birds in the Qíngua valley and also noticed one on the 5th July 1966 at Anivia, on 60°12′N, 44°07′W, not far from Qíngua valley. LARS MOTZFELDT and NIELS PAVIASEN have both told me that the Fieldfare was formerly breeding at a height of about 2 m in the small afforestation of various coniferous trees planted in the inner part of Tunugdliarfik, but that it had now disappeared. I visited this locality (called Qanagssiagssat) on the 17th June 1971, but did not observe or hear the Fieldfare anywhere. However, as recently as September 1979, POUL BJERGE found here a newly deserted nest of the Fieldfare about 2 m up in a Sibirian Larch (*Larix sibirica*) as well as a lost egg and some egg-shells below the tree.

ARNE RASMUSSEN, a teacher in Christianshåb, visited Qanisartût in the Igaliko Fjord in the summer of 1959, and told me that HENNING LUND, the sheepfarmer at this place, showed him 13 nests with eggs or young of the Fieldfare. In 1949 I visited the same place and found six nests (cf. SALOMONSEN 1951, p. 521). I collected a specimen on the 11th June 1949, a ♀ ad. with a wing-length of 141 mm. It is kept as a skin in the Zoological Museum of Copenhagen. The previous year Dr. CHR. VIBE visited Qanisartût and collected an almost fledged nestling on the 20th June 1948. It was a ♀, now kept in the Zoological Museum as a skin.

I revisited Qanisartût in 1971 (cf. my notes on p. 50), and HENNING LUND told me that until 1966 the Fieldfare bred in gradually increasing numbers on a rather steep bluff, about 40 m high and one km long,

Fig. 16. Qanisartût with southfacing bluff, former breeding-place of the Fieldfare, *Turdus pilaris*. (Phot. 24th June 1971 by F. SALOMONSEN).

situated just behind his house and facing due south (Fig. 16). Owing to the southern exposure the cliffs become snowfree rather early in spring and are, therefore, suitable as breeding places for the Fieldfare. The great number of sheep have destroyed all bushes of birch and willow on the cliffs, and the Fieldfare, therefore, were placing their nests on ledges or in recesses on the ground, as they are known to do in other, similar places in Greenland (cf. SALOMONSEN 1951, p. 522 and fig. 3). In 1966 no less than 50 pairs of Fieldfare were breeding here. That summer was followed by the disastrous snowy winter of 1966–67, in which the local Fieldfare population was entirely eliminated. In the following summer not a single Fieldfare was seen, and it has never turned up again.

During my sojourn at Qanisartût I investigated the southfacing cliff behind the sheep-farm (Fig. 16). The upper part was a rolling hill which on the south side continued downwards in a perpendicular wall, ending with a broad scree below. This scree, partly consisting of rough boulders, partly of gently sloping fertile soil, was covered with a profuse carpet of flowering plants with the yellow flowers of *Ranunculus acris* and

Taraxacum sp. particularly dominant. The flowering plants were mixed with taller bushes and formed a typical herb-mat, probably well-watered during spring when the snow melted. The forage conditions for the Fieldfare was, undoubtedly, excellent in this fertile habitat. The following species constituted the most common plants:

Salix glauca	*Viola canina*
Betula pubescens	*Erigeron uniflorus*
Cerastium alpinum	– *borealis*
– *fontanum*	*Thymus drucei*
Angelica archangelica	*Rumex acetosella*
Hieracium alpinum	*Viscaria alpina*[1]
Draba aurea	*Taraxacum sp.*
– *incana*	*Chamaenerion angustifolium*
Sedum rosea	*Campanula gieseckiana*
– *annuum*	*Veronica fruticans*
Alchemilla vulgaris	*Stellaria media*[2]
Ranunculus acris	*Botrychium lunaria*
Euphrasia frigida	*Woodsia ilvensis*

In the years following the catastrophic winter of 1966–67 a particular interest was attached to observations of Fieldfare, as it appeared to be very rare now and was said by many to be quite eliminated in Greenland. The following observations prove that this was not the case.

MELTOFTE (1975, p. 53) reports that a Fieldfare spent the period from the 3rd to the 15th of October 1970 at the weather station Danmarkshavn, in Germanialand, N. E. Greenland. It was feeding on blubber from a seal carcass on a meat rack at the station and survived two snow storms in this perlod. Probably it was a migrant from somewhere in northern Europe and via Iceland gone astray to N. E. Greenland, rather than an individual set out from southwestern Greenland.

POUL BJERGE observed a Fieldfare near the Uperniviarssuk station, Julianehåb District, on the 23rd March 1970. It stayed at this locality for a number of hours, then disappeared.

AAGE BARSTED, station leader of Narssarssuaq airfield, had found the Fieldfare breeding near his house at Narssarssuaq in 1970 and 1971. In 1970 he found its nest in a low bush of birch on the forest-covered slope just south of the airfield, and it probably also nested there in 1971. At any rate, the bird constantly appeared on his lawn where it collected food for its young. He had seen the birds a few days before my arrival

[1]) About 200 specimens observed, among which there was not a single var. *albiflora*.

[2]) This species is not native to Greenland, but has been introduced from Denmark. It was particularly common and widespread around the houses of the farm. It is especially interesting that it is growing in many sea-bird colonies (PEDERSEN, 1972, p. 13).

in Narssarssuaq at the end of June 1971. I did not succeed in seeing the birds which at that time had no doubt left the place with their fledged young.

FRANKLIN HØEGH OLSEN, Qagssiarssuk, in the summer of 1970 found a nest with eggs of the Fieldfare situated in a birch, at a height of about 2 m, not far from the conifer plantations in the inner parts of Tunugdliarfik.

NIELS HENRIK LYNGE on a visit to HANSÊRAQ FREDERIKSEN at Tasiussaq, at Nordre Sermilik, Julianehåb District (cf. p. 47), observed a Fieldfare on the 1st August 1970. He further adds that various inhabitants of the Tunugdliarfik area told him that a few Fieldfares were still left in the inner parts of the Fjord.

On the 15th June 1971 I visited Tasiussaq (cf. p. 47) and found two pairs of the Fieldfare breeding not far from the farm belonging to HANSÊRAQ's son ENOQAQ. He told me that after the cold winter of 1966–67 the Fieldfare was considerably reduced in number, but was not quite eliminated, and that in the subsequent years it had gradually increased again. We found the Fieldfares frequenting a south-exposed slope, which was densely overgrown with tall willow copse and looking very similar to the slope described above (p. 63) at Qanisartût. Beneath a perpendicular cliff wall almost void of vegetation there was a high and broad zone of debris consisting of enormous boulders, 4–5 m high, with an almost impenetrable growth of *Salix glauca* interspersed and mixed with a profuse vegetation of herbaceous plants. This herb-mat consisted mainly of *Ranunculus acris*, *Taraxacum sp.*, *Thalictrum alpinum* and *Rumex acetosella*, *i.e.* essentially like the vegetation of the scree at Qanisartût (p. 63). The Fieldfares anxiously flew around at some distance from us, settling on the large boulders (not in the willows), constantly uttering the snarling or chattering alarm cry, and we were quite sure that they were nesting somewhere in the vicinity. We succeeded in finding one nest, which was placed directly on the cliff, on a small ledge in the steep cliff wall, about 2 m above the scree. The nest was of the usual type, built of rootlets and twigs, and contained five eggs. The brooding bird settled on the nest when we had withdrawn only about 30–40 m from the nest, which implies that the eggs were nearly rady to hatch.

The Fieldfare was observed again in 1972 at Tasiussaq, according to information from LARS MOTZFELDT, who also tells me that various Danish workmen at Narssarssuaq airfield had observed the Fieldfare in 1972. Also Dr. LORENZ FERDINAND, who made ornithological observations in South Greenland in 1972, informs me that he found three pairs of Fieldfare at Narssarssuaq, and, further observed a pair in the inner parts (the Qíngua) of Tunugdliarfik; cf. also BOERTMANN 1979, p. 175.

Mrs. KRISTINE LOUISE EGEDE, working at the Transit Hotel at Narssarssuaq airfield, informs me (*in litt.*) that she in 1975 found the Fieldfare breeding on a mountain scarp near the hospital of Narssarssuaq. She removed the nest when the young had left it and kept it for some time. KNUD J. KROGH, keeper at the National Museum in Copenhagen, tells me that he during a visit to Narssarssuaq in the summer 1976 observed a Fieldfare in the vicinity of the airfield.

It should, finally, be mentioned that STIG JÜRGENSEN, superintendent in Angmagssalik, S. E. Greenland, reports (*in litt.*) that three specimens of Fieldfare stayed in Angmagssalik in the period 7th–17th November 1976. These specimens were probably remnants of the large influx of Redwings in Greenland in October-November 1976 (cf. above, p. 57), for both Redwings and Fieldfares shared in this invasion.

Haliaetus albicilla groenlandicus Brehm

The White-tailed Eagle belongs to the Palearctic faunal type and is widely distributed in the Old World, from Southern Greenland, Iceland, Scandinavia, East Germany and the northern Balkan Peninsula eastwards through Russia, Asia Minor and Siberia to northern China. It breeds mainly in the temperate and subtropical climatic regions, but in many places in northern Russia and Siberia it crosses the boundary to the lowarctic zone, and something similar is the fact even in southern Greenland. It has declined in number everywhere, owing to human persecution, use of pesticides and to other reasons, and is totally eliminated in large parts of Western Europe, including the British Isles, France, Denmark, and the Faroe Islands, but is still to be found in Iceland, where at most a dozen pairs breed. The distribution in the European and North Atlantic area is shown in Fig. 17. The White-tailed Eagle is sedentary, but the young birds, one or two years old, habitually move somewhat to the south during winter.

Like the subarctic birds in Greenland discussed above the White-tailed Eagle is an Old World species, which undoubtedly from Iceland has colonized southwestern Greenland, as to be seen in Fig. 17. Contrary to the other subarctic species it is an ancient immigrant in Greenland, and has always been known to inhabit the country, It must have occupied Greenland in prehistoric time, probably in the hypsithermal interval, between 6,000 and 4,000 years ago.[1] At any rate, the White-tailed Eagle is the only subarctic species in Greenland which has developed an indigenous subspecies adapted to the local conditions and isolated from the other populations of the species which all belong to the nominate form.

[1]) According to FREDSKILD *et al.* (1975, p. 7) the warmest phase in Greenland was the period 5300–2200 B.P., but FUNDER (1978, p. 177) holds it to be 7000–5000 years B.P.

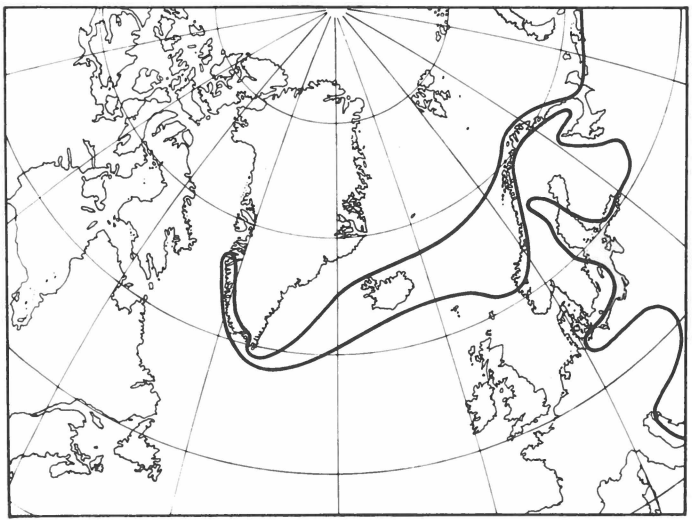


Fig. 17. The present distribution of the White-tailed Eagle, *Haliaetus albicilla*, in the European and North Atlantic area.

The Greenland subspecies, *H. a. groenlandicus*, is a perfectly valid form, a fact which I have emphasized in a number of publications, *e.g.* SALOMONSEN 1950, p. 420–421. Nevertheless, this form was usually not been accepted by other students. VAURIE (1965, p. 156) says about *groenlandicus* that its measurements "average somewhat larger than in the population of Eurasia, its wing length measuring 640–675 (655) in eight males and 650–715 (690) in twelve females, as against 605–660 (635) in nine males and 665–705 (685) in nine females from Sweden." On account of this very slight difference between the Greenland and Eurasian populations VAURIE synonymized *groenlandicus* with nominate *albicilla*. VAURIE is correct in as much as he states that the difference in wing-length between the two populations is too slight to base a subspecific distinction upon it, but no one has claimed this to be the case. To be sure, *groenlandicus* is a bigger and more powerful bird than nominate *albicilla*, more robust and strong in its structure, but with comparatively short wings, probably a result of Allen's rule. Undoubtedly, *groenlandicus* has a greater weight than *albicilla*, but no weights of the Greenland form are available. The greater proportions are primarily manifested by the much bigger sternal length (Fig. 18) and pelvic breadth, which give a measure of the size and extent of the wing and leg muscles. Even the tarsus and foot are longer and more strongly built than in *albicilla*, probably an adaptation favouring more firm and successful grasping of the prey, which is important for the natural selection in a country where prey is scarce, especially in winter. In my paper, mentioned above (SALOMONSEN 1950, p. 421) I made the following summarizing

remarks on the differences between *groenlandicus* and nominate *albicilla:* "The differences in bill-length, tarsus and particularly in the length of the breast-bone are very pronounced, while there is a considerable overlapping in the measurements of the wing. Also the eggs of the Greenland form are larger. In addition, the juvenile and immature plumages are generally of a darker and warmer brown hue than in the typical birds, but some are indistinguishable."

I wish to add some of the measurements given in my paper, quoted above, in order to show the considerable differences between the two forms:

Length of breast-bone (mm)[1]:			
groenlandicus.....	6 ♂♂	149–153	(151.0)
	5 ♀♀	162–168	(164.4)
albicilla	19 ♂♂	132–148	(139.7)
	16 ♀♀	135–156, one 166	(148.5)

The subspecific difference in the size of the breast-bone is shown in Fig. 18.

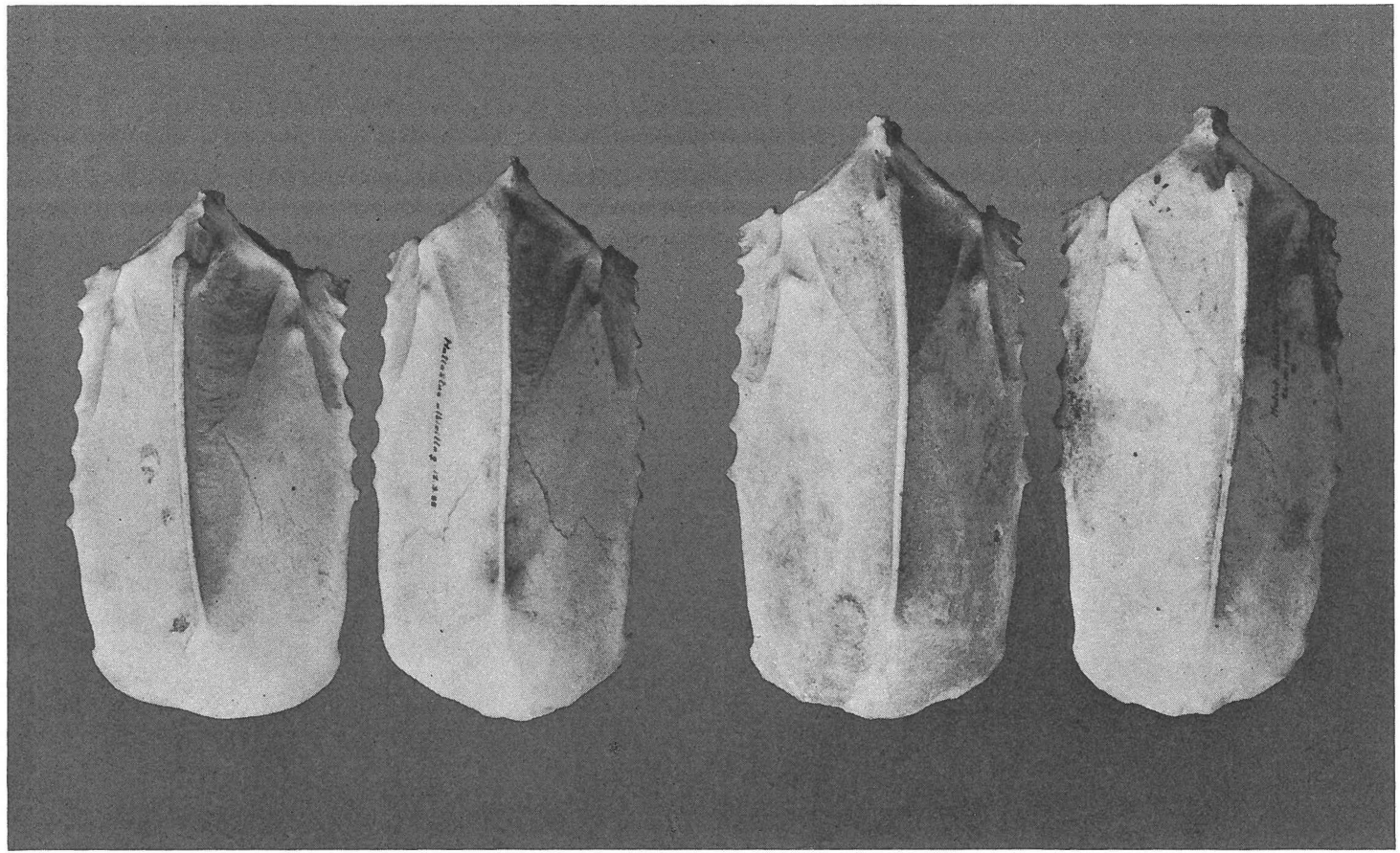
Length of tarsus (mm):			
groenlandicus.....	22 ♂♂	100–105	(101.9)
	18 ♀♀	99–107	(104.0)
albicilla	5 ♂♂	93–96	(94.8)
	4 ♀♀	93–99	(96.2)
Mean length of eggs (mm):			
groenlandicus.....	29 eggs: 75.3×58.3		
albicilla	21 eggs: 74.5×56.9		

I can add the pelvic measurements, not given in my paper:

Greatest length of pelvis (mm):			
groenlandicus.....	6 ♂♂	59–63	(60.4)
	5 ♀♀	63–66	(64.4)
albicilla	19 ♂♂	51–58	(55.0)
	16 ♀♀	53–63	(59.0)

HARTERT (1912–21, p. 1178) gives some measurements of eggs which are of interest: Mean of 23 eggs of *groenlandicus* 78.02×59.27 mm, and of 90 eggs of *albicilla* from Europe 73.38×57.60 mm. He adds that 12 eggs from Asia Minor measure on an average 71.80×56.26 mm, *i.e.* they are still smaller than the European ones. This agrees with the assumption recently put forward by GLUTZ VON BLOTZHEIM *et al.* (1971, p. 169) that the populations of the White-tailed Eagle form a cline for increasing measurements running from S. E. to N. W., the Asia Minor

[1]) The figures in brackets are the average measurements.



a b c d

Fig. 18. Breast-bones of two subspecies of the White-tailed Eagle, *Haliaetus albicilla*, to show difference in length. Left (a,b) *H. a. albicilla*, right (c,d) *H. a. groenlandicus*. All four specimens are females.

a: Sweden, November 1898. Length: 142.1 mm
b: Vallø, Denmark, 17th March 1888. Length: 150.8 mm
c: Nanortalik, July 1913. Length: 161.9 mm
d: Agto, Egedesminde District. October 1912. Length: 164.1 mm

The material belongs to the Zoological Museum in Copenhagen. (Phot. Zool. Mus. Copenhagen).

population and the Greenland one forming the two end links. GLUTZ VON BLOTZHEIM gives the following mean measurements of the wing length in males (in mm): Asia Minor 609, Central Europe 617, Scandinavia 635, Greenland 643. This cline includes also the bill length and egg measurements. On account of the existence of this cline GLUTZ VON BLOTZHEIM does not accept the subspecies *groenlandicus*. I do not agree with this conclusion. As said above, the differences in wing length between the Greenland and European populations are only average values, and there is a great deal of overlapping. The differences in the skeletal measurements are considerable, however, and show that *groenlandicus* is a much more powerful and sturdy bird. Moreover, the Greenland population is isolated from the remaining populations, and gene flow between them is quite out of the question. Therefore, the morphological characters of *groenlandicus* are more pronounced than those of the other populations, most of which are part of the very large, almost unbroken continental continuum. The Wheatear (*Oenanthe oenanthe*) forms a similar case. The Greenland form (*leucorrhoa*) is much larger than the remaining Eurasian populations and is accepted by all students as a well-marked subspecies, in spite of the fact that the differences between it and the nominate form are bridged by the North Atlantic populations, inhabiting Iceland and the Faroe Islands, and sometimes separated as an intermediate subspecies, *schioleri*. The Wheatear populations form a cline from Greenland to Europe, but nevertheless *leucorrhoa* is not rejected.

It is possible that the other end link of the cline in the White-tailed Eagle, the populations inhabiting S. E. Europe, is also separable, if the differences between them and the northern ones are sufficiently large and clear-cut. A name is available for this potential form, namely *funereus* Brehm, with type-locality Egypt. Two adult specimens from Turkey (Maslak near Istanbul, 11th September 1934) in the Zoological Museum of Copenhagen have wings measuring only ♂ 590 and ♀ 613 mm, and very small feet (tarsus cannot be measured). The claw of the middle toe measures ♂ 33, ♀ 35, compared with ♂ 38, ♀ 40 mm in *groenlandicus*.

It is peculiar that this size variation is present in so large a bird as the White-tailed Eagle, as Bergmann's rule does not hold true for the larger species of homeotherms. The variation is probably unconnected with the physiologically necessary reduction of heat loss (cf. SALOMONSEN 1972, p. 45–49) or of evaporation due to the "aridity effect" (cf. JAMES 1970, p. 388) in small species. I find it more likely that the size increase of this southern predator in northern areas is due to selection of the morphological factors influencing the capacity to catch big prey or to endure longer periods of hunger.

It appears from Fig. 17 that the White-tailed Eagle has widened its breeding range in Greenland much farther to the north than the other

subarctic birds. Still, it is much more common in the subarctic areas than further north. In Julianehab-Narssaq Districts and northern Nanortalik District, *i.e.* in the subarctic areas, are found almost two thirds of the entire eagle population of Western Greenland. At the same time the numbers of eagles in the northern parts of the breeding range, *i.e.* in southern Egedesminde District and in Holsteinsborg District have considerably decreased in recent years, probably due to persecution by man. In 1950 I indicated that the northernmost breeding pairs inhabit the hinterland of the outpost Igíniarfik and Kangâtsiaq at the northern Amitsuarssuk branch of the large Arfersiorfik fjord (about 68°15'n.lat.)[1] (SALOMONSEN 1950, p. 421). Still in 1954 the eagle bred at Ataneq fjord, slightly more to the south (about 67°58' n.lat.), according to information from the Greenlanders. On the 29th July 1954 I observed, myself, two adult birds soaring at a cliff in the interior of the Nagssugtôk fjord, not far from the bottom of the Ataneq fjord. They were undoubtedly the breeding pair mentioned to me by the Greenlanders. More recently, I have had a number of interviews with many Greenlanders, who all have told me that the eagle has now withdrawn from these regions and probably does not breed north of Sukkertoppen District. On the 29th July 1960 I observed an adult pair at Evighedsfjord (near Kangâmiut, at about 65°50' n.lat.), perhaps then the northernmost breeding pair in Greenland. In the summer of 1977 I again visited the Evighedsfjord, but did not then meet any eagles there.

In recent years the eagle may have slightly increased in numbers in the northern part of its breeding range, owing to the fact that the small outposts and hamlets of this area have been abandoned by the inhabitants. At least GÉNSBØL (1972, p. 117) says that there have been two occupied nests in the period after 1965 in the Kangâtsiaq region.

Further to the north single birds may now and then be seen roaming about. They are usually young birds, up to two years old. I have sometimes observed such single birds in Holsteinsborg District and they are known as very rare visitors right up to Upernavik District. Even in Thule District the Polar Eskimoes have told me that White-tailed Eagles may be seen, with intervals of several years, which was a somewhat surprising statement to me, since everything seemed to show that the eagle was quite unknown so far to the north (cf. SALOMONSEN 1950, p. 422).

In 1972 the Danish Ornithological Society made an expedition to Julianehåb District, under the leadership of Dr. LORENZ FERDINAND, in order to study the White-tailed Eagle. They discovered a total of 15 occupied nests and even recorded some unoccupied nests (FERDINAND 1972, p. 4). There are probably as many which were not discovered,

[1]) By misprint said to be 69°15' n.lat. in SALOMONSEN 1950, p. 421.

including the few ones in the Nanortalik District. According to information from local inhabitants, there is a pair breeding in Tasermiut fjord and another one further south, only about 7–8 km northwest of Kap Farvel. A total of about 30 pairs in the subarctic areas of Julianehåb and Nanortalik Districts would probably be a conservative estimate.

In 1973 the Danish Ornithological Society investigated the entire region between Ivigtut and Kap Farvel (*i.e.* Julianehåb, Narssaq and Nanortalik Districts) and found a total of 26 occupied nests of the Whlte-tailed Eagle (HALD-MORTENSEN *et al.* 1973, p. 135).

In the summer of 1974 the investigation was extended, now covering almost the entire distributional area of the White-tailed Eagle in Greenland. A total of 78 inhabited nests were found, of which, however, only 46 possessed young. There were 72 young in these 46 nests. In Frederikshåb District nine nests with young were found, and in Godthåb District seven nests (ANON. 1974, p. 5). The studies made during a new expedition in 1976 appear to show that the illegal shooting of the eagle has increased in recent years in the sheep-farming area of Julianehåb-Narssaq Districts (WILLE 1976, p. 2). There is reason to believe that this situation will be improved.

In Frederikshåb District the eagle has never been common, owing to the mountainous character of the country. According to information received by me in 1971 the number of occupied nests in the district was 4–5. In the large and broad Godthåb District with numerous lakes and rivers in rather low rolling areas the eagle is more common. During an investigation of the district in 1970 I observed 5–6 pairs, including one inhabited nest, and would estimate the population in the district to run up to about 10 pairs. North of Godthåb District the number has declined, as already said, and I have not been able to trace any certain information about occupied nests in recent years in Sukkertoppen-Holsteinsborg District. However, I should venture to say, as a cautious estimate, that at most five pairs breed in the area.

Altogether, the number of White-tailed Eagle in Greenland goes up to only about 50 pairs, certainly a very low figure. About 25 years ago I gave a list of the pairs inhabiting the different districts, showing a total of 74 pairs (SALOMONSEN 1950, p. 426). A few years later CHR. VIBE estimated the number to be only 50 pairs (ANON. 1960, p. 35) and at about the same time I gave the figure 50–60 pairs (SALOMONSEN 1959, p. 249). Further, in 1967 I estimated the number to be 50 pairs (SALOMONSEN 1967, p. 128), which last number — generally speaking — appears to hold to this day.

During my trip in 1971 I visited two nesting pairs of the eagle. The first was situated at the lake Taserssuaq, between the sheep-farms of Qanisartût and Eqaluit at the Igaliko Fjord. Both sheep-farmers,

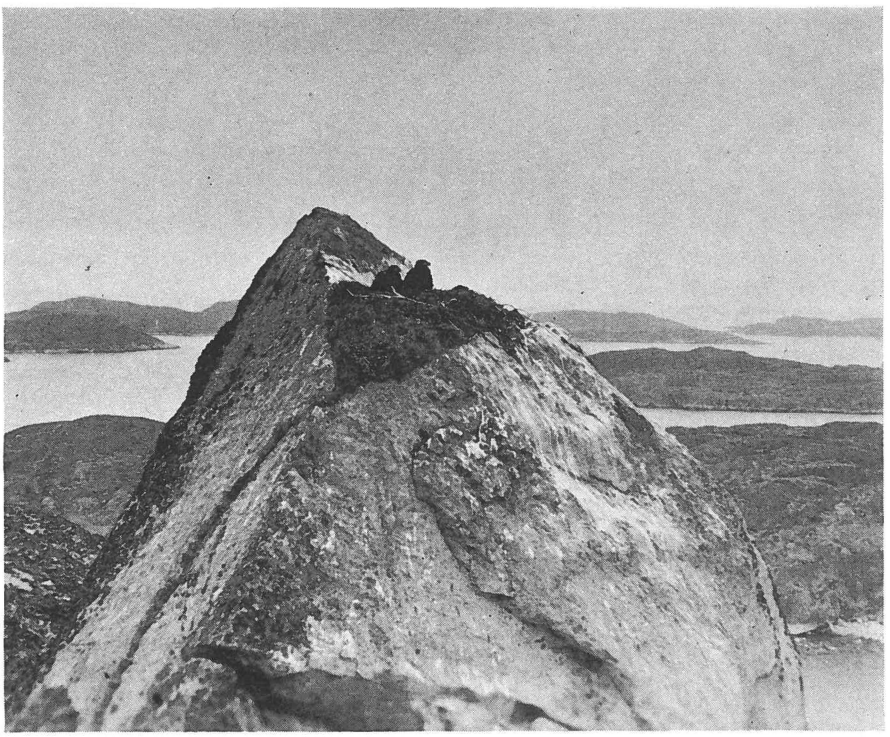


Fig. 19. Nest with two nestlings of the White-tailed Eagle, *Haliaetus albicilla*, on a hill top, height 75 m, on Kookøerne, Godthåb District. (Phot. 1947 by P. G. HENRIKSEN).

HENNING LUND and ABEL CHRISTIANSEN, have for years protected the breeding pair, and the result has been that the eagle has bred at the same place for about 25 years. Already in 1949, when for the first time I visited this part of Greenland, I observed the eagle pair nesting at the same place as in 1971. Even in 1972 when Dr. FERDINAND inspected the breeding place it was occupied, as in all the previous years. The nest visited by me on the 24th June 1971 was placed on a ledge on an almost perpendicular cliff, facing S. E., at an altitude of about 70 m. It was an enormous mass of sticks and branches and contained two young which were net yet fully feathered or fully grown. Both the adult birds were flying around rather close to the intruders or were sitting on projecting cliffs above the nest. The cliffs around the nest were beautifully orange-red coloured by the nitrophilous lichen *Caloplaca elegans*. While the nesting sites of the Gyrfalcon and the Peregrine Falcon invariably are sheltered above by an overhanging projection of the rock, such a canopy is never found at the nests of the White-tailed Eagle. This was distinctly to be seen at the nest at Taserssuaq, because it was placed near to the cliff wall, which towered up behind the nest without any formation of a

sheltering canopy. This situation is also distinctly seen at a nest near Godthåb, shown in Fig. 19 and in the nest from Frederikshåb District mentioned below (Fig. 20).

The other nest was inspected on the 1st July 1971 on the island Iterdlak, south of the outpost Avigait in Frederikshåb District. It was situated in the inland, about 2 km from the sea, at an altitude of about 150 m. The nest was placed on an even plateau on the edge of a longish hill, which on its south side was gently sloping and easy to scale, but on the north side steeply fell off toward a lake, situated about 120 m below the nest (Fig. 20). The nest itself had been newly erected that year according to information from the local sheep-farmer, JON CHRISTIANSEN, and was, therefore, very scantily built. It consisted of a few, scattered branches of willow and tufts of *Empetrum nigrum*, lined with moss. The diameter of the nest was about 1.5 m, and besides it was an even area of about one square meter, where remnants of the food for the young were scattered around. These remnants included one lump-sucker (*Cyclopterus lumpus*), one cod (*Gadus callarias*) two large arctic chars (*Salvelinus alpinus*), various other remains of fish and one hind-leg of lamb.

The nest contained one small young, still in down, probably about one week old (Fig. 21). There had been two young, but the other was taken by JON CHRISTIANSEN, who has kept it in his house as a pet, a common custom among Greenlanders, although now forbidden. He fed it with meat of char and sheep and promised to liberate it when it was able to fly. The young in the nest was supplied with one of our rings, but it did not live long. It was shot about 250 km southward along the coast, at Narssaq, Julianehåb District, 11th January 1972, which indicates how intense the persecution of the eagle in Greenland actually is. No less than 44 per cent of the young ones in their first year are shot, 39 per cent in their second year and 17 per cent in their third to fifth year, according to ringing (SALOMONSEN 1967, p. 131). The result will be that the young birds, rather easy to bag, especially in winter, will gradually be eliminated, while the adult ones, which are much more cautious against man, will continue to breed year after year, but will be followed by only very few successors. The eagle will, therefore, gradually decline in number and has already, as described above, reached a very low population size in Greenland. Proposals for protection have, for this reason, been discussed for a long time, and I shall briefly outline what has happened in this important field.

The main persecutors of the White-tailed Eagle in Greenland are, primarily, the sheep-farmers, who constantly complain of the damage done to the lambs by the eagle. It is incorrect, however, that the White-tailed Eagle takes sound and healthy lambs, as it feeds chiefly on fish and to a large extent also on birds, particularly sea-birds. It also eats

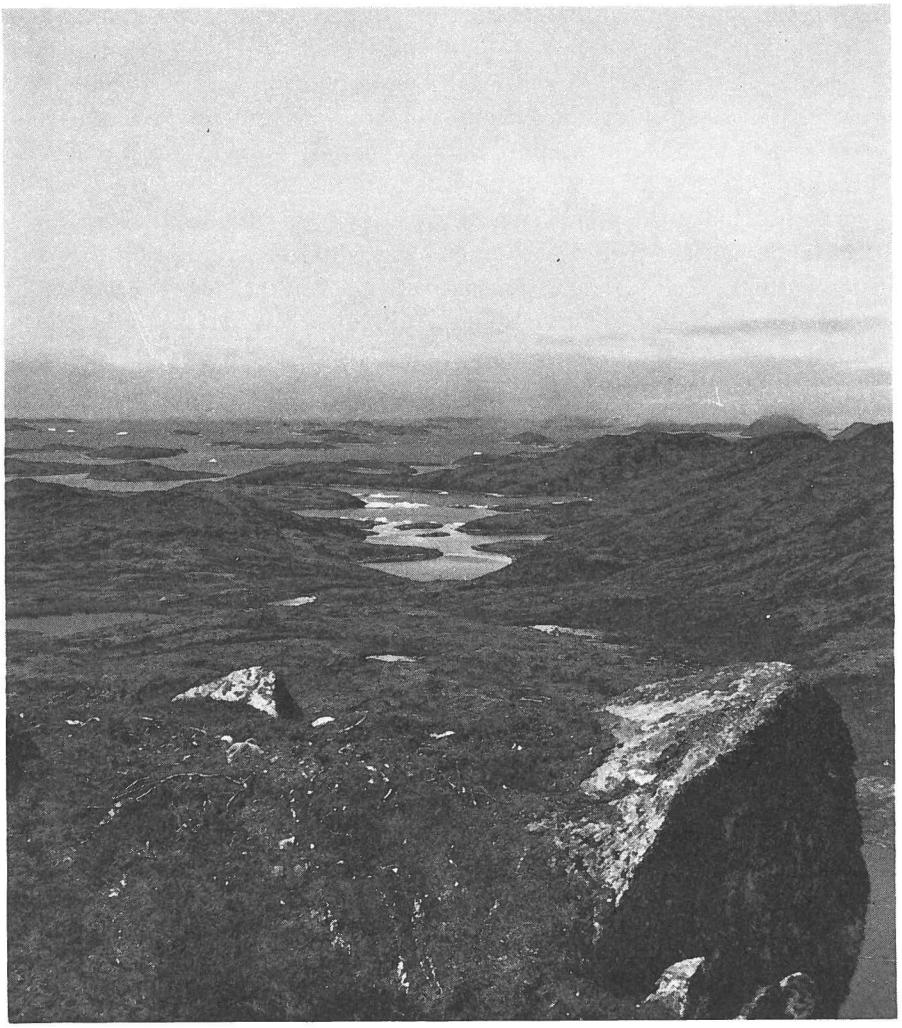


Fig. 20. Nest with one nestling of the White-tailed Eagle, *Haliaetus albicilla*, in an altitude of 150 m, on the island Iterdlak, Frederikshåb District. (Phot. 1st July 1971 by F. SALOMONSEN).

carrion, and the remnants of lamb, rather often found at the nest, have been taken when the lambs were dead or wounded. Secondly, the eagle is shot by trophy-hunters, especially those who want to possess a stuffed specimen as show-piece in their home. The legislative body of the Greenlanders (the Provincial Council, "Landsrådet") in 1947 put forward a proposal to pay a premium for every eagle killed, but this was, fortunately, not passed by the Greenland Administration in Copenhagen.

There has been much concern about the future of the White-tailed Eagle in Greenland, and warnings were issued at a rather early date by

SAND (1926, p. 137), SCHIØLER (1926, p. 145), KRABBE (1933, p. 135, and *in* SCHIØLER (1931, p. 85)) and OLDENDOW (1935, p. 129–142). In order to protect the eagle the Greenland Administration on 19th July 1933 promulgated a statutory provision which prohibited any export from Greenland of skinned or mounted specimens of the White-tailed Eagle. This rule had very little effect, however. As late as in 1950 I felt called upon to say that "the population of the eagle is so small that the utmost attention is needed in order to avoid a gradual extermination" (SALOMONSEN 1950, p. 430). The seriousness of the situation was subsequently emphasized by SALOMONSEN (1959, p. 249) and TRAP-LIND (1961, p. 33), and was mentioned also by SCHEEL (1965, p. 91).

In 1960 a proposal to protect the eagle by prohibiting all shooting and other persecution throughout the country was sent to the Provincial Council by the Danish Nature Conservancy. I had the privilege of presenting this proposal to the Provincial Council during its assembly in Godthåb in the summer of 1960, after discussing details with various members of the Council. The proposal was well accepted, but a complete protection was not possible to achieve, mainly due to opposition from the sheep-farmers in southern West Greenland. A compromise was reached, according to which the White-tailed Eagle was totally protected in the districts north of Frederikshåb District, while it remained an outlaw in the southern districts (Frederikshåb, Julianehåb, Narssaq and Nanortalik Districts). The law took effect from 1st January 1961, cf. Grønlands Landsråds Forhandlinger 1960, p. 21, 73 and 149; Nalunaerutit[1] 1960, ser. A, no. 2, p. 84–86. The provision was intended to apply for ten years, and in 1970 I again met with the Greenland Provincial Council in Godthåb, this time as representative of "The Ornithological Committee of the Ministry of Greenland." The Council agreed with the Committee that the precarious situation of the eagle made further protective measures necessary. Therefore, it was unanimously decided, in addition to the provisions given in 1960, to protect the eagle in the southern districts, as mentioned above, in the greater part of the breeding time, *i.e.* from the 15th May to the 31st August; cf. Grønlands Landsråds Forhandlinger 1970, Forårssamling 1970, p. 119–124; Nalunaerutit 1971, ser. A, no. 1, p. 7.

These provisions have given rise to some discontent in the sheep-farming districts, but in the recent period the tide has actually turned. The inhabitants in Greenland begin to understand that protection and conservation is necessary even in their almost desolate country, and from many sides it has been claimed that the White-tailed Eagle ought to be completely protected, *i.e.* that the closed season in the southwestern districts should be extended to the entire year. This general attitude has

[1]) Nalunaerutit = The Greenland Statute Book.

Fig. 21. Close-up of the nestling of White-tailed Eagle, *Haliaetus albicilla*, shown in Fig. 20. Remnants of food (fish) in the background. (Phot. 1st July 1971 by F. SALOMONSEN).

been backed up by several notes and letters in the Greenland newspapers, and lectures in the Greenland Broadcasting by Danish biologists like Dr. CHRISTIAN VIBE and myself, by activities undertaken by The Danish and Greenland Ornithological Societies and by The World Wildlife Fund and other organizations.

The hunters' association in Holsteinsborg in a letter of 31st May 1972 requested the Provincial Council to give the White-tailed Eagle full protection. Likewise, citizens of Frederikshåb in a letter of 2nd February 1973 to the municipality, signed by 106 people, asked for full protection of the eagle in Frederikshåb District. The letter was forwarded to the Ministry of Greenland. The Association of Open-Air Organizations in Denmark ("Friluftsrådet") in a number of letters to the Ministry of Greenland, the most recent one of 20th February 1973, requested the authorities to give the eagle full protection in the southern Districts of West Greenland. Further, during "The Plenipotentiary

Conference to Conclude an International Convention on Trade in Certain Species of Wildlife" in Washington, D.C., February 1973, the Greenland subspecies of the White-tailed Eagle was placed on the list of animals which ought to be strictly preserved. Finally, the Ministry of Greenland in a letter of 28th February 1973 to the Provincial Council announced that it was in favour of an extended or a total protection of the eagle in the southern districts, and urged the Council to reconsider the whole question.

On account of this multilateral pressure the Provincial Council, finally, on a meeting on the 4th April 1973 passed an act, carried unanimously, giving the White-tailed Eagle full protection throughout Greenland; cf. Grønlands Landsråds Forhandlinger 1973, Forårssamling 1973, p. 145.

Podiceps auritus Linnaeus

During an ornithological excursion to western Greenland in the summer of 1977 NIELS MUNK and HANS CHR. POULSEN found the Slavonian Grebe breeding in Narssaq District, close to Tunugdliarfik, in the same area in which the Black-headed Gull, the Redwing and the Fieldfare are known to breed. On the 25th June 1977 the two ornithologists discovered a pair of the Slavonian Grebe in a lake 2–3 km south of Qagssiarssuk and localized the nest, which contained three eggs.

The Slavonian Grebe belongs to the Siberian-Canadian faunal type, widely distributed in the boreal province of both the New and the Old World, and in Iceland approaching or transgressing the boundary of the lowarctic zone within the Arctic province. Like all the other recent immigrants to Greenland, mentioned in this paper, the Slavonian Grebe has recently increased in number and enlarged its breeding range considerably in Scandinavia (SALOMONSEN 1963, p. 32). Two subspecies are generally recognized, the nominate form breeding in the Old World and *cornutus* (Gmelin) breeding in North America. Both forms have been recorded in western Greenland (SALOMONSEN 1967, p. 22). Dr. J. FJELDSÅ, who is an expert on grebes, informs me that it appears from the photographs taken by MUNK and POULSEN that the male of the Greenland pair is a *cornutus*, while it is not possible to decide to which subspecies the female belongs. On the other hand FJELDSÅ (1973, p. 78) states that the Greenland skins of the Slavonian Grebe appears to be of Iceland provenience. For the time being I find it more cautious, therefore, to treat this record in a binominal way only. Incidentally, the differences are slight between the two forms, which perhaps should be synonymized. CRAMP and SIMMONS (1977, p. 105) say about this subject, that "naming of subspecies in the Slavonian Grebe is considered unnecessary as dif-

ferences are slight and partly clinal, intermediates occur, and single birds are rarely identifiable."

MUNK and POULSEN intend to write a paper on their most interesting record, in Dansk Ornith. Foren. Tidsskr., but this note has not yet been published.

Conclutions

It has been shown that a number of southern bird species have settled in the subarctic zone in South Greenland. Of the six species mentioned, five are recent invaders, which all have been subject to a considerable increase in numbers and in breeding range in Europe simultaneously with or prior to the occupation of subarctic Greenland. In three of the species which have immigrated to South Greenland the colonizing population has originated in Iceland, while the fourth (the Fieldfare) has come from the Scandinavian Peninsula. In the case of the fifth species, the Slavonian Grebe, it is not possible to say anything about the geographical origin of the Greenland invaders, and this species is, therefore, exempted from the following considerations. The sixth species, the White-tailed Eagle, has always been known in Greenland, where it has formed a local subspecies. It probably settled in Greenland in prehistoric times, during a period of similar increase of the European population and expansion of the breeding range which now can be followed in the other five colonizing species. It is noteworthy that all the subarctic species are of European origin, while there are no American ones. The only American subarctic bird said to have been breeding in Greenland is *Zonotrichia leucophrys*, which by HOLBØLL (1843, p. 36) was postulated to have bred in Ameralik Fjord, Godthåb District, in 1823. This occurrence has been often cited, *e.g.* by SCHIØLER (1926a, p. 50), but cannot be accepted. HOLBØLL stated that he captured an adult male on 12th August 1823 near the head of the fjord "where I heard its clear call note, which led me to suppose that it had a female or young ones in the vicinity". Nothing speaks in favour of this supposition, and the species has never been found there again.

The reasons why European and not American birds have recently settled in southern Greenland are difficult to decide, but they have probably something to do with the weather patterns in the areas around South Greenland. A high pressure area dominating the eastern Canadian Arctic with resulting airflow from the northeast would favour migration from Iceland towards west; cf. above, p. 38. At the same time, the increase and range extension in recent years has been much more pronounced in European than in North American bird species. This means that the odds for European origin of specimens or flocks searching for

new ground to colonize in the North Atlantic area must reasonably be supposed to be much greater than those for species of American origin.

Contrary to the situation in subarctic S. W. Greenland, it is in higharctic N. W. Greenland preferably North American species which have been able to colonize the country. This is no doubt due to the close proximity to Canada (Ellesmere Island) of the corresponding parts of Greenland (Thule District). The most outstanding avian examples of American colonizers are *Anser caerulescens*, *Calidris bairdii* and *Larus thayeri*.

The predominant European origin of the birds which have immigrated to Greenland across the North Atlantic has been emphasized by NØRREVANG (1963, p. 99). He does not mention the subarctic species, with exception of the Fieldfare, but deals particularly with the lowarctic species in S. E. Greenland, namely *Anthus pratensis* and *Motacilla alba* (briefly touched upon p. 19 in the present paper), and the higharctic species, mainly geese and shorebirds, in N. E. Greenland. According to him, the two lowarctic species mentioned above have immigrated to S. E. Greenland with the support of wind drift during their spring migration to Iceland, while the higharctic shorebirds and geese have colonized N. E. Greenland by means of prolonged migration of the Iceland populations. I am more inclined to think that weather patterns are responsible even for the Greenland occupation by the higharctic species. These species have undoubtedly crossed the North Atlantic at an early date, probably in the last part of the latest glacial period. In this period the cyclone trajectories over the Atlantic passed almost to the north and, therefore, made it possible for a number of strong-flying birds to be drifted northwards and eventually reach the Peary Land refugium in N. E. Greenland (cf. SALOMONSEN 1972, p. 42–43).

ECOLOGY OF ARCTIC SEA–BIRD COLONIES

It is a well-known fact that sea-birds breeding in colonies ("rookeries", "bird-bazaars", etc.) are extremely conservative in their choice of nesting sites. The fact that the sea-birds usually reach a considerable age, *i.e.* breed in a large number of years, and at the same time are very philopatric, has the effect that the population uses the same breeding places year after year, century after century. When the young birds of these highly social birds start to breed or begin nest-prospecting, they are attracted to the breeding places by the older breeding birds already present, in this way continually replenishing the colony and using the same place virtually forever.

The tendencies to nest repeatedly on or close to the same site and among the same neighbours are termed *site tenacity* and *group adherence*, respectively (McNicholl 1975, p. 98). Some of the oldest sea-bird breeding places known are the colony of *Morus bassanus* in the Faroe Islands, known to inhabit the very same spot on the island of Mykinesholmur since about the year 1500, and the colony of *Fulmarus glacialis* on the island of Grímsey off North Iceland known since 1640. In both cases the colonies must have been established many years, probably many centuries, before they were mentioned for the first time in the literature.

Something similar is the case in Frederikshåb District. The best known sea-bird colonies are those of *Rissa tridactyla* owing to the great economic importance of this species for the inhabitants and to the spectacular appearance of the colonies. Therefore, they have been mentioned or described at a rather early date. According to Winge (1898, p. 194) the following colonies of *Rissa tridactyla* were known in the 19th century or still earlier. Those colonies which still exist are supplied in the enumeration below with the figure given to them in the present review (p. 141):

(1) (F. 2) Qagssit fjord, known by Fabricius about 1770, still in existence.

(2) Kangerdluarssuk fjord, somewhat north of Frederikshåb City, known from 1842, now abandoned.

(3) (F. 5) Kuánersôq fjord, known from 1823 and again mentioned in 1842, still in existence.

(4) (F. 8) Ivnaq, in the outer part of the Sermilik fjord, known by FABRICIUS about 1770, still in existence but inhabited now only by *Larus glaucoides*.

(5) North of Iluilârsuk (between Frederikshåb and Narssalik outpost), known since 1842, now abandoned.

(6) (F. 10) Arsuk Fjord, known from 1842, still in existence.

Apart from these colonies, present in the 19th century, there is only one other big colony (F. 9 in Sermiligârssuk fjord) which is probably also very old. It is situated so far from any inhabited place that it was unknown to the Danish officials in the 19th century. Of the colonies mentioned above, nos. (1), (3) and (6) are all large, numbering "thousands" of breeding birds, and still existing, while nos. (2), (4) and (5), which are abandoned now by the Kittiwakes, were small and insignificant, and at the same time situated so close to inhabited places that the birds simply were wiped out by man. A similar extinction of small or medium sized bird colonies has in our time, with its enormous increase in human population, taken place in many localities in Greenland, mostly in places situated close to the bigger cities. It is, therefore, important to make a census of the sea-birds before it is too late.

The census of seabird colonies which I have carried out for a number of years along the entire West-coast of Greenland, from Thule to Kap Farvel, performs a number of functions:

(1) It gives the numerical size of the populations of the species of seabirds in the different parts of West Greenland, either under climax conditions or during decline caused by human persecution.

(2) It shows the sociability of various species, *i.e.* which species breed in company and under which circumstances.

(3) It gives a number of adaptations to the choice of nesting site, due to habitat selection or preference and to predation pressure. These aspects include steepness and exposition of the cliffs and structural or geological factors, presence of fresh-water, use of ledges, fissures, plain ground, turf, subterraneous holes, or small islands as breeding ground, altitude and inaccessibility of nesting site, nest material if any, etc.

(4) It considers the importance of the avian guano, the result of its concentration and of the way in which it is deposited, and primarily its edaphic significance for the coprophilous vegetation.

In the following, as well as in future papers dealing with these conditions in other parts of Greenland, every breeding place examined will be described according to the points outlined above.

Methods

In the description of each sea-bird colony the following details are considered:

(1) Locality, coordinates, and name, if any; date for examination.

(2) Exposition.

(3) Height of cliff or mountain.

(4) Configuration of cliff (general description, promontories, bastions, side-walls, etc., presence of boulders and other results of frost erosion, steepness of cliff wall, development and height of talus below cliff, crannies, fissures, cavities, holes in the cliff, presence of glacier, geological notes if necessary).

(5) Presence of fresh-water (waterfall, trickling, seeping or percolating water, moist crevices, development of cyanophycean bands, ponds on small plane islands).

(6) Breeding birds (number of pairs, altitude of nest sites of each species).

(7) Presence of guano (extension, density and form of guano and faecal patches on the breeding place and its immediate surroundings, presence of scoured or cleaned cliff-areas due to high concentration of nitrogen in the avian feces, which have scorched all vegetation).

(8) Presence, colour and extension of *Caloplaca* growth, development of a *Caloplaca* arch.

(9) Coprophytes (species present, height and dimensions of specimens, formation of varieties or mutants, zones of vegetation).

(10) Other remarks, including edaphic conditions.

Many of these items have never been studied before, but are of considerable biological interest. Some of the points mentioned, particularly the botanical ones, require further information, which is given in the following passages.

In some ways the census-methods described above resemble those used in arctic Canada for the census-work there. Particularly points (1)–(6) are very similar to concepts in the Canadian census technique,

while points (7)–(10) are not considered in Canada. The Canadian procedure has been thoroughly described by NETTLESHIP (1976, 1977a, 1977b). The botanical description of several Spitsbergen bird-cliffs, recently undertaken by EUROLA & HAKALA (1977, p. 2), is very similar to the methods used by me in this paper.

Exposition

The exposition towards the sun is of great importance for the arctic sea-bird colonies. Those exposed to the south receive a much greater amount of sunlight than those exposed to the north, to the effect that the snow melts much faster and much earlier in spring and that erosion due to the daily temperature differences is allowed full blast. The slopes are, therefore, generally rather steep with a well-developed talus below. During summer these cliffs are often completely dry and covered with xerophytic plants, like *Artemisia borealis*.

The north-exposed cliffs are even in summer much moister than the south-exposed ones, because the snow melts at a much slower rate and is present as scattered snow drifts even in July or August. The vegetation in high-summer is usually more lush and green than on the south-exposed cliffs with their often desertlike appearance. The erosion of the north-facing cliffs is as a rule not so strong as that of the south-facing ones, to the effect that the former sometimes appear as gently rolling hills without any development of a talus. At the same time the exposure of the cliffs has a very considerable effect on the microthermic conditions. In clear weather significantly higher temperature maxima are reached on the south-facing cliffs than on the north-facing ones, which of course is of great importance for the vegetation (HANSEN 1973, p. 29).

It is of importance that even the hydrogen ion concentration differs remarkably in the soil of the north- and south-exposed cliffs. The sunny, dry slopes of the south-exposed cliffs in Søndre Strømfjord have a pH of 6.4–8.4, while those of the north-facing ones have a pH of only 4.8–5.4, thus having a much more acid reaction (BÖCHER 1949, p. 28).

Similar differences between north- and south-facing cliffs are, of course, to be found everywhere under arctic or boreal climate regimes, and have particularly been studied in Sweden. The term "Sydberg" (*i.e.* south-exposed cliff) is often used by Swedish botanists to define precipitous southward exposed cliff-walls in northern Sweden, which on account of the local mitigated microclimate have a growth of more southerly distributed plants than the north-exposed cliffs. This was first described by ANDERSSON & BIRGER (1912) and has subsequently been used by zoologists to point out the significance for the distribution of various

animal groups, including birds, such as *Columba palumbus* (cf. EKMAN 1922, p. 74; ANDERSSON 1957, p. 178).

The above differences between cliffs facing due north or south are not always developed at cliffs by the sea, but are more apparent in the inner and drier parts of the fjords or at lowland lakes in the interior part of the country. The differences are particularly well marked in the middle parts of West Greenland, where the long fjords usually cut into the country in a west-easterly direction and, consequently, are bordered by coast cliffs which are either south- or north-exposed. The clear-cut division of the fjord cliffs into these two categories is, therefore, to be seen almost everywhere in central West Greenland. This is, of course, a well-known fact among biologists in Greenland, but very little has been written about it, and it is necessary to go almost a hundred years back to find a description of this phenomenon, which was observed at the Nordre Isortoq fjord: "Very prominent in this area is a character which is to be seen in many parts of Greenland. The north-exposed cliff-sides are covered with a more lush and exuberant verdure than the south-exposed ones, although the opposite trend should be expected. This is apparently not difficult to explain. On the cliffs which directly face the sun, the snow will have melted very soon in the summer, and the vegetation will, therefore, in a dry summer suffer from deficiency of water. On the north-exposed slopes the snow will remain for a much longer period and continuously produce an irrigation of the lower parts of the cliffs by means of the numerous small rivulets, formed by the gradual melting. Even when the snow is completely melted the soil will never attain the dryness found on the south-facing slopes which are exposed to the more vertical rays of the sun" (JENSEN 1881, p. 134).[1]

During a visit to Søndre Strømfjord airfield in late March 1970 I was satisfied that the explanation given by JENSEN was the right one. It was distinctly to be seen already now in late winter that the snow had commenced to melt and to disappear on the south-exposed cliffs, while it formed a dense cover on the north-exposed ones. Two years previously, to be exact on the 21st July 1968, I had some photographs taken in the same area to show the differences between the north- and south-exposed cliffs. These photographs are shown on plate I (fig. A–C), and a sketch of the situation is given in fig. 22. The north-exposed coast of "Lake Ferguson" is shown on plate I, fig. A. The south-exposed coast of the lake, given on plate I, fig. B, is formed by a mountain, which on its northern (north-exposed) side constitutes one part of an U-shaped valley, of which the remaining part is south or south-west exposed. Both sides of the valley is shown on plate I, fig. C. On fig. A the green, densely overgrown north-exposed lake-shore is shown. It forms a gentle slope towards

[1]) Translated from Danish by me.

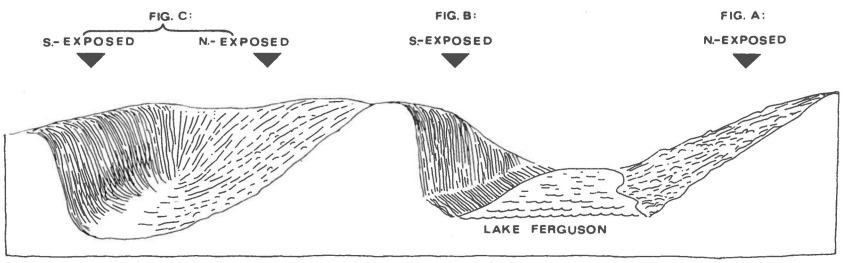


Fig. 22. North- and south-exposed cliffs at "Lake Ferguson" at Søndre Strømfjord airfield. The sketch is made to show the situation of Fig. A–C on Plate I. Cf. also text on p. 85.

the lake. The south-exposed lake-shore on plate I, fig. B is barren, almost devoid of vegetation and steeper than the north-exposed one, with a distinct scree. Finally, on plate I, fig. C, both the green, fertile north-exposed side and the barren, dry and sun-scorched south-exposed side of the U-shaped valley are to be seen.

It appears that *Larus hyperboreus* as well as *Larus glaucoides* prefer to place their colonies on the dry south-exposed cliffs, probably because they are usually snow-free when the breeding begins. The same is the fact with the large solitary breeders (*Falco rusticolus*, *Falco peregrinus*, *Corvus corax*). On the other hand, *Rissa tridactyla*, apparently prefers moist north-exposed breeding cliffs, possibly because it prefers nesting sites "near a water-fall or on cliffs with small rivulets running down the rocky walls or with water oozing and trickling over large surfaces of the cliffs" (SALOMONSEN 1950, p. 327). Species like *Uria lomvia*, *Phalacrocorax carbo*, *Alca torda*, *Plotus alle* and *Cepphus grylle* have no particular preference as to the exposition of their breeding cliffs. Generally speaking, however, the number of south-exposed breeding cliffs in Greenland is much greater than that of the north-exposed ones.

From a botanical point of view the different exposition of the bird cliffs gives rise to a considerable variation in the composition of the flora. It is necessary to distinguish between a south-exposed type of cliff, here called the *Caloplaca* cliff, and a north-exposed one, the *Cochlearia* cliff. The *Caloplaca* cliff is named after the lichen *Caloplaca elegans*, which as a very pronounced heliophyte is profusely developed on south-exposed bird-cliffs, while it is usually absent or very loosely and thinly developed on the north-exposed ones. The Greenlanders are well aware of the close connection between the bird-cliffs facing south (towards the sun) and the presence of *Caloplaca elegans*. The orange areas, stained by this lichen, which form a colourful contrast to the white manure of the birds, they call *seqernup anâ*, *i.e.* the dung of the sun.

The *Cochlearia* cliff gets its name from *Cochlearia officinalis*, which

is always present on the north-exposed bird-cliffs, but usually absent from the south-exposed ones. This difference may be due to the fact that it is a distinct sciophyte, or more probably that it is hygrophilous, *i.e.* demands a moist habitat, and, therefore, is desiccated on the dry south-exposed slopes. At any rate, these two plants are practically always unfailing character species of the two types of bird-cliffs. They have been chosen as common denominators because they occur in entire Greenland, and for that matter in the greater part of the Arctic region. Thus it appears that *Cochlearia officinalis* in Spitsbergen is diagnostic for the moist type of bird-cliffs (Eurola & Hakala 1977, p. 9).

Sometimes intermediate types between the *Caloplaca* and the *Cochlearia* cliffs are developed, particularly on bird-cliffs facing east or west, but they are not common in Greenland, where most fjords go in an east-west direction. There may also be other types than the two mentioned, but I have seen this only in very few cases, even though I have examined more than a thousand bird-cliffs in Greenland.

Guano

The appearance of the bird-cliffs is dependent on the way in which the guano of sea-birds is deposited, and the density, extension and localization of the feces. Each species behaves in a special way in this respect. Gulls of the genus *Larus* breeding in colonies on steep cliff-walls defecate on the ground not far from the nest or in the air about 25–50 m from the nest. The feces are seen as the white spots staining the cliffs or vegetation in front of the breeding site. The gulls do not usually defecate over water where they forage (Brackbill 1972, p. 4), and the greater part of the guano is, therefore, deposited at the nesting site and its surroundings.

The deposition of feces in *Larus* appears, however, to be subject to a certain geographical variation. Sobey (1977, p. 515) states that Herring Gulls (*Larus argentatus*) usually defecate in certain "latrine areas" at some distance from the breeding area. The reason for this may be the fact that the nest is not rendered conspicuous to predators by the presence of feces (Sobey 1977, p. 519). However, in the Greenland species the breeding sites placed on vertical cliffs are well protected against predators, and it appears that defecation takes place also near the nest. On the other hand, the nest areas of the Herring Gull are heavily fouled by the chicks, while the nest areas are kept free of feces up to hatching. During "anxiety defecation" due to stress situations feces may be dropped everywhere, in gull-colonies breeding both in arctic and temperate regions. It is a well-known fact, both in Europe and Greenland, that during visits of human trespassers by boat to a gull-colony feces may be

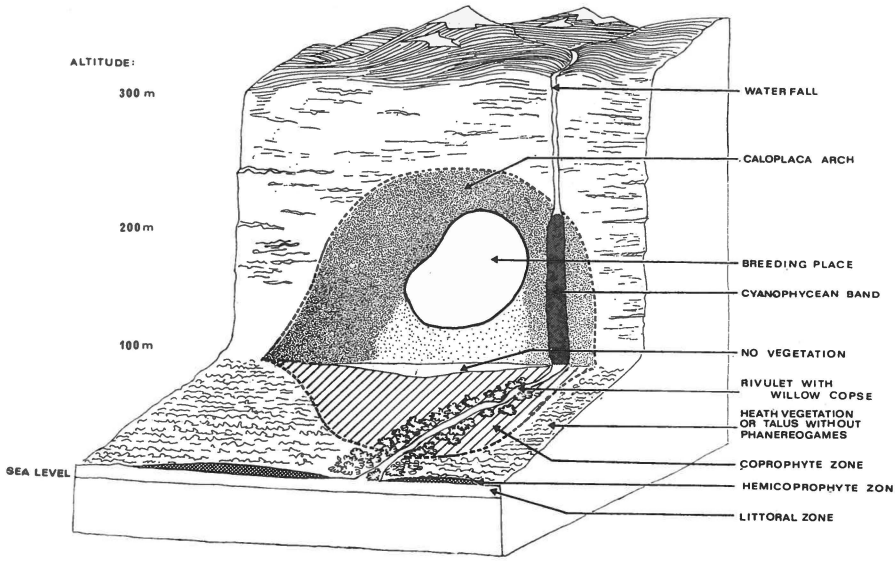


Fig. 23. Diagram of a south-exposed gull-cliff (*Caloplaca* cliff). Cf. text p. 116.

dropped over the intruders in order to drive them away, during which procedure the greater part of the feces end in the water in front of the colony.

The guano which is deposited in the breeding area proper is usually carried further about, either by means of percolating water into the soil or downwards to the scree below the breeding place, or it is in a desiccated state in the form of dust carried by the wind to the surrounding cliffs. Regarding the larger gulls, particularly those breeding in single pairs on islands along the coast, mainly *Larus marinus* and *L. hyperboreus*, much guano is piled up on the "standing place", where a *pingo* gradually is formed (SALOMONSEN 1950, p. 295; cf. also Fig. 28 and p. 112 below in this paper). Of the gulls breeding in colonies (*Larus glaucoides*, the majority of *L. hyperboreus*) usually choose their nesting sites on inaccessible cliff-walls which usually are supplied with a talus below, as shown in Fig. 23 and on the photograph Fig. 24. Large quantities of nesting material are piled up on the scree, either lost by the nest-building gulls or blown down after the breeding season. A number of smashed eggs, crushed egg-shells, dead nestlings and remnants of fish and other food items are found among the masses of moss, straw and twigs, the whole substance being squirted with manure of gulls. This creates excellent conditions for the growth of coprophytes and subsequently, after some years, for thick layers of peat. Further down on the scree the ground either consists of raw boulders without vegetation (except lichens) or is covered with ordinary heath vegetation or willow shrub (Fig. 23 and Fig. 24).

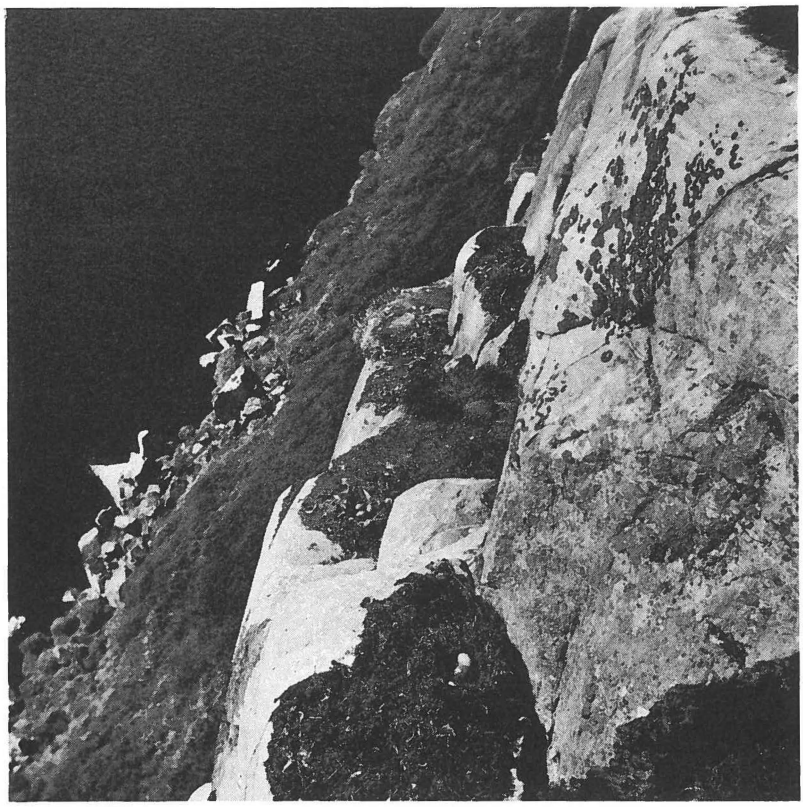


Fig. 24. View from above of a colony of Iceland Gulls, *Larus glaucoides*, breeding on a south-exposed cliff at a fresh-water lake on an island in Nivâp suvdlua, Egedesminde District. The cliff below the nests is white-washed by the guano and quite sterile, while above the nests there are scattered spots of *Caloplaca elegans*. On the scree below, coprophytic vegetation is growing (white flowers are vaguely visible) and at the bottom of the scree, at the lake shore, are raw boulders without vegetation. (Phot. 6th June 1954 by F. SALOMONSEN).

The excretion of the Kittiwakes (*Rissa tridactyla*) is more concentrated to the nesting sites proper and to the standing places than in the *Larus* species breeding in colonies. The manure of the Kittiwake is then smeared over the cliffs or slides down to a large extent by means of rain or by water seeping down. The perpendicular cliffs just under the breeding sites are therefore, as a rule, quite destitute of all vegetation, even lichens, because the high concentration of nitrates and other salts in the guano acts as a herbicide and scorches all floral elements. This is, of course, well-known in all other large colonies of sea-birds when the birds deposit a dense layer of guano. According to HUTCHINSON (1950, p. 370) the Bounty Islands lack vascular plants altogether, which is due to the destructive effect of the guano of the immense bird colonies of the group.

He mentioned also other examples, especially some due to the genus *Phalacrocorax*. Also the case of St. Paul Island in the South Atlantic, known from DARWIN's visit with "Beagle", is often quoted as an example of a sea-bird locality covered with guano and quite destitute of vegetation of any kind (cf. SERNANDER 1912, p. 815; GRØNLIE 1948, p. 166). A similar situation is apparent in Greenland at the breeding places of *Phalacrocorax carbo* (Fig. 25) and a few other birds. The chemical processes which give rise to the scorching of the vegetation by guano has been well studied by GESSNER (1932, p. 113). Recently GILLHAM has studied these phenomena, particularly the total elimination of plant-life by heavy deposition of guano on bird-islands in Western Australia (GILLHAM 1961, p. 289) and South Africa (GILLHAM 1963, p. 275).

The genera *Uria* and *Phalacrocorax* have a much higher production of guano on the breeding place than do the gulls. Both groups are especially prone to deposit the greater part of their manure on the colonized land area. This is not accidental, but a definite feature of the birds. In many tropical species, *e.g. Phalacrocorax bougainvillei*, the fecal material is used in nest construction, and the nest may almost entirely be composed of guano. A great accumulation of guano is found even on the resting-places and sleeping-places of the Cormorant in Greenland.

The accumulative effect of the guano in big bird-colonies makes the breeding locality visible as white cliff-walls at a great distance. This appearance is also preserved in winter, when the birds have left the breeding places, and it even remains for many years in cases when the breeding place has been abandoned by the birds. Even if rain and snow removes the guano the excretion must somehow influence the cliffs chemically. As is well-known, the uric acid in avian excretion is a rather stable and insoluble substance.

It may be added, however, that there are no stable guano deposits in the Arctic. They are restricted to the tropics and are strictly limited to the equatorial belt south of the Doldrums and in the vicinity of the equatorial divergence. The islands on which guano is deposited all have mean annual rainfalls of well under 1000 mm, and it has long been realized that the incidence of guano deposition is determined by precipitation. It has been supposed that more than 1000 mm of precipitation prevents the deposition of guano (HUTCHINSON 1950, p. 364). This cannot be the whole truth, however, for in the Arctic the annual rainfall is constantly much lower than 1000 mm, apart from certain areas on the border of the subarctic zone (cf. p. 11), but in spite of this no genuine guano accumulation takes place.

The guano of *Uria* and *Phalacrocorax* is carried downwards with rain or percolating water to the scree below the breeding cliff or into the sea. According to the distribution of the nitrophilous coprophytes at such

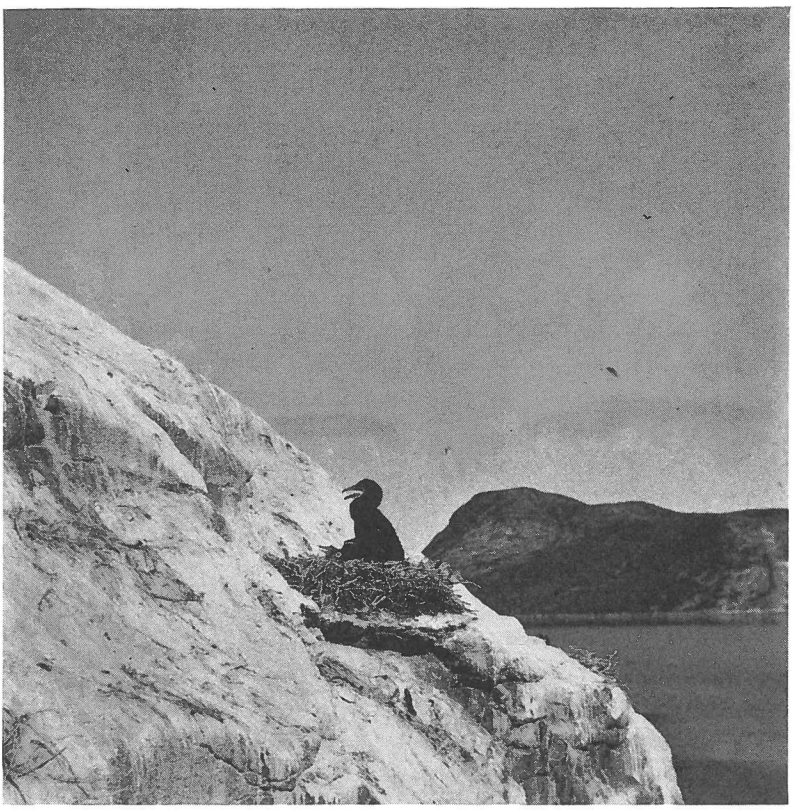


Fig. 25. Breeding-place of Cormorant, *Phalacrocorax carbo*, completely covered with guano and quite sterile. (Phot. 31st July 1954 in Nordre Strømfjord by F. SALOMONSEN).

colonies only small amounts of guano are carried further away by the wind, which appears to differ from the situation in the gull colonies. This may, however, be due to the fact that *Uria* and *Phalacrocorax* rarely defecate beyond the nesting site or the nearest surroundings, while the gulls defecate in the air up to 40–50 m from the nest. As is the case with the Kittiwake the cliff-walls under the nesting sites of *Uria* and *Phalacrocorax* are quite destituee of vegetation. This is much less distinctly to be seen in colonies of *Larus*.

The defecation of the remaining alcids, namely *Alca torda*, *Cepphus grylle*, *Fratercula arctica* and *Plotus alle*, follows the schedule of *Uria*. All these species breed in holes, crevices or caves, *i.e.* not in the open as does *Uria* lomvia. Comparatively little manure is deposited in the nesting holes or caves, a greater amount outside on stones or boulders. From here it disappears in the soil with rain or snow, or it is blown as dust to the surrounding areas. However, quantitatively the amount of manure per individual is much smaller than in *Uria* or *Phalacrocorax*. Highly nitro-

philous coprophytes usually grow just around the nesting holes of these species, evidencing that the concentration of nitrates must be great in these places.

In the Fulmar (*Fulmarus glacialis*) the defecation particularly of the nestling, which remains for a long time in the nest, takes place at or near the nesting site, but to a large extent disappears with the rain or with the wind and is transported to the surrounding cliffs or to the soil of the talus below the breeding cliffs.

In *Sterna paradisaea* and *Somateria mollissima*, both breeding on low islands, the dung is more or less scattered on the ground, not particularly close to the nests. *Somateria mollissima* eats very little while brooding and, therefore, produces only small amounts of guano on the breeding places. *Sterna paradisaea* uses projecting stones and boulders as roosting or standing places, where a certain amount of manure is deposited. *Stercorarius parasiticus* and *S. longicaudus* also breed on low islands or on plateaus on the mainland and have, like the bigger gulls, distinct standing places which develop into small *pingos*, often called "Skua hummocks" (SUMMERHAYES & ELTON 1923, p. 233).

The terrestrial solitary breeders among the birds-of-prey deposit a comparatively great amount of manure at the nest and at the plucking-places nearby. By means of wind and rain this guano gets a wider distribution and exerts its influence at a varying distance from the nest. This influence is similar in *Corvus corax*, although much less marked, because this species does not defecate at the nest and usually removes the dung of its nestlings. Generally speaking it may be claimed that the excretion of all bird species in the Arctic region, even that of the small passerines, is of importance and influences the biosphere in various ways, as shall be dealt with further below.

A study of the importance of the avian excretion for the Arctic biosphere and an analysis of its widespread implications has virtually never been made. Investigations of the avion guano, particularly the economically important deposits in the tropics have been carried out mainly by MURPHY (1925), MEISE (1938) and HUTCHINSON (1950). Even in these regions much research is still to be done. HUTCHINSON (1950, p. 372) is right when stating: "A fascinating field for further research on the interaction of precipitation, bird colonies, and vegetation on tropical islands is evidently open to anyone in a position to take advantage of it." It goes without saying that this conception still more strongly applies to the Arctic region.

HUTCHINSON (*l.c.*, p. 373) is of the opinion that the great concentration of nutrients washed into the sea by rain or wave actions at a large bird-cliff will materially contribute to increase the littoral productivity and possibly even the fish production. "It is," says HUTCHIN-

SON, "conceivable that large bird colonies, far from reducing the commercial catch of fish by competition, may actually increase the catch by a process of biochemical concentration." This most important economic question is difficult to analyze, at least in Greenland, where a strong tide and currents give rise to a rapid transportation of the sea-water with its suspended components. At any rate, I have not been able to discover any difference in the size or density of the littoral algal vegetation between areas in front of bird colonies and in surrounding stretches of fjord coasts in Greenland. It appears, however, that in temperate areas with a very slight sea-current, as in lagoons in the Baltic Sea, and with the presence of many breeding gulls, various algae (*Fucus*, *Ulva*, *Enteromorpha*) are capable of using the suspended nitrogen compounds, due to the guano, for their pigment synthesis. This is of importance especially in the littoral zone or in the upper water layers where the excessive sunlight inactivates the chlorophyll through a photochemical process (BAUCH 1956, p. 329). It should also be mentioned that GOLOVKIN (1974, p. 90) draws attention to the fertilization of Atlantic surface water by avian guano. The annual enrichment of phosphates attains 12 mg/m^2, this figure, however, occurring only near coastal sea-bird colonies. It exerts, nevertheless, an influence on the biological productivity of marine communities.

Cyanophycean Bands

Wherever water seeps down over the cliff-walls of bird-colonies rich vegetation of cyanophycea develops. These populations form black streaks, covering the moist parts of the cliffs, sometimes forming bands up to 5–6 m wide and several hundred metres high (Fig. 23). On southerly exposed cliffs these bands are soon desiccated in the summer, but keep their black colour even when they are quite dry. They are able to survive a long drought period, and in periods with heavy rain or with much moisture the algae are revived, and the population may again begin to grow. Even with continued desiccation the population remains fairly constant for several years. When the wet period starts, the algae immediately resume growth (MULDER *et al.* 1969, p. 169).

These black streaks of considerable size and prominent colour are usually a characteristic feature of the birdcliffs, and they must be mentioned in the description of the bird colonies. As far as I know they have no designation in English, and I have, therefore, christened them "*cyanophycean bands.*" In German these bands are called "*Tintenstriche*" (*i.e.* ink-streaks). They appear to be frequent in cliffs in the Alps (cf. FOTT 1959, p. 416), but they are there by far not so strikingly

developed as in the Arctic regions, where they, however, have not attracted the attention of students.

To be sure, cyanophycean bands are found everywhere in Greenland on moist cliffs, but appear to be particularly well developed on the bird cliffs. This may have something to do with the large amounts of nitrogen compounds and other nutrients, supplied by bird excretion in the water seeping down, but nothing is known about it. As is wellknown many cyanophycean algae are capable of fixing molecular nitrogen. This activity is affected by edaphic as well as climatic conditions. In calcareous soil the fixation is much greater than in loess, lime and mull (HENRIKSSON *et al.* 1972, p. 420), and it is possible that the level of fixation is higher under the chemical conditions caused by bird manuring than it is elsewhere in the Arctic. At any rate, nitrogen fixation is one of the most important biological processes, and the presence of these cyanophycean bands in the bird-cliffs may contribute directly to the nitrogen input in the coprophytic plant communities (cf. SCHELL & ALEXANDER 1973, p. 131). The possible contributions of nitrogen by cyanophycean crusts in the arctic region has been stressed also by BILLINGS (1974, p. 419). The nitrogen fixation is particularly important in northern regions, not because of spectacularly high rates compared with, for example, tropical and subtropical environments, but because in arctic regions there are everywhere — except in areas with bird manure — only two sources of "new" nitrogen input, namely rain and nitrogen fixation (ALEXANDER 1974, p. 119). However, the optimal temperature for nitrogen fixation is about 15°C, and the plants are inactive at 0°C. Therefore, it must be admitted that nitrogen fixation is not well adapted to arctic conditions, and this fact may also account for the low nitrogen content of arctic soil (KALLIO 1974, p. 194).

The cyanophycean bands possess a rich fauna of invertebrates. In samples collected at the bird-colony Skarvefjældet near Godhavn on Disko in June 1973 a great number of a rotifer, *Philodina sp.*, and a tardigrade, probably *Macrobiotus coronifer* (cf. PETERSEN 1950, p. 60 and Fig. 18), were found; identified by Dr. ULRIK RØEN. I do not know if these and other organisms living in the moisture of the cyanophycean bands may be regarded as coprozoans (cf. p. 139). A study of the ecology of the animal life in such places has never been carried out and must be left to future investigations.

Caloplaca Arches

The heliophytic orange-coloured lichen *Caloplaca elegans* is a never failing attendant on the presence of bird manure, provided that there is a sufficient amount of sun-light. On bird-cliffs with an extreme northern

exposure it is virtually absent, while it is profusely developed on south-exposed cliffs. For this reason the bird-cliffs with the latter exposition are here called *Caloplaca* cliffs. This lichen is extremely nitrophilous, and it is evident that avian or mammalian (or human) excrements must have been present wherever it is growing, *i.e.* it is an obligate coprophyte. This is most distinctly to be seen at the sea-bird colonies, where *Caloplaca elegans* may cover large areas, sometimes even thousands of square metres. It is found, however, at all places where birds nest, roost or perch, except at the nests of passerines, which remove all droppings from the immediate surroundings of the nest. On the other side, *Caloplaca elegans* grows most profusely at the nests of the birds-of-prey, at standing places of gulls and skuas, at resting and sleeping places of the Cormorant, at cliffs and stones where terns roost, and even at the sleeping sites of Snow-Buntings. It is further found at burrows of the Arctic Fox, at places where hares, foxes and other mammals have defecated and at sites of old Eskimo settlements, in short on all manured ground.

It is evident that *Caloplaca elegans* is a typical lithophyte, being attached particularly to cliffs and houlders and usually avoiding vegetation or loose earth, where it is sometimes replaced by another nitrophilous lichen, *Xanthoria candelaria*, which is also orange-coloured. However, I have in exceptional cases found *Caloplaca elegans* growing on grass, twigs and loose earth. The ecology in Greenland of *Caloplaca elegans* has been briefly described by Daniëls (1975, p. 26–29), but he does not mention its relation to sea-bird colonies.

At sea-bird colonies dried manure is caught by the wind and deposited as dust on the cliff-walls around the bird-sites. In temperate regions a similar procedure takes place near farm-yards, where dust originating from cattle and horse dung is carried by the wind and deposited on stones and trees and utilized by coprophilous lichens in these places (Sernander 1912, p. 843).

The rather low concentration of nutrients present in the fine dust on the bird-cliffs appears to be optimal for *Caloplaca elegans*, and in such areas the cliffs are coloured fiery orange by the lichen. Below the nesting places of the birds the manure is smeared over the cliffs, mainly by rain, and its concentration is usually too high to give rise to any growth of *Caloplaca* or, for that matter, of other plants. The whole vegetation is scorched and the cliffs appear to be almost sterile, or possess only some few and scattered *Caloplaca* elements (cf. Fig. 24). The result is that the areas covered by *Caloplaca* form a huge arch, beginning just above the talus or a few metres above high tide, continuing round the nesting area and above it and then, on the other side of the bird-colony, again descending to the talus or to sea-level. This *Caloplaca* arch, as it is called here, is most typically developed in gulleries, inhabited by *Larus glau-*

coides, *L. hyperboreus* or *Rissa tridactyla*, as shown in Fig. 23. On the figures in plate II are shown two typical examples of *Caloplaca* arches. If the gullery is very small and situated high up on a steep cliff-side, the *Caloplaca* growth does not form an arch, but is also found beneath the bird-colony, in such cases constituting a more or less circular area around the nesting sites. These latter then form a whitish central area, on all sides surrounded by lichen-clad orange-coloured areas.

The distance from the bird-cliff, from which the fecal dust is carried by the wind and to the outermost limit to which the *Caloplaca* vegetation penetrates, differs greatly, dependent on local conditions, form of the cliff, force of the wind, etc. Usually the breadth of the *Caloplaca* arch is less than 50 m, but sometimes it is as narrow as 10 metres and in a few cases up to 200 m broad, which is the maximum measured by me.

There is often a difference in the breadth of the two sides of the arch. On south-exposed bird-cliffs in narrow and windy fjords the western side of the arch is often much broader than the eastern one, which is shown in the example in Fig. 23. The reason for this difference is the heavier force and the greater carrying capacity of the easterly cathabatic winds, blowing from the ice-cap, than of the more clement sea-winds blowing from west to east.

It is obvious that *Caloplaca* prefers a dry air with a low relative humidity. Therefore, it is best developed and most brillantly coloured on the dry south-exposed cliffs, especially those with a broad talus below. At such places ascending moist air-currents from the sea or fjord below influence the bird-cliffs only to a slight degree. For similar reasons *Caloplaca* is less well developed on bird-cliffs facing the open sea, because wet and salt air-currents or foggy weather are very frequent phenomena there. On west-exposed cliffs at the outer coast the *Caloplaca* vegetation may, therefore, be as reduced as that on north-exposed ones in the fjords. In exceptionally cold and moist fjords with much fog, like the inner parts of the Evighedsfjord in Sukkertoppen District, the *Caloplaca* development may be reduced even on south-exposed cliffs. At north-exposed cliffs the air is as a rule so moist that the avian guano dries up only to a small extent, and is, therefore, not carried by the wind as desiccated dust to the surrounding cliff areas. This fact, together with the restricted sun-light, may contribute to the virtual absence of this heliophytic lichen on the north-exposed bird-cliffs. When it is present on such cliffs it is evident that its growth is inhibited. It is pale yellow, not orange or reddish, and appears in many cases to be dead or dying. Altogether, *Caloplaca* is missing in all places where there is constant moisture. It is never developed on the cyanophycean bands and in places sprayed by waterfalls or rivulets running down the bird-cliffs. South-exposed bird-cliffs with a large scree form the optimal habitat for *Caloplaca*

elegans, but even in such places it is lacking on the boulders in the scree except on those nearest to the cliff-wall itself. The reason for this is probably that all air-currents lead upwards or to the sides and thus give no impetus to the accumulation of fecal dust in areas far below the bird-cliff.

The *Caloplaca* growth is not particularly well developed in the subarctic and southern lowarctic part of Western Greenland. Not before the Godthåbsfjord begins *Caloplaca* to form its profuse growth on the bird-cliffs.

It is for many reasons of interest to know the influence of the time factor in the formation of a *Caloplaca* vegetation and its disappearance. When a bird-colony is established, or simply when some fecal material is deposited, how much time passes before the *Caloplaca* begins to grow and before it becomes visible? No lichenometrical studies have been carried out on *Caloplaca*, but extensive investigations of the common Greenland lichen *Rhizocarpon geographicum* have shown that its growth in the first 20 years is virtually zero, this period including the lagtime for colonization and the very smallest initial growth. Then this species grows approximately 1 mm every 4.4 years in S. W. Greenland. For a given lichen diameter the age with confidence limits can be determined (Pitman 1973, p. 9). No doubt *Caloplaca* possesses a similar very slow growth rate, and it is possible, therefore, to draw the conclusion that the vegetation in the bird-colonies must be extremely old. I have measured a number of thalli of *Calaplaca* and found many specimens which were as large as 60 mm. According to Pitman (l.c.) this would in *Rhizocarpon* correspond to an age of 286.14 ± 57.86 years. I am sure that the *Caloplaca* vegetation on well manured localities is much older than that, indicating how extremely conservative the choice of nesting sites and feeding and roosting places of birds is in the unchangeable and static Arctic landscape. This view agrees with the statement of Beschel (1958, p. 254) that the growth of *Rhizocarpon* in West Greenland is so slow that the largest thalli may well be 4,500 years old.

When a sea-bird colony is deserted by its inhabitants the *Caloplaca* vegetation remains, but for how many years? This has not been studied, but I am sure that the *Caloplaca* may remain as a silent witness of a former bird-colony for hundreds, possibly thousands of years. Such ancient abandoned bird-colonies traced through the occurrence of extensive *Caloplaca* vegetations are not common. However, I have found about a dozen in West Greenland, deserted so long time ago that the existence of former bird-colonies in these localities was quite unknown to the local Eskimo inhabitants. Even when kept in collections the *Caloplaca* may last for a very long time; how long is unknown. I have collected some stones with *Caloplaca* attached and have kept them in a box,

deprived of light, water and nutrients for more than 10 years, but the appearance of the lichens is still the same as when they were collected. Their orange-red colour, due to the dye parietin, has not changed at all. I have investigated the Greenland collections of *Caloplaca elegans* in the Botanical Museum in Copenhagen, together with Dr. ERIC STEEN HANSEN, and found the oldest specimens, from 1895, to be as brilliantly orange as seen in nature. Such old preparations kept in dry air in museum boxes are completely desiccated and sapless, and are, therefore, easy to scrape off from their foundation with a knife. However, in the field the lichens are regularly moistened by rain and may remain on the cliffs almost forever.

A number of other lichens are distinctly nitrophilous and many of them are found in the sea-bird colonies. Each species of lichens has its own demand for nitrogen, and finds its place as near its optimum requirements as the severe competition with other nitrophilous lichens will allow (cf. LYNGE & SCHOLANDER 1932, p. 7). Most important are species within the genera *Xanthoria*, *Parmelia*, *Lecanora* and *Physcia*, but none of them cover as large areas and are as strictly attached to manured ground as *Caloplaca elegans*, although *Physcia tribacia* may be as nitrophilous as *Caloplaca elegans*. Many of these genera are found also in the Antarctic region, connected with the penguin colonies (SERNANDER 1912, p. 877). However, only *Caloplaca elegans* is considered in my studies of the sea-bird colonies. In boreal latitudes this species is replaced by its near ally, the highly nitrophilous *C. granulosa*, while *C. elegans* here appears to be much less coprophilous, or perhaps to lose in the competition with *granulosa*. *Rinodina balanina* and *Buellia coniops* are other highly coprophilous lichens in the boreal region (GRØNLIE 1948, p. 223). Where there is a heavy contamination of guano even *Lecania aipospila* and *Lecanora poliophaea* may occur (GILBERT and WATHERN 1976, p. 497).

Most biologists have not realized the close connection between these lichens, particularly *Caloplaca elegans*, and the sea-bird colonies. A closer analysis of this relationship is given in this paper, but has previously been neglected. Still, many botanists, particularly lichenologists, have described the nitrophilous status of the lichens, but no comprehensive paper on the relations between birds and lichens have been published. The most important contributions about arctic and boreal nitrophilous lichens (particularly about *Caloplaca*) have been published by SERNANDER 1912, SUMMERHAYES & ELTON 1928, DU RIETZ 1932, LYNGE & SCHOLANDER 1932, LYNGE 1934, *idem* 1940, SCHOLANDER 1934, GRØNLIE 1948. Works on lichens in Greenland (but not mentioning any species growing in sea-bird colonies) have been published in recent years by DAHL 1950, HANSEN 1971, HANSEN 1978, *idem* 1978a.

The Coprophytes and their Biological Foundation

The manure of sea-birds is of extreme importance for the distribution of arctic plants, and to a lesser degree even for the growth of plants in boreal and more southern regions. In the Arctic the manure in dry periods is blown away by the wind, as already described above (p. 95-96), and the fertile dust is carried down into the soil by the rain or melting snow to supply the plants with valuable nutritive salts.

It must be borne in mind that arctic soils are usually very unfavourable for the development of plants, being poorly drained, poorly aerated and deficient in nutritive salts. This is due to the low temperature, which retard organic decay by bacterial action and accordingly slows down the production of nitrates and phosphates as well as other salts needed by plants. Particularly the poorer adaptation to low temperatures of the putrefactive and nitrifying organisms, which are responsible for the formation of nitrogen compounds, as compared with that of the energy supply via photosyntesis of the plants, makes the nitrogen deficiency in the Arctic understandable.

The level of plant growth in the Arctic is usually very low, and this has been attributed to the low level of soil nitrogen. It has been stated by many students (*e.g.* by Russell *et al.* 1940, p. 270) that nitrogen dificiency results from low bacterial activity due both to low temperature and low nutrient supply. It is significant, therefore, that plant growth is more luxuriant where manured by animals (Bliss 1962, p. 122). It must be admitted, however, that the physical and chemical factors of the arctic environment and their effect on the growth of bacteria are not too well understood. It is known that nutrition will affect the growth rate of bacteria, and that nutritional demands will increase with increasing temperatures. Thus, in arctic habitats nutrition may be the limiting factor (Boyd & Boyd 1971, p. 41). Throughout the Arctic bacterial populations appear to be smaller than normally found in temperate regions, where counts for uncultivated soils range from 1 to 50 millions per g (Waksman 1952), and for cultivated field soils from 10 to 80 millions per g (Jensen 1951, p. 27) or from 100 to 3,000 millions per g (Stålfelt 1960, p. 70). In Peary Land, in higharctic North Greenland, the number of bacteria varies from 2.2 million to 14.1 million per g of moist soil, which is a rather low density (Jensen 1951, p. 27). Naturally, the thermophilic bacteria are usually present in very low numbers in arctic soil, and they may be lacking completely, although they are usually present where they can use animal manure as a nutrient (Boyd & Boyd 1971, p. 41).

Students do not agree, however, in the assumption that the number of bacteria is lower in arctic soil than in boreal and temperate areas.

New investigations carried out in the northern Taimyr Peninsula in Siberia have shown that the quantity of bacteria in the upper horizons of most soils is large, showing little or no difference from the soils of more southern latitudes as regards the total bacterial content. According to ARISTOVSKAYA & PARINKINA (1972, p. 82) it is obvious that the micro-organisms, although viable, do not show intense activity, and in this way the great amount of bacteria observed in the Taimyr soils is not indicative of the biological activity in the soil. The fact that temperatures above freezing point, which are essential for enzymatic processes, prevail in the soil for a short time only, limits considerably the biochemical activity of the microflora. Usually, +5°C is accepted as the temperature below which biological activity is very slow or prohibited. Thus the period during which soil genesis proceeds most rapidly can be approximated by the time soil temperature is +5°C or above (RETZER 1974, p. 781). Besides, in all the soils examined the microbes were most abundantly developed exclusively in the upper, frequently very narrow horizon of the soil profile. This shows that in the Arctic all active life is confined to the soil surface, the number of life-limiting factors increasing with depth (ARISTOVSKAYA & PARINKINA 1972, p. 86; PARINKINA 1974, p. 65; DUNICAN & ROSSWALL 1974, p. 89).

This theory explains satisfactorily why the bacterial activity is so low and, consequently, the production of nitrogen and other plant nutrients so extremely modest in the Arctic. On account of the nitrogen supply being so utterly low in the Arctic soil, any additions will have a most marked effect. Such additions are primarily supplied by sea-birds, and the nitrogen which they deposit in guano is a constant and very considerable additive factor, the feces adding appreciably to the actual quantity of nitrogen in the soil. RUSSELL *et al.* (1940, p. 274), in their microbiological studies on Jan Mayen, found a marked correlation between the activity of nitrofying bacteria and the presence of vegetation. The bacteria were absent from localities where vegetation was sparce, while they were most abundant in localities with a luxuriant vegetation associated with the accumulation of bird or mammal excreta. RUSSELL adds that where there was a well-developed vegetation in areas unfrequented by animals the activity of nitrifying organisms on the basis of the laboratory tests was very low. This indicates that the occurrence of the bacteria is correlated directly with the distribution of animal guano.

An adequate supply of mineral nutrients, especially nitrogen, phosphorus and potassium is essential for plant growth, and nitrogen is particularly important and is required in the largest amount. This is due to the fact that proteins and nucleic acids, the building blocks of living material, consist of more than 15 per cent nitrogen. Therefore,

large amounts of this element are required for optimal plant growth. It is obvious that in the Arctic, where the nitrogen level is low, it is a controlling factor in plant growth. Consequently, in areas frequented by sea-bird colonies and where for this reason the nitrogen level is higher,the vegetation is much more luxuriant. It follows that nitrogen supply must be regarded as a most important ecological factor in Arctic regions.

Some students maintain that the effect of the sea-bird guano is not due solely to the increase of nitrogen. Other nutrients, especially phosphorus, will also be increased and are assumed to be responsible in part for the greater growth (R. S. Russell *et al.* 1940, p. 270; Grønlie 1948, p. 172). Du Rietz (1932, p. 105) is even of the opinion that the coprophilous species of certain lichens are possibly rather phosphatophilous than nitrophilous. I do not think this is correct, for excess of phosphate over the amount required gives rise to reduction of the vegetative growth, while the growth is excessive near the sea-bird cliffs. Moreover, plants are relatively inefficient users of phosphates in fertilised fields, where rarely more than 20 to 30 per cent of the amount supplied is taken up (E. W. Russell 1961, p. 38). Even R. S. Russell *et al.* (1940, p. 277) found, themselves, that away from bird-cliffs (on Jan Mayen) where guano was less frequent there was a very marked fall in the level of both total and inorganic nitrogen and the activity of the nitrifying bacteria decreased. It should further be mentioned that the experiments of Gessner (1932, p. 127) in sea-bird colonies have shown that it is the accumulation of nitrogen which plays a role, while other matters are without significance, and that in this way nitrophilous plants will predominate and nitrophobous ones entirely disappear.

It appears that the species of bacteria found in the arctic soil are largely the same as those found in soils from other geographical regions and that most of the common species of soil bacteria are ubiquitous (Barthel 1922, p. 25; Jensen 1951, p. 24; Russell 1961, p. 215). There are some distinct differences, however. The decrease or absence of thermophilic bacteria in the Arctic region has been mentioned above (p. 99). The well-known nitrogen-fixing bacteria *Azotobacter*, so widespread in boreal and temperate regions, appears to be completely lacking in the greater part of Greenland (Jensen 1951, p. 25) and in northern Siberia (Russell *et al.* 1940, p. 287). This was to be expected, because the activity of *Azotobacter* diminishes sharply with falling temperature and the minimum temperature of development of *Azotobacter* evidently lies a little above 0°C (Michustin & Shilnikova 1969, p. 81).

The proteolytic decomposition is considerably inhibited in the Arctic region, mainly on account of the low temperature and the extreme humidity or moisture in the soil. The majority of the bacteria active in the proteolysis have a higher temperature optimum (30°–45°C) than

Fig. 26. Peat-formation in the coprophyte zone of a *Uria lomvia* colony in the Carey Øer, Thule District. In the centre left is a large tussock of *Cerastium alpinum* (sterile) with a tuft of *Alopecurus alpinus* on the top. To the left under *Cerastium* are one to two years old withered straw to be seen, while these are removed to the right in order to show the black layer of peat underneath. The folding rule to the left is exactly one metre. (Phot. 27th July 1973 by F. SALOMONSEN).

usually present under an arctic regime. It is true that selection has produced populations active at lower temperatures, but, nevertheless, the decomposition goes on with a very slow velocity everywhere in the Arctic. In the ordinary tundra long term rates of total decomposition will approximately equal the production, and there will be no accumulation of organic matter. However, it will take almost a hundred years before organic accumulation and decomposition under uniform climatic conditions are assured of reaching a steady balance (BROWN *et al.* 1970, p. 43; HEAL 1972, p. 94).

Such a balance is never reached in the coprophyte vegetation on the bird-cliffs, for the intense plant production will soon accumulate and outweigh the modest amount of decomposed material. The result will be the formation of thick layers of peat, which always will take place

when the plant production is encouraged and the decomposition inhibited. Under the profusely growing plants withered straw from many generations are accumulated, frozen for the greater part of the year and only slightly decomposed, if at all (Fig. 26). At the bottom of this layer the straw become denser and gradually form a tight peaty material in which ventilation is very slight. Consequently, oxygen is almost lacking and this will inhibit or prevent the activity of aerobic nitrifying bacteria. In addition, the formation of ammonia, the usual product of decomposition, is hampered, thus inhibiting the activity of the nitrifying bacteria in transforming ammonia into nitric acid. The material is therefore piling up, especially in so cold regions as the arctic ones, and will be inaccessible to the plants, even though nitrogen is present in large quantities. However, as soon as aqueous ammonia compounds are formed they are at once absorbed by the plants and also, to some degree, leached in the cold and moist climate. This accumulation of non-decomposed material takes place in all soils covered with coprophyte vegetation in the Arctic, but is much more pronounced in the higharctic than in the lowarctic zone. The piling up of organic material, especially nitrogen and phosphorus compounds, in the soil of the coprophyte areas is to be seen in some soil samples which I collected in the higharctic Carey Øer, Thule District, on the 19th August 1975. Sample A was collected in the coprophyte area (zone B; cf. below p. 114) on the scree under a cliff inhabited by *Uria lomvia* and densely grown with a lush and high vegetation of *Cochlearia officinalis*, the control sample B in dry mosscovered ground far from any influence from the bird-colony. The samples were analyzed by P. Milan Petersen, the Institut of Ecological Botany, at the University of Copenhagen, and demonstrated a remarkable difference between the coprophyte area and the control area, as to be seen in the following table.

	A	B
Water content (in fresh material), percent	321	276
Organic matter, determined by wet combustion, percent	54	59
Loss on ignition, percent	80	87
The following figures give the values in ppm		
N	351	11
P[1]	14,740	261
Cu	52.5	13.8
Zn	112	10.8
Ni	12.2	7.2
Li	2	1.2
Sr	314	19

[1]) Soluble in 0.2 N H_2SO_4.

The huge figure for phosphorus is especially noteworthy. Soils of higharctic and lowarctic areas are generally low in available phosphates, the concentration usually ranging from 1,000–2,000 ppm (HANSON & JONES 1975, p. 212). Bone constitutes a major reservoir of phosphorus, and the significant excess of phosphorus at the bird-cliffs, therefore, no doubt is due to the fish-eating habits of Brünnich's Guillemot.

During his studies in Spitsbergen, REMMERT (1968, p. 47, and 1972, p. 41) arrived at a new theory concerning these problems. Since there is some plant growth in Spitsbergen, but only a very slight decomposition owing to the low temperature, various homoiothermous herbivores are stated to be responsible for the energy flow of the tundra ecosystem by feeding on the vegetation. This does not appear to be probable, at least not in Greenland, where herbivorous mammals and birds are scarce or absent, and at the bird-cliffs it is definitely incorrect. The abundant plant growth is formed into peat, as described above.

The layers of peat at the bird-cliffs are a striking phenomenon. They attain a thickness of up to two or four metres and are in many places in Greenland still utilized by the inhabitants for fuel. On some localities peat has been dug for over a century, and the amount appears almost inexhaustible. Most peat-winning takes place on small islands formerly inhabited by numerous *Sterna paradisaea* and situated near inhabited cities or outposts. One of the bestknown "peat-islands" is situated near Egedesminde (cf. HARTZ 1898, p. 35 and PORSILD 1921, p. 14), but the peat of the talus on real bird-cliffs could be used just as well. At any rate, the coprophytic peat is an important economic asset for the inhabitants.

It would be highly interesting to make a radiocarbon dating in the lowest horizon of these peat layers to determine their age. The biggest layers are found in the higharctic zone, where the peat formed on the breeding places of *Plotus alle* may attain a thickness of 4 m (SALOMONSEN 1950, p. 402). Recently BLAKE (1977, p. 451) has made a radiocarbon age determination of a peat deposit on Nordvestø, Carey Øer, in Thule District (*i.e.* in the higharctic zone). The peat, which was of "the palsa type" (interspersed with ice lenses), was situated "at an elevation of 140 m on the edge of the plateau, overlooking the north coast of the island." The presence of this peat deposit here must have been the result of a local sea-bird colony, which, however, does not exist any more. The peat layer had a depth of 258 cm and appeared to be 6300 ± 80 years old. The peat consisted of only one species of plant, the moss *Aplodon wormskioldii*. This species is known to be a very pronounced nitrophilous plant, restricted to growing on feces or carcasses, *i.e.* an obligate coprophyte. This former bird-cliff must have been established as soon as the ice withdrew from the high-arctic areas after the glacial epoch.

The production of bird guano has a pronounced selective effect.

Some species of plants are kept totally away from the bird-cliffs while other species, able to thrive there, grow very vigorously. Virtually all heath-plants are completely absent from the coprophyte vegetation (cf. p. 118). The question is whether these plants are directly killed by the large content of nitrogen in the soil or whether they simply are losers in the competition for nutrients. GESSNER (1932, p. 127) is of the opinion that since heath-plants are very sensitive to a high content of nitrogen compounds in the soil, this factor influences the plants directly and causes them to disappear. It is, therefore, not competition which makes it possible for better adapted nitrophilous plants to crowd out the heath-plants. STÅLFELT (1960, p. 319), on the other hand, maintains the view that the coprophytes have a higher optimum for nitrogen, which enables them to tolerate a greater content of nitric acid in the soil and a consequent accumulation of this matter in the cells, while other plants growing at bird-cliffs would take into their tissues more nitrogen compounds than they could tolerate. Probably both factors play a role in the composition of the coprophyte vegetation.

The plants constituting the vegetation of the bird-cliffs and dependent on the high concentration of ammonia and nitric acid in the guano are here called *coprophytes*. They have already received various names. The designations *nitrophilous plants* or *nitrophytes* are too futile and insignificant, whereas the terms *ornithogene plants* (used mainly by Russian biologists) or *ornithocoprophilous plants* are too narrow and limited in their scope. SERNANDER (1912, p. 805), who created the latter clumsy term for various lichens, wanted to distinguish plants dependent on bird manure from those dependent on mammalian dung. It is true that the excreta of the two animal groups differ considerably. The semisolid excretion of birds is rich in chlorine and its main nitrogen compound is uric acid, which is a stable and insoluble substance. The mammals produce a liquid urine, in which the main nitrogen compound is urea, an unstable and soluble substance. Moreover, the fecal material of mammals is poor in nitrogen (HUTCHINSON 1950, p. 5). However, the differences in vegetation between places with bird guano and with mammal dung appear to be negligible, if present at all. As an example can be mentioned that *Stellaria media*, the wide-spread weed, is as common in bird-cliffs as in sheep-pastures both in Greenland and elsewhere. This plant is well-known for its capacity of accumulating nitrogen compounds in its cells. Its wide-spread distribution at bird-cliffs in southern Greenland is probably due to dispersal by birds (BÖCHER 1959, p. 16). GRØNLIE (1948, p. 234) found in boreal Norway the same species of grass (*Festuca rubra*, *Poa pratensis*, *Agrostis tenuis*) on cattle pastures as on the bird-cliffs. By far the majority of vascular plants are the same in both biomes, and it does not appear necessary to distinguish between

coprophytes connected with avian manure and with mammalian dung. The same grassland species as those mentioned from Norway are abundant on bird islands in western Scotland (Flannan Isles, St. Kilda and North Rona), but apart from them also *Holcus lanatus* is common. It appears that gulls (but not sheep) are responsible for the abundance of this "nitro-tolerant and trampling resistant" species (GILBERT & WATHERN 1976, p. 492).

The Hydrogen Ion Concentration in the Coprophyte Vegetation

It is generally maintained that one of the conditions for nitrification is an alkaline or at least a neutral reaction in the soil. According to STÅLFELT (1960, p. 106) the optimum reaction for the activity of nitrifying bacteria is a pH of 8–9, although he admits that these bacteria are present also in more acid soils. It should, therefore, be expected that the reaction optimal for soils with coprophyte vegetation would be distinctly alkaline. This does not appear to be the case. Everything tends to show that the hydrogen ion concentration only indirectly, if at all, influences the change of vegetation from ordinary heath to coprophytic communities. Nitrification can take place even in acid peat at a pH lower than 5. Excessively manured soil may have a neutral or weakly acid reaction. GESSNER (1932, p. 121) on a very large material found in Germany in heath grown with *Calluna vulgaris* the hydrogen ion concentration to be 4.0–4.2, but when the vegetation was destroyed by bird manure the pH rose only slightly, to 4.3–4.8. GRØNLIE (1948, p. 166) found the pH in pure guano at bird-cliffs in Norway to be 6, in soil covered with coprophyte vegetation 4–5. In bird-cliff plant communities on Jan Mayen the pH varied between 7.1 and 7.6 (RUSSELL *et al.* 1940, p. 277). In soils with extremely nitrophilous lichens the pH was 6.0–6.1, in those with lichens of lesser nitrophily it was about 5 (DU RIETZ 1932, p. 94). All these investigations tend to show that the acidity diminishes slightly with increasing guano concentration. The same appears to be the case in Greenland material, collected by me. In 23 samples of soil collected from the 22nd July to 1st August 1960 in coprophytic zones of various bird-cliffs in the fjords of Holsteinsborg and Sukkertoppen Districts, the pH was 4.2–6.3, with an average of 5.5. In four control samples from heath the pH was 4.2–5.1, average 4.7. The values of pH were kindly determined by Prof. M. KØIE. The differences between the two series of samples are slight, almost of the same order of magnitude as those found by the students mentioned above. A similar very small difference was present at the gull-colony at Igpik, Disko, where two samples taken in the coprophyte vegetation on the 8th July 1973 had a pH of 6.8 and 7.0, while a control taken in heath with *Vaccinium uliginosum* had a pH of 6.5. The general value of pH in tundra soil appears to be 4.0–6.5 (FLINT and GERSPER 1974, p. 377).

The ordinary heath-plants, growing on poor acid soil, such as *Cassiope tetragona*, *Dryas integrifolia*, *Empetrum nigrum*, *Betula nana*, *Ledum palustre* and others, which are completely absent from coprophytic communities, are in Greenland found only on soils with a pH of 5–7. These figures do not differ from the pH values in soils with coprophytic vegetation and, therefore, the differences between heath vegetations and coprophytic ones cannot be due to changes in the hydrogen ion concentration.

On the skerries along the coast or in the open sea the conditions differ remarkably. On bird-islands of this kind the ground is more or less saturated with salt, originating from winds or fog from the sea or spray from the wawes. The surface values of pH in the open ocean usually range from about 8.1 to 8.3 (Moore 1964, p. 90). For this reason the pH in the soil on skerries off the coast is much higher than in cliffs protected from the oceanic climate. On the skerry Asigsut, a bird-island in Disko Bugt with a rich and variegated sea-bird fauna, the coprophyte vegetation differed from that of ordinary bird-cliffs, no doubt on account of the salty soil. Samples of water from two fresh-water pools, with much guano, examined on the 30th July 1973, had pH's of 8.7 and 8.9, which are exceptionally high figures. It can be mentioned that in Baltic rock-pools with much suspended bird-guano still higher pH values have been recorded, with a maximum value of 10.3 (Ganning & Wulff 1969, p. 278). Three further samples from Asigsut taken in the soil covered with coprophytic vegetation had a pH of 9.1–9.2. Controls taken the same day on nearby Kronprinsens Ejland, in moist heath covered with *Empetrum nigrum* and *Salix herbacea* had pH's of 8.8 and 9.3, which values are just as high as in the coprophytic areas on Asigsut. The pH of the 1973 samples were kindly determined by Dr. Ulrik Røen.

It appears from the investigations mentioned above that the pH of areas with coprophyte vegetation is virtually the same as that of soil covered with ordinary heath-plants and that differences in that measure is not correlated to any variability in the plant communities, in so far as connection to coprophytic vegetation is concerned.

Usually a plant species is tied to a particular fixed pH value, but in certain cases the pH amplitude is subject to a geographical variation, changing in accordance with the climatic zone in which the species grow (Stålfelt 1960, p. 302). It is possible that such differences may be present in some coprophytes which show a pronounced geographical alteration in their sensibility to guano. Such differences appear to be developed between the boreal and the arctic populations of *Caloplaca elegans* (cf. p. 98) and *Elymus arenarius* (cf. p. 130), but whether they somehow are connected with a different adjustment to pH is quite unknown.

Previous Investigations on Coprophytes

The formation of the coprophyte plant communities shows how paramount is the lack or presence of nitrogen in the Arctic. However, the significance of sea-bird colonies in this respect is little known and little studied by botanists. Every student who has specialized in the coprophytes has been struck not only by the importance of the connection between birds and plants, but has even given expression for the exuberance and beauty characteristic of the coprophytic plant communities. SCHOLANDER (1934, p. 118) states about the plants from northern Spitsbergen that "if the ground is manured from an overhanging bird cliff the favourable conditions of vegetation thus created in such places are not equalled in any other localities of the Arctic." Something similar is said by SUMMERHAYES & ELTON (1928, p. 239), also about the coprophyte communities in Spitsbergen: "Some of the communities are particularly striking as they form oases of green vegetation in some of the most desolate and barren regions of the archipelago." BERTRAM & LACK (1938, p. 31) state about Bear Island that on ledges and on slopes below cliffs with bird colonies "occurs the most luxuriant vegetation on the island." SCHOLANDER (1934, p. 124) says about the bird-cliffs of northern Spitsbergen: "Characteristic is the close plant cover which even at a distance can be seen as green patches in the landscape; this is otherwise very rare in North-East Land." The same phenomenon has been described from Novaya Zemlya, where "the immense bird colonies are largely responsible for an extraordinary development of the flora" (HUTCHINSON 1950, p. 369). LYNGE studied the coprophytic flora on Novaya Zemlya and says about a typical *Caloplaca* cliff that its "continuous cover of vegetation, a soft carpet of mosses, brillant *Caloplaca* and a number of fine flowers everywhere" was a real "hot-bed of great beauty" (LYNGE 1934, p. 166). He repeatedly speaks of "the most beautiful flowers" on the bird-cliffs and that they were "revelations of beauty" (p. 164). It must be added that both Spitsbergen and Novaya Zemlay belong to the higharctic zone, where I have found myself that the contrast between the splendour of the multicoloured flower mats at the bird-cliffs and the modest vegetation elsewhere is most striking. However, it is true that nowhere in the Arctic region are flowering plants found in such a lush exuberance, forming such extensive and variegated mats and growing in such large quantities as in the comparatively restricted space on the bird-cliffs (Fig. 27). Let me take the liberty to quote what I have said myself about this matter at a previous occasion: "A visit in summer to such a bird colony with its variegated vegetation is a marvel of beauty, unsurpassed in the Arctic. The polychrome cliff, white in the breeding area, surrounded by red lichen flats for perhaps hundreds of yards, and

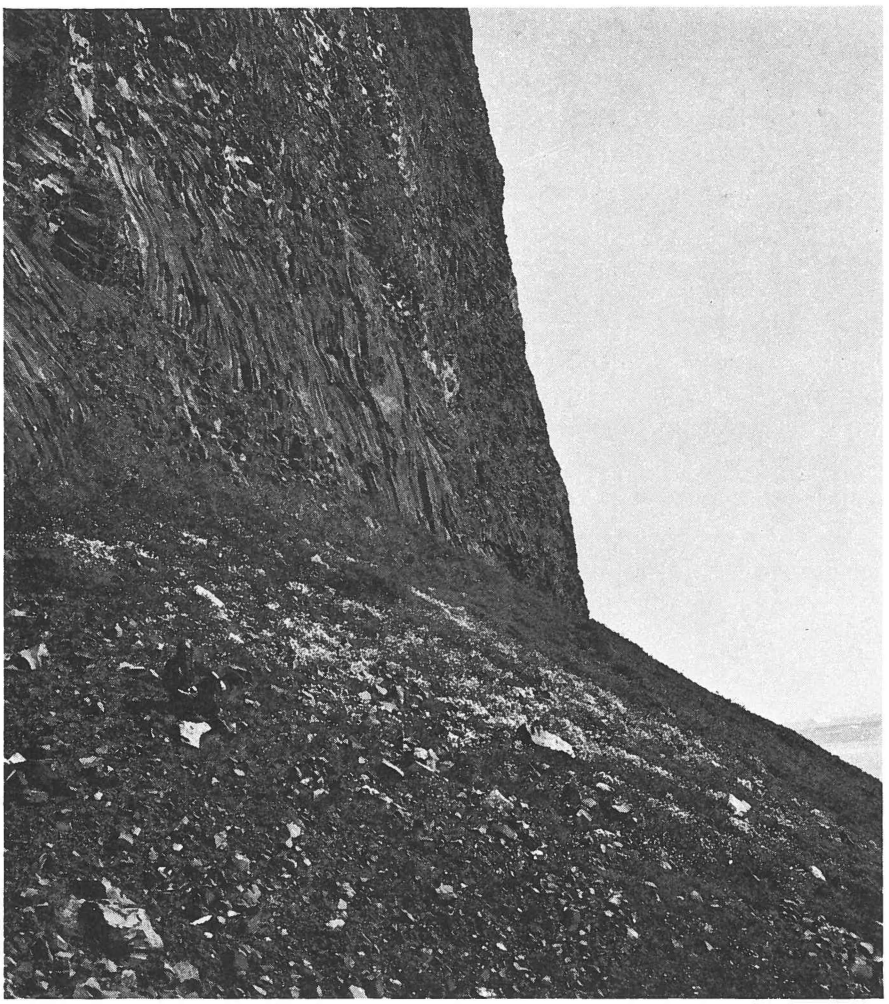


Fig. 27. The colony of Glaucous Gull, *Larus hyperboreus*, at Igpik, Disko, showing luxuriant growth of flowering *Arabis alpina* and *Taraxacum sp.* on the scree. The cliff-walls are stained red by *Caloplaca elegans*. (Phot. 8th July 1973 by F. SALOMONSEN).

with an apron of lush verdure in glaring contrast, is visible far away and at once attracts the attention" (SALOMONSEN 1958, p. 271). Plate III gives an idea of this impression of beauty.

Considering the importance of the coprophyte vegetation and its principal significance in arctic ecology it is amazingly little that has been published about it. In the following a short outline shall be given of the most important publications.

Scandinavian botanists were the first to discover the coprophyte vegetation at bird-cliffs, and FRIES (1869) and NATHORST (1888) gave

good descriptions of this phenomenon on Bear Island and Spitsbergen. However, the vegetation on "manured soil" has been described much earlier in arctic North America (RICHARDSON) and Siberia (MIDDENDORFF); cf. WARMING 1886, p. 152. Spitsbergen and Bear Island are still the best known parts of the Arctic in this respect, and good descriptions of the coprophyte vegetation have been given by SCHOLANDER (1934), SUMMERHAYES & ELTON 1923, *idem* 1928, BERTRAM and LACK 1938, EUROLA & HAKALA 1977. Novaya Zemlya has been mentioned already (p. 108), and from the Murman Coast rather short notes have been published by TATARINKOVA (1967) and BRESLINA & KARPOWITCH (1967). Excellent studies on coprophytes and the nitrophilous microorganisms have been carried out on Jan Mayen by RUSSELL & WELLINGTON (1940) and RUSSELL *et al.* (1940). Unfortunately, very little work has been done in Iceland, where apparently no collection of plants have ever been made on bird-cliffs. However, some scattered remarks have been published by THORODDSEN (1914, p. 318) and GRÖNTVED (1942, p. 73). Even in the Faroes very little work has been done (OSTENFELD 1908, p. 1003; SSLOMONSEN 1935, p. 182), but an excellent survey was made by RASMUSSEN (1946, p. 46). In Norway splendid work has been done by NORDHAGEN (1922), HOLMBOE (1925) and especially by GRØNLIE (1948). In Sweden mainly the coprophilous lichens have been studied (SERNANDER 1912, DU RIETZ 1932).

In Greenland surprisingly little work has been done. Concerning the higharctic region, HART (1880) described the results of the British Polar Expedition 1875–77 and included some very interesting notes on the bird-cliff vegetation. More recently LYNGE and SCHOLANDER (1932 and 1940) have given valuable information on the coprophilous lichens, while there are published some few notes on the nitrophilous vegetation by GELTING (1934) and by SEIDENFADEN & SØRENSEN (1937). In the well-known careful botanical investigations in East Greenland (*e.g.* KRUUSE 1912, p. 285, HARTZ 1896, p. 105) there is virtually no information on the nitrophilous vegetation. In the lowarctic part of West Greenland practically nothing has been done. In the two classic descriptions of the botany of S. W. Greenland (WARMING 1886, ROSENVINGE 1896), neither of the authors have investigated any bird-cliffs, but they give good descriptions of the flora on "manured soil," mainly on Eskimo habitations. BÖCHER (1963, p. 159–272) gives in great detail a list of all Greenland plant communities, but does not at all mention the coprophyte vegetation. Even KRUUSE (1898, p. 348) and PORSILD (1902, p. 91) have completely avoided the investigation of the vegetation on bird-cliffs in low-arctic West Greenland. Personally, I have been much interested in the coprophyte problem, which has considerable ornithological interest, and have collected a number of coprophytes on the bird-cliffs, which were

presented to the Botanical Museum in Copenhagen. These plants have been dealt with by SØRENSEN (1943, p. 65) in the passage "Ornithocoprophilous vegetation" and by BÖCHER (1959, p. 16) in the passage "The flora of bird-cliffs." Finally, in my book on the birds of Greenland (SALOMONSEN 1950) I have mentioned the connection between sea-birds and coprophyte vegetation in many passages, *e.g.*, on p. 34, 295, 304, 314, 327, 370, 393, 402, and 416.

The greater part of the authorities, quoted above, do not so much describe the coprophytes of the cliffs with sea-bird colonies, as the vegetation in numerous other manured places, including what they call "bird-stones," "bird-mounds," "bird-hummocks" ("skua-", "gull-," "crow-hummocks"), "resting places of terrestrial birds," "bird-islets," or in places with the manure originating from mammals or man, as "burrows of Arctic Foxes," "lemmings," "skeleton remains," "whale oil," "human habitation," "Eskimo settlements," "pitches of tents," "cities," "miners' lavatory."

Just like the development of coprophytes at bird-cliffs in the arctic and boreal regions, similar phenomena, usually to a much smaller degree, have been developed in other parts of the world and have been described by a few students, *e.g.* by ARDAMATSKAYA (1967) from Orlow Island in the Black Sea, LOVRIC (1971) from the Yugoslavian coast of the Adriatic Sea, GILLHAM (1964), SOBEY (1976) and GILBERT & WATHERN (1976) from Scotland, and GILLHAM (1961 and 1963) from Australia and South Africa, respectively, and also a number of older papers, not considered here but summarized in GILLHAM 1964. Finally, HUTCHINSON (1950, p. 370) has studied various islands in the tropical Pacific and some subantarctic islands of New Zealand. The association between coprophytes and bird-colonies in these areas is much less known than in the areas of the Arctic region.

General Description of the Coprophyte Zones

Although the zones of coprophytic vegetation are of much greater extension on the bird-cliffs than anywhere else, it is appropriate shortly to mention the most imporrant other places where they are developed owing to a surplus of nitrogen compounds and other plant nutrients.

Generally speaking, there are two different ways in which an increase of nitrogen may occur in the Arctic. The first is the deposition of refuse around the settlements of the Eskimos and other tribes, especially at places with many sled dogs, or with primitive sanitary conditions. This usually gives rise to the development of fresh green grass-fields, sometimes to flower-mats of dandelion (*Taraxacum sp.*) and a few other species.

The second way is manuring by birds and mammals, and this is by far the most important one. The effect is seen wherever birds breed or where mammals leave their droppings, but the effect is naturally greater where the deposit of manure takes place continually for years. This is the case in places where birds-of-prey, skuas and gulls keep watch from stones and hummocks, on cliffs under the nests of falcons, eagles and other big birds, on sites where geese habitually feed or where small passerines sleep at night. The dens of wolves and foxes produce the same effect and may always be identified from afar by a lush growth of grasses and weeds.

An especially prominent feature in the arctic landscape is formed by the so-called gull-hummocks, for which the Eskimos have a certain name, *pingo*, identical in all dialects.[1] The large species of gulls nesting solitarily on small islands, such as *Larus hyperboreus* and *L. marinus*, at breeding time all have a certain standing-place situated not far from the nest. There they keep watch and eat, rest and generally spend the time when they are not brooding. This standing-place is thoroughly manured by the birds, which gives rise to a rich vegetation, mostly of grasses. The standing-place is used year after year, generation after generation, and in the course of time the grass is converted into peat, and a steadily growing hummock is formed in this way. Such a *pingo* can attain a height of more than one metre (Fig. 28), and as it is usually placed on the top of an island, it is visible for long distances as a distinct landmark.

When such comparatively insignificant deposits of guano have such remarkable effects, it is no wonder that the manure deposited by immense colonies of sea-birds is of the greatest importance for plant life and completely changes the aspect of the vegetation. Optimum conditions for plants are found in places where a bird-colony is situated in the inner parts of a fjord where the climate is dry and sunny, especially if the colony is placed on a cliff exposed to the south and supplied with a broad, gently sloping scree. In such places the vegetation is extremely rich and luxuriant. An example of this is shown on the photograph on plate III.

It is possible to divide the coprophyte vegetation on most bird-cliffs into various zones in accordance with the concentration of guano. As far as I know such a division into vegetation zones has been made only by GRØNLIE (1948, p. 137) in Norway and by RUSSELL & WELLINGTON

[1]) Unfortunately, the term *pingo* has been used by American geologists for another phenomenon. In Alaska and western Canada a *pingo* is a plug of ice often forced up in the bed of a lake or moor in permafrost areas. These pingos may attain an enormous size and be as high as about 100 metres in the Mackenzie delta. In the Old World the Finnish term *palsa* is generally used for this phenomenon instead of *pingo*.

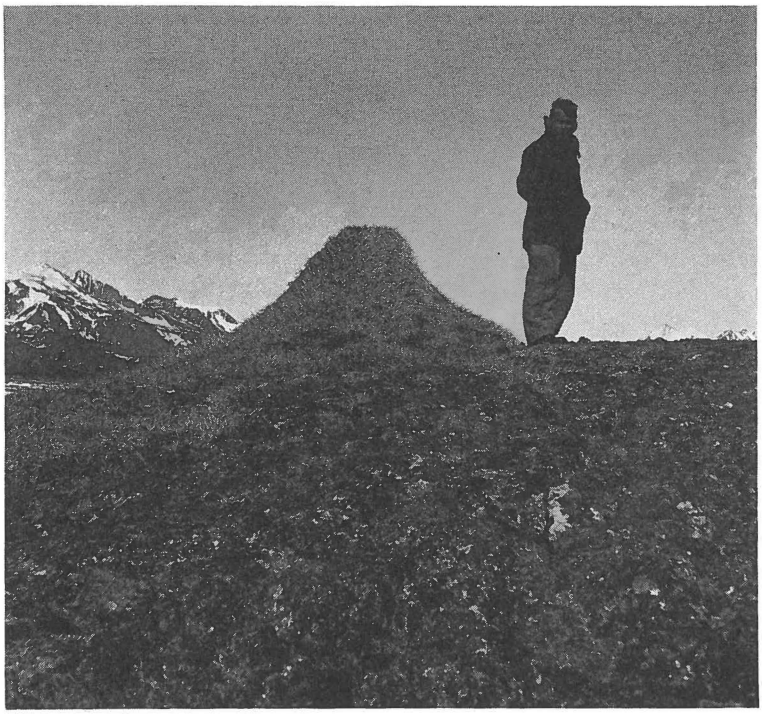


Fig. 28. *Pingo* on small islet off the island Sermersôq, Nanortalik District. (Phot. 16th June 1949 by F. SALOMONSEN).

(1940, p. 171) in Jan Mayen. Since they have investigated only a few bird-cliffs in a restricted area their results do not generally apply to the Arctic, although they agree in many ways with my experience with Greenland conditions. It should be remembered, however, that a number of local factors, nature and stability of the soil, water supply, shelter from winds and other climatical conditions, magnitude and formation of the guano accumulation, etc. make the picture very complex and render it impossible to obtain a zonation which applies in all cases. The following division is based on the vegetation on the scree and the greater ledges, while the scattered growth of vascular plants on the actual rock surface, in crevices and ravines have not been considered. A division into petrophytes, chomophytes and lithophytes, as used by GRØNLIE (1948, p. 177), has not proved necessary. The division given below is held in very general terms and should, therefore, be usable at most arctic bird-cliffs of some size. Only the south-exposed *Caloplaca* cliffs are concerned, whereas the north-exposed *cochlearia* cliffs are quite different and will be dealt with below, p. 115.

Zone A: Areas devoid of any vegetation. When the bird-cliff rises precipitously from the scree an area devoid of vegetation will develop

along the rock face on account of overmanuring (Fig. 23). The top layer of the soil consists here of pure guano. The transition between this nude zone and the plant-covered areas is formed by scattered individuals of plants, belonging to different highly nitrophilous species. In some instances I have in West Greenland found *Stellaria media* there, just as GRØNLIE (1948, p. 166) describes it from Norway. The zone A is always found in large breeding colonies of *Uria lomvia*, *Rissa tridactyla*, and *Phalacrocorax carbo*, but is often missing in bird-cliffs inhabited by *Larus*. When zone A is not developed, the next zone (B) is found on the scree right up to the perpendicular cliff-wall.

Zone B: Areas with a high concentration of guano. This zone follows zone A on the scree and is, in lowarctic West Greenland, often characterized by a dense vegetation of *Elymus arenarius* and *Chamaenerion angustifolium*, interspersed with *Taraxacum sp.* and some other species (Fig. 29) and in moist areas with *Oxyria digyna*. This agrees with Zone I of RUSSELL & WELLINGTON (1940, p. 174), on higharctic Jan Mayen, characterized by a closed association exclusively of *Oxyria digyna* and *Taraxacum croceum*. In the northern part of West Greenland, where *Elymus* and *Ch. angustifolium* have disappeared they are replaced almost exclusively by *Oxyria digyna* on the bird-cliffs. It is in my opinion quite certain that the lowarctic *Elymus arenarius* and *Chamaenerion angustifolium*, just like rockery plants, are favoured by the ability of the rock wall to absorb solar heat. This may be the main reason for their predomination in this zone, but they may both be found on the scree up to 30 m from the cliff wall. This zone is further characterized by the complete absence of bryophytes.

Zone C. Area with a moderate concentration of guano. This is the main zone of the coprophyte community and is inhabited by a great number of different species. It corresponds with Zone II of RUSSELL & WELLINGTON (1940, p. 174), and the plants mentioned by them all belong to species which are found in this zone in Greenland.

Zone D. Areas with a slight content of guano. This zone forms the transition to the ordinary vegetation and is characterized by a varying amount of coprophytes mixed with non-coprophytic plants. Lichens which are wide-spread in the ordinary heath communities, like *Cetraria* and *Stereocaulon*, begin to occur in this zone. The Zone D agrees fairly well with the zone III of RUSSELL & WELLINGTON (1940, p. 174), found 20–30 m from the cliff-wall and characterized by a mixture of coprophytes (*Cerastium alpinum*, *Draba arctica*, *D. nivalis*, *Saxifraga caespitosa*, *Luzula sp.*) and non-coprophytes (*Silene acaulis*, *Salix herbacea* associated with mosses). In West Greenland the coprophytes are found in a steadily decreasing number a long distance from the bird-cliff, usually to about

Fig. 29. The colony of Glaucous Gull, *Larus hyperboreus*, at Igpik, Disko, showing zone B of the coprophytic vegetation, with *Elymus arenarius* on top of the scree and with *Arabis alpina* and *Taraxacum sp.* just below. (Phot. 8th July 1973 by F. SALOMONSEN).

25–30 m from the border of the bird-cliff, but sometimes scattered remnants are found 150–200 m away. Usually they have a wider distribution on south-exposed than on north-exposed cliffs. On breeding places of *Cepphus grylle* they are rarely found further away than 10 m from the border of the bird-cliff.

Also EUROLA & HAKALA (1977, p. 10) have shown, by means of chemical analyses, that there is a gradual decrease in the concentraton of the plant nutrients from the base of the bird-cliff to the lower part of the talus below it.

The north-exposed *Cochlearia* cliffs display a zonal division similar to that of the *Caloplaca* cliffs, but the zones are usually not so distinct. Owing to the relatively large amount of moisture which usually is present, *Cochlearia officinalis* often forms huge masses of vegetations, covering zones B and C, and growing so densely that it covers the whole available

space and makes it impossible for other species to get a foothold (Fig. 30). Its occurrence is determined by a high concentration of nitrogen compounds, a large amount of moisture and comparatively reduced light or pure shade. In moist, shadowy ravines or caves in the cliffs it predominates, only *Saxifraga rivularis* also occurring in such places. South-exposed cliffs are usually dry, but in some rare cases they are as moist as the north-exposed ones. Even in these localities *Cochlearia officinalis* is usually absent, probably because the light is too strong, and it here loses in the competition with *Sedum rosea*, *Oxyria digyna*, *Stellaria calycantha* or *S. media*.

Only in places with still greater moisture in the north-exposed cliffs, especially where water oozes or trickles down along the cliff-wall, does *Cochlearia officinalis* give way to *Sedum rosea*, which then becomes predominant, usually in enormous specimens. However, *Sedum rosea* does not tolerate as great concentrations of guano as *Cochlearia officinalis*. Although *Sedum rosea* is found on both south-exposed and north-exposed cliffs, there is a principal difference. Since this species is highly hygrophilous it attains much bigger proportions and forms much denser growth on the moist north-exposed cliffs than on the drier south-exposed ones. On the latter it is found only in crevices or along edges of the cliff where water oozes down, whereas on the north-exposed cliffs it forms dense stands or long, spectacular festoons along water-soaked fissures of the cliffs. The tussocks of this species shown in Fig. 31, growing on the north-exposed bird-cliff at Eqalugssuit (67°35′n.lat.), are so big that a breeding *Mergus serrator* had sought shelter for its nest between them. A common coprophyte is even *Oxyria digyna*, just as on the south-exposed cliffs, and when *Sedum rosea* disappears in the northern parts of West Greenland, at Disko Bugt, *Oxyria digyna* replaces it, usually growing in very large specimens. *Saxifraga rivularis* and *S. cernua* are much more common on the north-exposed bird-cliffs than on the south-exposed ones.

In Fig. 23 is given a sketch of the common type of a gull-colony, in a West Greenland fjord, facing south. It is a typical *Caloplaca* cliff, with a broad *Caloplaca* arch, which is wider on the western than on the eastern side, as is often the case (cf. p. 96). A waterfall runs down the vertical cliff and continues as a rivulet across the talus, which is densely overgrown with a copse of *Salix glauca*. For some reason gull-colonies prefer cliffs with such waterfalls, possibly because they give the birds opportunity for bathing, which, at least in the period of postnuptial moult, appears to be a necessity for them. As usual a cyanophycean band is developed along the watercourse on the cliff-wall. On the talus, which in Fig. 23 attains an altitude of about 100 m, the coprophyte zones are to be seen, uppermost the narrow zone A with no vegetation. Below the coprophyte zone is an area with ordinary heath vegetation, but then

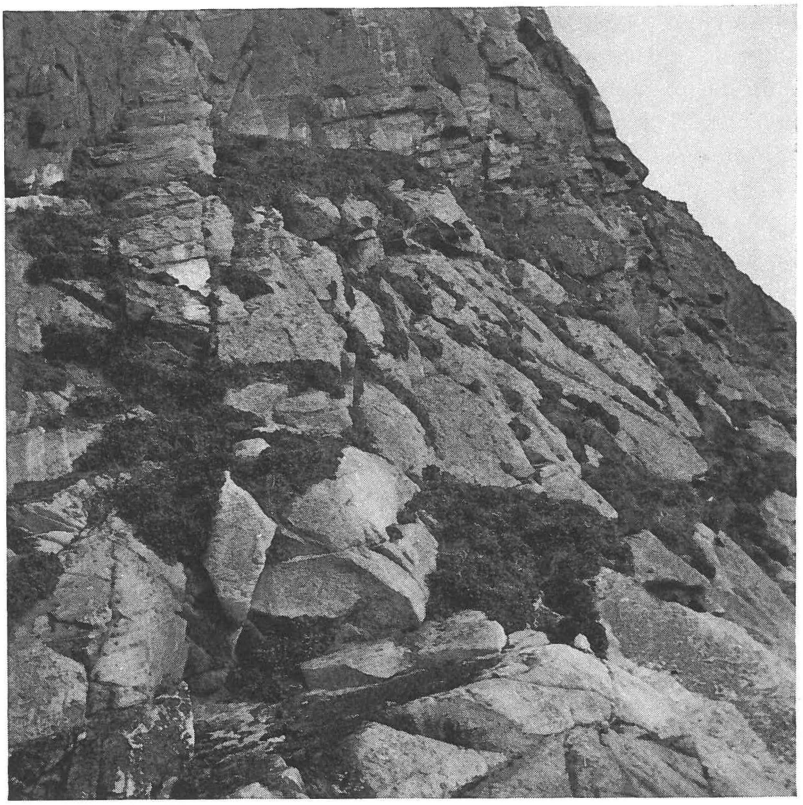


Fig. 30. The north-exposed bird-cliff at Eqalugssuit, Egedesminde District, with dense growth of *Cochlearia officinalis* below the breeding-sites of the birds. (Phot. 16th July 1960 by F. SALOMONSEN).

again follows a narrow coprophyte zone, lowest on the scree, just above the sea shore. This isolated zone is the resting and gathering place of the young birds in the period when they have just left the nests and before they scatter in the surroundings. Their manuring of the ground gives rise to this special zone of coprophytes, detached from the genuine vegetation of coprophytes. I have called this area the *hemicoprophyte zone*, for the lack of a better name. Such a hemicoprophyte zone is developed at various places, primarily at the sea coast below bird-cliffs, but also at the mouths or deltas of rivers, and other resting or bathing places for flocks of gulls. The gulls apparently prefer bathing places without vegetation, especially low sandy or gravelly localities at the mouths of rivers, but if they use rocky coasts a coprophyte vegetation, including a growth of *Caloplaca elegans*, will gradually develop. Even flocks of non-breeding one- or two-year old gulls sometimes gather in the hemicoprophyte zone.

When a well-established bird-cliff is abandoned by the breeding

birds the coprophyte vegetation will remain for a considerable period, although not nearly as long as the frugal *Caloplaca* (cf. p. 97). When a bird-cliff has been used by a great number of birds over a long period and the layer of manure, consequently, is considerable, the coprophytes will undoubtedly still be present some hundreds of years after the cliff has been abandoned by the birds. I have a number of times discovered such abandoned bird-cliffs, with a luxuriant coprophyte vegetation, but do not know for how many years they have been given up by the birds. It is well-known, however, that there is a rich coprophyte vegetation around old Eskimo house-sites which have been abandoned for many years, and ROSENVINGE (1898, p. 177) draws attention to the fact that a similar vegetation is still present at the old Norse ruins, left about five hundred years ago. This is evident still now (in 1978). MCGHEE (1974, p. 852) has drawn the attention to the building of permanent winter-houses, which has left obvious surface remains over a period of 2000 years around Bering Strait (Old Bering Sea culture) and 1000 years across the Canadian Arctic (Thule culture), and that these houses are still covered by thick vegetation enriched by the slowly decomposing refuse deposits.

On the other hand, if a bird-colony is established at a new locality the coprophytes do not appear at once. I have seen a few such bird-colonies without any corpophytic vegetation and without any *Caloplaca*, but I do not know the exact year for the foundation of the breeding place. Still, the inhabitants with whom I discussed the matter did not know the existence of these particular bird-cliffs, so they must at any rate be very new breeding-places.

On the Isle of May in Scotland it took less then 36 years for the vegetation to change, under the influence of the quickly colonizing Herring Gulls, from the typical maritime vegetation of *Armeria maritima* and fescue sward to plant communities dominated by coprophytes (SOBEY 1976, p. 484).

Composition and Characterization of the Coprophyte Vegetation

The composition of the coprophyte plant association is characterized by the presence of a large number of species and by the absolute absence of other species which elsewhere are of widespread occurrence. Most distinctive is the fact that virtually all lignified species belonging to the mixed dwarf-bush heath, the *Cassiope* heath and similar plant communities never occur in the coprophyte vegetation, and this negative character is one of the best distinguishing marks for this vegetation. The most important plants which are always lacking in the coprophyte associations are the following:

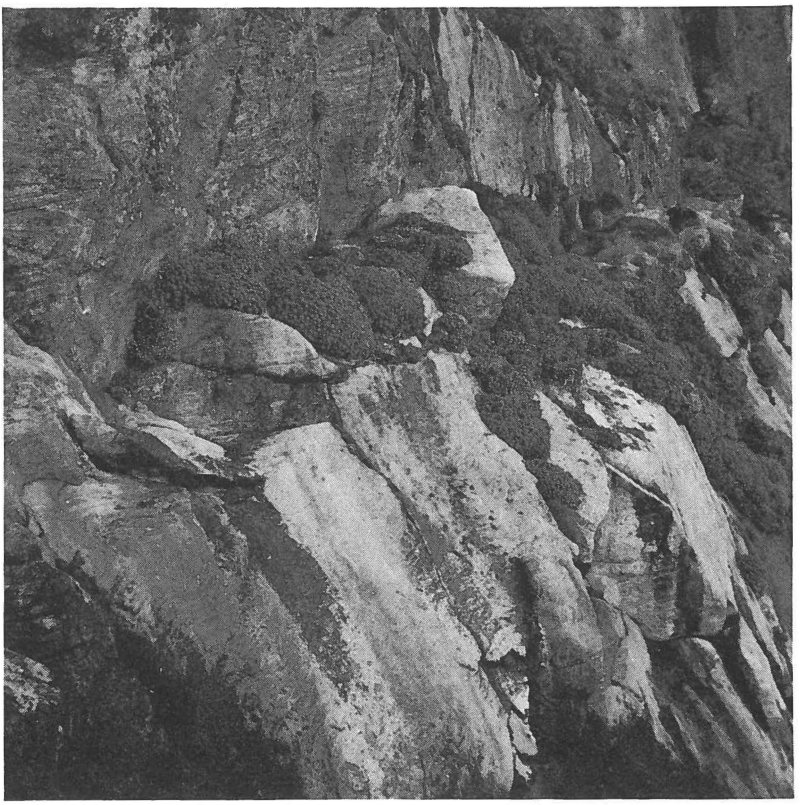


Fig. 31. The north-exposed bird-cliff at Eqalugssuit, Egedesminde District, with tall specimens of *Sedum rosea*, giving shelter for a breeding *Mergus serrator;* also a few *Cochlearia officinalis* can be seen. (Phot. 16th July 1960 by F. Salomonsen).

Dryas integrifolia
Saxifraga oppositifolia
Chamaenerion latifolium;
Papaver radicatum
Betula glandulosa
– *nana*
Salix herbacea
Silena acaulis
Armeria scabra
Pyrola grandiflora
Cassiope tetragona
Harrimanella hypnoides
Ledum groenlandicum
– *palustre*
Loiseleuria procumbens
Phyllodoce coerulea
Rhododendron lapponicum
Vaccinium vitis-idaea
– *uliginosum*
Empetrum nigrum
Diapensia lapponica
Pedicularis lapponica
– *labradorica*
– *flammea*
– *lanata*
– *hirsuta*
Bartsia alpina
Pinguicula vulgaris
Tofieldia pusilla
– *coccinea*

It should be added that a few scattered specimens of *Bartsia alpina*, *Chamaenerion latifolium*, *Pedicularis sp.* and *Pyrola grandiflora*, may occur in the coprophyte associations, but it is only as rare exceptions in a few places. It appears that *Papaver radicatum* is subject to a slight geographical variation in this respect, as it is practically always absent in the coprophyte vegetation in the lowarctic zone, while I have found it now and then in this vegetation in higharctic West Greenland. It has been found on bird-cliffs also in higharctic Spitsbergen (SUMMERHAYES & ELTON 1928, p. 239) and on "bird-places" in N. E. Greenland (SEIDENFADEN & SØRENSEN 1937, p. 118). A great number of herbaceous plants could be mentioned among the species which are non-coprophytic, but most of them are not as commonly distributed as the heath plants, mentioned above, and are, therefore, not considered.

The following list of plants gives the names of all the species which I have found in the coprophyte vegetation at bird-cliffs in West Greenland:

Huperzia selago
Selaginella selaginoides
Equisetum arvense
Botrychium lunaria
Woodsia ilvensis
Cystopteris fragilis
Dryopteris filix-mas
– *dilatata*
Juniperus communiz
Ranunculus hyperboreus
– *pedatifidus*
– *pygmaeus*
– *sulphureus*
Anemone richardsonii
Coptis trifolia
Thalictrum alpinum
Potentilla tridentata
– *pulchella*
– *rubricaulis*
– *hookeriana*
– *crantzii*
– *hyparctica*
– *nivea*
Alchemilla alpina
– *glomerulans*
Sedum rosea
– *villosum*
– *annuum*
Saxifraga nivalis
– *stellaris*
– *cernua*
– *rivularis*
– *hyperborea*
– *caespitosa*
– *aizoon*
– *aizoides*
– *tricuspidata*
Chamaenerion angustifolium
Epilobium palustre
– *anagallidifolium*
– *lactiflorum*
Draba nivalis
– *cinerea*
– *arctica*
– *lanceolata*
– *aurea*
– *glabella*
Cochlearia officinalis
Arabis alpina
– *holboellii*
Halimolobus mollis
Angelica archangelica
Salix glauca
– *arctica*
Alnus crispa
Oxyria digyna

Polygonum viviparum
Rumex acetosella
Montia fontana
Cerastium alpinum
Stellaria longipes
– *laeta*
– *humifusa*
– *calycantha*
– *media*
– *monantha*
Minuartia rubella
Melandrium affine
– *triflorum*
Viscaria alpina
Gentiana nivalis
Thymus drucei
Veronica fruticans
– *alpina*
Euphrasia frigida
Campanula gieseckiana
Erigeron compositus
– *uniflorus*
Antennaria canescens
Gnaphalium norvegicum
Artemisia borealis
Arnica alpina
Hieracium alpinum (*et sp.*)
Taraxacum sp.
Leucorchis albida
Luzula spicata
– *arctica*
Casex glareosa
– *subspathacea*
– *rupestris*
Festuca rubra
Poa glauca
– *nemoralis*
– *arctica*
– *pratensis*
– *alpina*
Puccinellia andersonii
– *phryganodes*
Phippsia algida
Calamagrostis langsdorffii
– *purpurascens*
Alopecurus alpinus
Roegneria violacea
Elymus arenarius
Potamogeton groenlandicus

This list, numbering more than a hundred species, constitutes the coprophyte vegetation of West Greenland bird-cliffs. Apart from these species, *Plantago maritima* and *Rhinantus minor* have been found in the coprophyte associations, but only in a single locality, and *Rubus chameamorus* only on a single *pingo* (cf. p. 112), and are, therefore, not incorporated among the real coprophytic species in the list above.

I shall not comment on the list, only add that it is possible that some small or rare species have been overlooked by me. A few of the species are less coprophilous than the usual coprophytes and mainly appear in the zone D of the bird-cliffs. This holds true for *Thymus drucei*, *Potentilla tridentata*, and to some extent even for *Campanula gieseckiana.*

Some of the coprophyte species on the list are much more common than others and may form dense and extensive vegetations, while others occur only as scattered sub-constituents of the main pattern. This pattern is extremely variable, dependent on a number of complicated edaphic and microclimatic factors. The list includes plants from both lowarctic and higharctic bird-cliffs and it is, therefore, not possible to find all the species at one locality. On the contrary, there is a very

pronounced geographical variation in the occurrence of the different species. The case of *Oxyria digyna*, *Chamaenerion angustifolium* and *Elymus arenarius* has been mentioned above (p. 114), and that of *Sedum rosea* on p. 136. As further examples can be mentioned that *Saxifraga tricuspidata*, a northern species, disappears in the northern part of the Godthåbsfjord and is not found at bird-cliffs further south. On the other hand, various ferns gradually predominate in the southern parts of West Greenland, beginning the increase in Godthåb District. The southern species *Botrychium lunaria* begins to appear commonly in the coprophyte vegetation in Godthåbsfjord, but only at a few bird-cliffs in this fjord do this fern and *Saxifraga tricuspidata* occur side by side. Among the grasses the northern *Alopecurus alpinus* is not quantitatively of any significance until Holsteinsborg District, while further north it partly replaces various species of the genus *Poa*. Other examples of geographical variation are given below, p. 130. There is also a pronounced ecological variation, and many xerophytes are found at bird-cliffs in the arid interior country, but are lacking at the coast.

Unlike the lichens, no vascular plants are exclusively coprophytic, but they are all to be found in other plant communities where they are not affected by any manuring of the ground. However, many species form dense vegetations in the coprophyte association while they do not occur at all in the surrounding areas or are found only very rarely, usually in south-facing herb-mats. This especially applies to the high-arctic region.

The list of coprophytic plants in West Greenland does not essentially differ from similar lists in Spitsbergen and other arctic areas, because a great number of the species are circumpolar. However, no such synopsis has been published from any other area, only local lists from a few selected bird-cliffs.

The coprophytic vegetation differs from all other arctic plant communities by a number of distinct criteria, which shall be mentioned in the following.

Number of species. Most botanists maintain that the number of plant species growing in the coprophyte vegetation on bird-cliffs is considerably smaller than in similar habitats elsewhere (FRIES 1869, p. 148, on Bear Island; NATHORST 1883, p. 59, on Spitsbergen; OSTENFELD 1908, p. 1003, on the Faroe Islands; SUMMERHAYES & ELTON 1923, p. 237, on Spitsbergen; HOLMBOE 1925, p. 35, in Norway; GRØNLIE 1948, p. 239, in Norway). Also a number of other students have discussed the small number of species in places manured by birds, both in Scandinavia and England. A different view is held by SCHOLANDER (1934, p. 124), who studied the vegetation of North-East Land in northern Spitsbergen and

described the coprophytes in the entirely overgrown talus of a bird-cliff with the suggestive name "Flora Mountain." This vegetation consisted of the following species: *Alopecurus alpinus*, *Festuca rubra*, 3 species of *Poa*, 3 species of *Ranunculus*, 5 species of *Saxifraga*, 2 species of *Potentilla*, 3 species of *Draba*, *Cerastium alpinum*, *Stellaria longipes*, *Oxyria digyna*, *Polygonum viviparum*, *Minuartia rubella*, *Salix polaris*, *Taraxacum arcticum*, *Pedicularis hirsuta*. He concludes that in comparison with other plant associations in northern Spitsbergen "the list of species is considerably lengthened" in the coprophyte vegetation on Flora Mountain.

According to my view the flora of most coprophytic areas in the lowarctic region is poorer in species than that on rich, south-exposed hefb-mats with good drainage. At some bird-cliffs the number of plant species, however, is extraordinarily large. In the higharctic region the situation is quite different, for I have never seen so many plant species in a restricted habitat as on the bird-cliffs. This is in agreement with SCHOLANDER's statement, above, regarding northern Spitsbergen.

The whole question is far from being solved, however. I can mention that Orlow Island in the Black Sea, far south in the temperate region, was made a bird-sanctuary in 1927 and in the following years became an enormous colony of various gull-species. At the same time the selective influence of the increasing amount of guano resulted in the disappearance of 10 plant species, but the appearance of 24 new species, thus a considerable floral enrichment (ARDAMATSKAYA 1967, p. 113). Isle of May in Scotland was formerly covered with heath including four species of vascular plants, but when the colonizing Herring Gull population had grown big the vegetation consistzd of 16 species of vascular plants (SOBEY 1976, p. 474 and p. 477).

Luxuriant growth. The coprophyte vegetation is everywhere characterized by its luxuriant development and dense growth which results in a fresh green colour. Such an intensely green patch of verdure is visible far away and, therefore, becomes one of the most characteristic features of the flora in the manured areas. It has been noticed by virtually all botanists working in the Arctic. The reason for this very distinct coloristic phenomenon is the fact that a large nitrogen supply darkens the green colour of the leaves. The leaves of plants growing with a *low* level of nitrogen compared with other nutrients are pale yellowish to reddish green, but darken rapidly when the nitrogen supply increases and become very dark green when it is excessive (RUSSELL 1961, p. 31).

Excessive size. The extremely large size of plant specimens in the coprophyte vegetation is another well-known phenomenon, due to the high concentration of nitrogen in the soil. As the level of the nitrogen supply increases compared with other nutrients, the extra protein

produced allows the plant leaves to grow larger and hence to have a larger surface available for photosyntesis. The amount of leaf area available for photosyntesis is roughly proportional to the amount of nitrogen supplied (RUSSELL 1961, p. 30; STÅLFELT 1960, p. 316).

The excessive size of the coprophytes is such a striking phenomenon that no students have failed to notice it. Only a few examples shall be given. SCHOLANDER (1934, p. 50) mentions from North-East Land, northern Spitsbergen, that *Oxyria digyna* and *Polygonum viviparum* are very small, not exceeding a few cm in length, but that at bird-cliffs they attain a length of up to 15 cm.

It appears that *Cochlearia officinalis* is particularly susceptible to high concentration of nitrogen, and many students have described the gigantic proportions of this species in the bird-cliffs (*e.g.* FRIES 1869, p. 148; NATHORST 1883, p. 59; SUMMERHAYES & ELTON 1923, p. 219; BERTRAM & LACK 1938, p. 31; RASMUSSEN 1946, p. 65; GRØNLIE 1948, p. 180). SUMMERHAYES & ELTON (*l.c.*) mention that on Bear Island *Cochlearia officinalis* is "7–8 inches high and very bushy" at the bird-cliffs, and very much smaller elsewhere. BERTRAM & LACK (*l.c.*) reported from the same island that *Cochlearia officinalis* "on the unmanured cliff tops were closely oppressed to the ground and the leaves were less than 2 inches long, but below the Kittiwake colonies growth was luxuriant and the leaves up to a foot in length." In Norway the species appears to be able to reach still larger proportions. *Cochlearia officinalis* is there "the most ornithokoprophilous of all plants and develops in the bird-cliffs to such proportions that it becomes unrecognizable, 50 cm high and with single leaves 9 cm long. That it endures intensive manuring and grows exceedingly vigorous has been emphasized by all students of habitats of sea-birds in Norway" (GRØNLIE 1948, p. 203). I measured some specimens of *Cochlearia officinalis* at a bird-cliff in Thule District, higharctic West Greenland, where it appeared to be particularly large. It attained a length of 36–45 cm, with a mean of 40.7 cm.

Similarly, RASMUSSEN (1946, p. 52) mentions the gigantic size of *Ranunculus acer* in the bird-cliffs of the Faroe Islands, where the species attained a size of 70–90 cm, whereas in other places it measured only a few cm. Well known is the case of *Festuca rubra* var. *fraterculae*, growing abundantly at the breeding-places of *Fratercula arctica* in the Faroe Islands (RASMUSSEN 1928, p. 51) and Norway (GRØNLIE 1948, p. 138) and characterized by its considerable size and vigorous growth. Further, HART (1880, p. 241) says that *Carex stans*, growing at a deserted Eskimo village near Etah, in northern Thule District, "attained a height of close on two feet, by far a greater growth than that of any other herbaceous plant seen north of Disco."

Finally, I wish to mention some plants collected by me in 1954 at

bird-cliffs in Nordre Strømfjord, West Greenland, and commented on by BÖCHER (1959, p. 16). The ordinary length, quoted from BÖCHER *et al.* (1966), is compared with the huge size of my specimens (in cm):

	Ordinary length	Length at bird-cliffs
Saxifraga aizoon	10–25	25–31
– *cernua*	10–20	34
Draba aurea	10–40	48
Erigeron compositus	10–20	31

A few other examples of excessive size are also given in this paper; cf. for instance Fig. 38–39.

Sterility. When the surplus of nitrogen is particularly large, the plants will not only be excessively large, as described above, but it might happen that the flowers and the fructification are reduced (STÅLFELT 1960, p. 316). GRØNLIE (1948, p. 140) has found this phenomenon to be rather common in the boreal coprophyte vegetation of Norway, but no other student has drawn attention to it. It cannot, therefore, be a widespread character of the coprophytes. GRØNLIE describes a "*Festuca* meadow," developed in the areas of the bird-cliffs where the nitrogen concentration was very high. The greater part of the species in this zone never occurred with flowers. This was the case with *Matricaria inodora*, *Melandrium rubrum*, *Rumex acetosa* and *Anthriscus silvestris*, while *Festuca rubra* was frequently sterile, and *Deschampsia flexuosa* only rarely appeared with spikes. With the exception of *Festuca rubra* these species are southern ones, unknown in the Arctic region or only found in the southernmost part. It is possible that these boreal-temperate plants are more sensitive to high nitrogen concentrations than the arctic ones. In the lowarctic parts of Greenland I have only seen a few examples of sterility among the coprophytes, *e.g.* in *Stellaria longipes* and *Ranunculus hyperboreus*[1], and to the best of my knowledge no one has described it from the lowarctic zone. However, by "sterility" is here meant the reduction of flowers, not loss of the capability to produce ripe seeds, which is known in many plants in Greenland, *e.g.* the profusely flowering coprophyte *Chamaenerion angustifolium.*

[1]) In *Ranunculus hyperboreus* the sterility may be due to other reasons, for PORSILD (1902, p. 170) found it to be completely sterile on small pools far from manured soil, and GELTING (1934, p. 93) states that the aquatic form of this species is always sterile on the outer coast of Northeast Greenland. It appears that this species is sterile when it floats in freshwater, but possesses flowers when it grows on solid, although very moist ground. I have observed this distinction in many places in West Greenland.

Fig. 32. Mutants of *Saxifraga caespitosa* with supernumerary (6 or 7) petals, growing in the coprophyte zone of a *Uria lomvia* cliff on Carey øer, Thule District. (Phot. 27th July 1973 by F. SALOMONSEN).

In the higharctic region sterility appears to be more widespread, as I have found it many times in the vegetation at bird-cliffs. On Fig. 26 is shown a sterile tussock of *Cerastium alpinum*. Only in a few publications is sterility in higharctic coprophytes indicated. SEIDENFADEN & SØRENSEN (1937, p. 119) state from N. E. Greenland that "on very dry and meagre bird-places the plants often occur in the vegetative state only." LYNGE (1934, p. 166) says about *Cochlearia officinalis* in Nowaya Zemlya that it looked like "mighty "cabbages" with few flowers."

Development of mutants. Apart from their excessive size and their more lush and luxuriant appearance the lowarctic coprophytes are very similar to the non-coprophytic specimens of the same species. Only in one instance have I found that a mutant is favoured by the high nitrogen concentration in the coprophytic vegetation, *i.e.* the so-called var. *albiflora* of *Viscaria alpina*, which is much more commonly found at bird-cliffs than elsewhere. This situation is quite different in the higharctic zone where a multitude of mutant forms have developed among the coprophytes. These mutants are morphologically peculiar by having different coloration of the petals, supernumerary sepals, petals, styles and stamens or other characters. This distortion of the flowers may possibly be connected with the tendency to sterility found among the higharctic coprophytes, but nothing is actually known about it. It is peculiar that no botanist has mentioned this highly interesting evolution in the higharctic coprophyte flora. The only scientist who has mentioned one of the mutant forms is HART (1880, p. 207) who in the description of

Fig. 33. Mutant of *Saxifraga rivularis* with three fruit-bodies (left), and a normal specimen with two fruit-bodies (right), from the coprophyte zone of a *Cepphus grylle* cliff on Carey øer, Thule District, collected by F. SALOMONSEN on 22nd August 1975. (Phot. Zool. Mus. Copenhagen).

the vegetation in Thule District, N. W. Greenland, says of *Saxifraga cernua:* "At Foulke Fjord under and amongst the breeding places of the Little Auk, this plant was remarkably luxuriant; specimens gathered there were eight and ten inches in height, with many flowers, often as much as an inch across, and with six, seven, or eight petals apiece." I have also found this mutant of *Saxifraga cernua* in the coprophyte flora in Thule District, among several other mutants. One of these, a mutant of *Saxifraga caespitosa*, is shown on Fig. 32, and a very interesting one in *Saxifraga rivularis* on Fig. 33. I want to emphasize that the so-called *Saxifraga caespitosa* var. *cryptopetala*, with minute petals, has nothing to do with the higharctic mutant shown in Fig. 32, but must be regarded as a local monstrosity. It is known only from Egedesminde City (HARTZ 1898, p. 36), apart from one single locality in East Greenland (KRUUSE 1905, p. 171), and may very well have developed as a result of high nitrogen concentration in the manured ground around Egedesminde.

Predominance of gramineae. Virtually all students of the arctic coprophyte flora have emphasized the distinct predominance of grass in this vegetation, both at bird-cliffs, at "bird-hummocks" and, for that matter, even around deserted Eskimo dwellings and other human settlements. It appears that a production of a dense grass-mat in the arctic region is found only in connection with manuring, usually in dry areas, but also to some extent on moist ground. In other places grass-land is usually scarce in the Arctic, but various types are well-known, at least in many localities in Greenland, mostly in xerophilous sociations, usually mixed with many other, non-gramineous species. However, the abundance of grass in the coprophyte vegetation at bird-cliffs and elsewhere is most striking and has been described both from Greenland (WARMING 1888, p. 147; ROSENVINGE 1898, p. 175; SEIDENFADEN & SØRENSEN 1937, p. 118), Jan Mayen (RUSSELL and WELLINGTON 1940, p. 172), Spitsbergen and Bear Island (FRIES 1869, p. 148; NATHORST 1883, p. 59; BERTRAM & LACK 1938, p. 31; SUMMERHAYES & ELTON 1928, p. 238; SCHOLANDER 1934, p. 124), on the Faroe Islands (RASMUSSEN 1946, p. 64), in Norway (GRØNLIE 1948, p. 136) and in Scotland (GILLHAM 1964, p. 26; GILBERT & WATHERN 1976, p. 492; SOBEY 1976, p. 484).

The most widespread species of gramineae in the arctic coprophyte vegetation are *Alopecuruz alpinus*, *Festuca rubra*, *Poa alpina*, *P. glauca*, *P. arctica*, *P. pratensis*, *Hierochloe alpina*, *Deschampsia flexuosa*, *Elymus arenarius*, *Phippsia algida* and *Calamagrostis langsdorffii*. Most interesting is the remark by GRØNLIE (1948, p. 239) that the growth of grass is stimulated in the bird-cliffs and that the effect is the same as that produced by manuring and grazing by sheep. Something similar is said by SUMMERHAYES & ELTON (1928, p. 247) about the coprophytic grass communities on Spitsbergen, "which are similar to those communities occurring in more temperate countries in soils capable of considerable nitrification."

Absence of bryophytes and certain lichens. On most bird-cliffs, at any rate on the south-exposed *Caloplaca* cliffs, bryophytes are absent. This has also been noticed by GRØNLIE (1948, p. 148) in Norway and by OSTENFELD (1908, p. 894) in the Faroe Islands. On the other hand, SUMMERHAYES & ELTON (1928, p. 241) and EUROLA & HAKALA (1977, p. 9) state that on bird-cliffs in Spitsbergen, particularly on the moist ones, mosses are often more abundant than phanerogams. This does not agree with my observations in Greenland. It is true that in wet and dark places, especially in narrow north-exposed ravines, mosses grow profusely, but this is not a usual situation in the coprophyte association. It is possible, however, that mosses are more common in the bird-cliffs of the highartic region than in those of the lowarctic one. It should be

borne in mind that the vegetation of the large talus below the breeding places of *Plotus alle* in higharctic N. W. Greenland at some localities mainly consists of mosses (especially of *Dicranum* and similar forms), often virtually without any admixture of vascular plants (SALOMONSEN 1950, p. 402). Cf. also the remarks on moss in peat on Carey Øer p. 104.

Even a number of lichens commonly found in heath vegetation are absent from the coprophyte communities, where they do not appear until zone D (cf. p. 114). This holds good of the genera *Cladonia*, *Stereocaulon* and *Cetraria*. GRØNLIE (1948, p. 194) has remarked that in Norwegian bird-cliffs *Cladonia* is absent as soon as the slightest manuring occurs.

Presence of ferns. Among the vascular plants there is reason to emphasize only the presence of ferns, which in the bird-cliffs have a peculiar distribution. They are practically absent in the higharctic and the northern part of the lowarctic region, with the exception of *Woodsia ilvensis*, which is relatively rarely found, however. From about 65°–66° n.lat. this situation changes, and to the south a gradually larger proportion of the coprophyte vegetation consists of ferns, especially *Cystopteris fragilis* and *Dryopteris filix-mas* and, to some extent, also *D. dilatata.* From Godthåbsfjord and southwards even *Botrychium lunaria* is found in the bird-cliffs, but as scattered individuals only. This distributional pattern agrees with the records from other polar areas. No ferns are mentioned among the coprophyte communities of higharctic countries, but from the boreal region and from the southernmost part of the lowarctic region the same species as those mentioned above are recorded in the coprophyte vegetation. *Dryopteris filix-mas* as well as *Cystopteris fragilis* have been found in the bird-cliffs of Norway (GRØNLIE 1948, p. 183–185) and the latter species also in the Faroese bird-cliffs (RASMUSSEN 1946, p. 65). Even *Botrychium lunaria* is recorded from Faroese bird-cliffs (RASMUSSEN 1946, p. 66) as well as from the coprophyte flora of "manured ground" in S. W. Greenland (ROSENVINGE 1898, p. 178). No other notes on the occurrence of ferns in coprophyte vegetation has been published.

Red Snow. The so-called red snow is due to the presence of the alga *Sphaerella nivalis.* Red snow appears to be particularly often developed on snow-covered talus below bird-cliffs. I have observed it rather often under breeding-cliffs of *Plotus alle* and *Uria lomvia* in higharctic West Greenland. It must be admitted, however, that the droppings of these two species sometimes look like red snow, and unfortunately I failed to collect any material for further examination. SUMMERHAYES and ELTON (1928, p. 199) state that; "Others have found red snow below bird-cliffs to contain *Sphaerella nivalis* as well as droppings. It is obvious that

specimens are desirable to confirm records of red snow in such places." It is probable that quano deposited on the snow by birds leaving their breeding place may serve as nutrient for *Sphaerella nivalis* ,and that this alga, therefore, is more common and widespread near bird-cliffs than elsewhere, but at the time being this has not been proved. LØVENSKIOLD (1964, p. 309) gives a full discussion of this question for the Spitsbergen area.

Notes on Selected Species of Coprophytes

Some species of vascular plants are of particular interest as far as their connection with the coprophyte vegetation is concerned. Some of them appear to be subject to a significant geographical variation in their susceptibility to guano. Other species are mentioned here on account of their adaptation to extremely high concentrations of guano, while others for unknown reasons are very sensitive even to small amounts of guano and do not at all occur at the bird-cliffs in spite of the fact that most other congeneric species are common there. I wish to draw the attention of botanists to these interesting biological phenomena which, with a few exceptions, have not at all been studied.

Elymus arenarius. This plant is widespread in the temperate and boreal regions and is there exclusively a halophyte, growing along the sea-shores, mostly on sandy dunes. In lowarctic Greenland, where the nominate form is replaced by the subspecies *mollis*, its ecology differs markedly. In Greenland it is mainly a coprophyte, occurring in localities with a high concentration of nitrogen compounds, in bird-cliffs found mainly in zone B (cf. p. 114), but only where the ground is dry. It is, therefore, not so common on the more moist north-exposed *Cochlearia* cliffs as on the south-exposed *Caloplaca* cliffs. In the large guano concentration in zone B it is superior to all other species, perhaps with the exception of *Chamaenerion angustifolium.* It is a condition that the soil is absolutely dry. If the ground is slightly more moist *Calamagrostis langsdorffii* turns up, and with increasing moisture it predominates in this zone. In many places this plant is again replaced by *Stellaria media* if the ground becomes soaked with water. On bird-cliffs in the interior country *Elymus arenarius* is sometimes found at an altitude of up to 3–400 m, *i.e.* quite independent of the sea and the fjords. Apart from its occurrence as coprophyte in the bird-cliffs, *Elymus arenarius* is commonly found on coastal dunes just as in the boreal region south of Greenland.

This ecological deviation of the arctic populations of *E. arenarius* has not been noticed by botanists. GRØNLIE (1948, p. 205), studying the vegetation of bird-cliffs in boreal Norway, states that *E. arenarius* "occurred in one single patch and is probably not coprophilous." ROSENVINGE (1898, p. 175) was very surprised to find *E. arenarius* as one of the

most prominent plants on manured soil at the Norse ruins in S.W. Greenland, and said of its occurrence there: "The presence of *Elymus arenarius* cannot be regarded as an accidental intermixture in the vegetation of the manured soil, but it must be considered as one of its most widespread and most characteristic representatives." PORSILD (1902, p. 137) states that *Elymus arenarius* is sometimes found at some distance from the sea-shore in Greenland, and that the most vigorous specimens grow on strongly manured ground, even when this is more clayey than sandy. I have not been able to find other notes on the coprophytic status of *Elymus arenarius* in the Arctic, but recommend this phenomenon to further study. The species does not occur in the higharctic region.

Chamaenerion angustifolium. This species grows in close association with *Elymus arenarius* on the bird-cliffs in the zone of greatest concentration of guano (zone B; cf. p. 114), where the ground is dry. Just like *Elymus arenarius* it is a typical lowarctic species in Greenland. It is found in scrub and coppices, in dry herb-mats, on gravelly talus, particularly on south-exposed slopes and on manured soils at house ruins and similar places, but nowhere in so large and dense growth as on bird-cliffs. In boreal forests it is known to turn up on felling areas with a considerable nitrificatory activity, and to disappear when the nitrogen is exhausted. It is ,therefore, often used by foresters as an indicator for the presence of nitrogen. Moreover, it is well-known for its ability to accumulate nitric acid in its cells (STÅLFELT 1960, p. 318). It is evident that its adaptation to soils with a large content of nitrogen compounds makes it highly efficient in the competition for a habitat in the Greenland bird-cliffs. It should be added that a similar physiological adaptation is unknown in *Elymus arenarius.*

A map of the distribution in Greenland of *Chamaenerion angustifolium* is given in BÖCHER 1938, p. 142. It appears from this map that the species does not occur between Nordre Strømfjord and Egedesminde. However, I have found it at several places in this area, but restricted to the corpophyte vegetation of the bird-cliffs.

Taraxacum sp. A total of 24 species of this genus have been recorded from Greenland. I have not been able to identify them and have, therefore, treated them collectively under the name of *Taraxacum sp.* The greater part of these species occur on herb-mats on sunny slopes, but some of them are extremely numerous on manured soil in the lowarctic region, both at human habitations and on bird-cliffs. On the latter localities they may form large fields of flowering plants (cf. Fig. 27), and they are at least almost always present in the coprophyte vegetation on bird-cliffs, preferably where the ground is moist. In the higharctic part

of Greenland *Taraxacum* is much rarer on the bird-cliffs where it appears only as scattered specimens and often is completely missing. It is known from bird-cliffs on higharctic Jan Mayen and Spitsbergen, but does not appear to be particularly numerous. Neither in the boreal region does *Taraxacum* constitute any appreciable part of the coprophyte vegetation. GRØNLIE (1948, p. 213) records *Taraxacum*, identified as *T. croceum* and *T. naevosum*, only from a few places in Norwegian bird-cliffs and adds: "It is difficult to give an opinion as to whether *Taraxacum* is ornithokoprophilous or not." On the other hand, RASMUSSEN (1946, p. 68) found it everywhere in the Faroese bird-cliffs. I am quite sure that the different apomictic species of *Taraxacum* possess dissimilar adaptations to the nitrogen concentration in the soil.

Angelica archangelica. This boreo-lowarctic species is a pronounced coprophyte in the southern part of its range, but does not appear to be so in the northern part. In Norway it is "highly nitrophilous" (GRØNLIE 1948, p. 201) and in the Faroe Islands it is even "only to be found growing wild in the bird-cliffs" (OSTENFELD 1908, p. 894). Something similar is the fact in S. W. Greenland, where it forms profuse stands in the bird-cliffs, but is rarely found elsewhere. To the north it becomes more scattered, and the northernmost place at which I have found it is the bird-cliff on Kíngatsiaq (66°10′ n.lat., in Holsteinsborg District) and at one single bird-cliff in the inner part of Nordre Strømfjord. It is not known to go farther north on the Greenland mainland, and according to BÖCHER (1963, p. 26) it is very rare north of Nordre Isortoq fjord, which is situated somewhat south of Nordre Strømfjord. It turns up again in southern Disko Island, where it grows very luxuriantly, especially along "hot wells," *i.e.* wells not freezing in winter (cf. PORSILD 1902, p. 233). This particular distributional pattern with the reappearance of a southern species on Disko Island is due to the same high amount of precipitation in this area as in the mainland south of Holsteinsborg, as convincingly demonstrated by BÖCHER (1938, p. 12 and 1963, p. 40). However, in Disko *Angelica archangelica* is not coprophytic, in so far as it does not at all occur in the zone of coprophytes at bird-cliffs, where I have never seen it. Other southern species of the same distribution, like *Leucorchis albida* (map in BÖCHER 1963, p. 45), do not lose their attachment to the coprophyte vegetation of the bird-cliffs in Disko, but are found there just as in southern Greenland.

Cochlearia officinalis. This species is the character plant, so to speak, of the coprophyte vegetation, according to most botanists. It can endure very intensive manuring, appears in many places to be the dominant species and sometimes constitute the entire plant growth in a coprophyte locality, where it attains enormous proportions (cf. p. 124). It is

a boreo-panarctic species, found from Scandinavia, the Faroe Islands and Iceland to the northernmost higharctic regions, but its predominance in the coprophyte vegetation is restricted to low bird islands and to very moist soil. It must be considered a pronounced hygrophyte and partly a halophyte. Sometimes I have found it far from sea-water on very moist north-exposed bird-cliffs in the inland. Nobody has noticed its preference for the north-exposed localities and its almost complete absence from the south-exposed ones, which fact has been discussed earlier in this paper (p. 87). The reason for this omission is probably the fact that this phenomenon is most apparent in the lowarctic area, while it is much less distinct in the higharctic one. This geographical difference is, undoubtedly, due to the prolonged period of midnight sun in the higharctic region, which in many ways neutralizes the difference in solar light between north-exposition and south-exposition of the bird-cliffs. Likewise, in the boreal region differences in the exposition appear to influence the vegetation only slightly. On Lofoten Islands in Norway, GRØNLIE states (1948, p. 136) that: "It is apparently of no consequence whether the mountain side faces south or north. Naturally, southern slopes in hot and droughty summers, when the insolation is extensive, will easily become parched and poor in bottom vegetation, but this occur seldom out here." In lowarctic Greenland, however, the differences between north-exposed and south-exposed bird-cliffs are very pronounced, as described above, p. 84.

It is a well-known fact that *Cochlearia officinalis* is very rich in vitamin C, an important fact in the Arctic, where the usual one-sided human meat diet is deficient in vitamins and in former days gave rise to scurvy. The trivial name of *Cochlearia officinalis*, viz. "Scurvy Grass" (or "Scurvy Cress" or "Scurvy Weed") indicates that in the old days this plant served as an antiscorbutic and as such has saved the lives of many people forced to winter in the Arctic (cf. SALOMONSEN 1958, p. 391). In our days scurvy is unknown, but in war situations or under other serious circumstances it would be of significance for the public health that plants with antiscorbutic effects, primarily *Cochlearia officinalis*, *Angelica archangelica* and *Oxyria digyna*, grow profusely in the coprophyte vegetation on bird-cliffs, where they are easily localized, while they are very scattered and difficult to find in all other plant communities, where they neither attain the exuberant size nor possess the lush growth found in the bird-cliffs.

Saxifraga oppositifolia. In the list of plants found in the coprophyte flora of bird-cliffs in Greenland (p. 120) no less than nine species of *Saxifraga* are mentioned. It is peculiar, however, that *S. oppositifolia*, which is so common in the greater part of Greenland, particularly in the

northern parts of the country, does not occur in the coprophyte vegetation. In the numerous bird-cliffs examined by me in entire West Greenland I have only in two places found a single tussock of this plant, but they must be the exception that proves the rule. Its absence from bird-cliffs has been noticed by some other scientists. From Thule District HART (1880, p. 79) gives the following description: "About aukeries and below bird-cliffs, as at Cape York and Foulke Fjord, certain plants are most at home, as all Saxifrages (except *S. oppositifolia*), etc." On bird-cliffs in Spitsbergen "the absence of *Saxifraga oppositifolia* is interesting" (SUMMERHAYES & ELTON 1923, p. 237). In another paper the authors mention that they have found *S. oppositifolia* growing on the breeding-places of *Fratercula arctica*, but add: "this being very exceptional" (*idem* 1928, p. 241). The authors explain its absence from the coprophyte vegetation by asserting that "it seems to be sensitive to competition and is often absent in closer communities" (*idem* 1923, p. 237). I do not think this is the correct explanation. It is more likely to assume that this plant is simply non-coprophytic. In many bird-cliffs the soil is gravelly, not densely covered with plants, more of the fell-field ("fjældmark") type, and in such places there would be room for *S. oppositifolia* if it was a coprophyte at all. It should be added that another species of *Saxifraga*, the extremely higharctic *S. flagellaris*, also preferring gravelly fell-fields, has never been found by me in the coprophyte zone on the bird-cliffs in Thule District, although it is common elsewhere in the district.

The majority of the nine species of *Saxifraga* mentioned in the list p. 120 are commonly found in the coprophyte vegetation. The most widespread and common species is *S. tricuspidata*, which in the bird-cliffs often forms dense and luxuriant growth with numerous flowers. It is noteworthy that this species is not found in East Greenland except in the outer part of Scoresby Sund, the only area along the East-coast with bird-cliffs, the breeding-places of many thousand *Uria lomvia*, millions of *Plotus alle* and hundreds of *Cepphus grylle*, which species are absent as breeding-birds in the remaining parts of N. E. Greenland. The presence of great quantities of guano in this part of East Greenland is no doubt the reason for the occurrence there of *S. tricuspidata.* It is noteworthy that KRUUSE (1905, p. 171) found the species in Scoresby Sund only at localities where *Cochlearia officinalis* occurred, which in Northeast Greenland is exclusively coprophytic; cf. p. 136. BÖCHER (1938, p. 121) gives a totally different explanation of the occurrence of *S. tricuspidata* in East Greenland and compares its distribution with that of *Arabis holboellii.* This species, however, is found in the inner parts of Scoresby Sund, where there are no sea-bird colonies, and it is even found in other parts of East Greenland.

Range Expansion of Coprophytes

It should be expected that the surplus of nutrients available to the coprophytic vascular plants on the bird-cliffs and on similar manured ground would make it possible for certain species to expand their range further to the north in such areas than it would be feasible if they only kept to other habitats. This appears distinctly to be the fact, and in the following the best known cases shall be mentioned.

SCHOLANDER (1934, p. 32) states that *Draba cinerea* is found in the North-East Land, northern Spitsbergen, only on ledges in the bird-cliff Floraberget, and (p. 92) that *Poa alpina* is found in North-East Land only under the bird-cliff Raudstupet.

SUMMERHAYES & ELTON (1928, p. 240) say of the vegetation of Spitsbergen: "Examination of charts of the distribution of certain species suggests that they may occur in the localities with more extreme climate only as far as bird-cliffs are present, *e.g. Ranunculus pygmaeus*, *Alopecurus alpinus*, *Potentilla emarginata*[1] and *Saxifraga hieraciifolia*." More generally the same fact is expressed by EUROLA & HAKALA (1977, p. 17) who state that: "On bird-cliffs in Spitsbergen a continuous vegetation cover extends higher in the mountains and more northernly than is usual for the vegetation."

ROSENVINGE (1898, p. 195) mentions from S. W. Greenland that the southern species *Polygonum aviculare*, *Stellaria media* and *Achillea millefoleum* occur on manured ground only. They have been transferred to Greenland by means of migratory birds or have been unintentionally introduced by the Norse settlers about a thousand years ago.

RUSSELL *et al.* (1940, p. 273) say that on Jan Mayen *Alchemilla glomerulans* was found only at a manured lair of an Arctic Fox, but was not observed elsewhere on the island.

In 1936 I collected various coprophytic plants in Upernavik District. On the bird-island Itugdlalik at 72°45′ n.lat. I collected *Carex subspathacea* and *Potamogeton pusillus groenlandicus*, of which the former was previously not known further north than at 71°30′ n.lat. on Svartenhuk Halvø, while the latter was known northwards only to 70°0′ n.lat. on Nûgssuaq. Itugdlalik was the most northern locality of any species of *Potamogeton* in West Greenland (SØRENSEN 1943, p. 16).

On a visit in July 1968 to the bird-cliff Igpik on the south coast of Disko I found *Roegneria violacea* growing in the zone B (cf. p. 114) of the bird-cliff. It was previously not known north of Holsteinsborg District, more than 200 km further south.

The following species shall be treated separately.

[1]) = *P. hyparctica*.

Sedum resea. This species appears everywhere to be a coprophyte, although not so pronounced in the boreal region. In western Norway it is rarely found in the bird-cliffs, but "makes the impression of being ornithokoprophilous" (GRØNLIE 1948, p. 212). It is widespread in the Faroese sea-bird colonies (RASMUSSEN 1946, p. 65). In the northern parts of its range it is definitely restricted to bird-cliffs and other manured ground and does not appear elsewhere. In West Greenland its northern limit runs through the southern part of Disko Bugt. I have seen it growing profusely there on various bird-cliffs, but have never found it outside this habitat. In East Greenland botanists have noticed the same dependence on manured ground. GELTING, studying in the area between Kejser Franz Joseph Fjord and Dove Bugt says the following of *Sedum rosea:* "It is most luxuriant in the manured ground near the old Eskimo sites and at the foot of bird-cliffs. Very common on the extreme southern point of Eskimonæs, where the barnacle geese breed" (GELTING 1934, p. 56). SEIDENFADEN & SØRENSEN (1937, p. 36) studying somewhat further north, found *Sedum resea* growing at a large colony of "sea-gulls", undoubtedly *Larus hyperboreus*, in Grandjeans Fjord, by far the northernmost record of this species in Greenland, and add that "it is no doubt due to the nitrous manure that the species occurs so far to the north."

Cochlearia officinalis. The occurrence of this species almost everywhere in the higharctic region is undoubtedly dependent on the presence of manure, *i.e.* nitrogenous compounds, on which it react promptly. In Northeast Greenland it "is found almost exclusively in manured spots, ruins, fowling cliffs and islets and gull hillocks" (KRUUSE 1905, p. 160). This shows that *Cochlearia* would not be able to grow in these higharctic areas, or at any rate would be very rare, if it could not attach to the manured localities.

Anthriscus silvestris. This boreal species is well-known as a coprophyte. In Norway GRØNLIE (1948, p. 201) states that it is "highly nitrophilous". It has in various areas expanded into the Arctic region, but only in places with manured ground. In S. W. Greenland it is found as a weed in the cities Ivigtut and Godthåb, but nowhere else. It is found also on islands with big gull-colonies off the Murman Coast in North Russia, and appears to be common there (TATARINKOVA 1967, p. 112).

Chrysosplenium alternifolium tetrandum. This southern species is in Greenland found only in the Clavering Ø area, on the middle part of the East-coast. It has been studied there by GELTING (1934, p. 116), who says the following of this species: "It is found on soil manured by barnacle geese and at old Eskimo sites, where the barnacle also grazes. Thus it

seems very probable that the dispersal of *Chrysosplenium* within the area in question takes place through the agency of the barnacle geese."

Matricaria inodora. This boreal species has, just as *Anthriscus* and *Chrysosplenium*, invaded parts of the Arctic region, where it, however, has a much wider distribution than the two latter genera. I include in *inodora* the many subspecies, varieties or closely allied forms described (*maritima*, *ambigua*, *hookeri*, *phaeocephala*, *grandiflora*). This species is known everywhere to be a distinct coprophyte. In Norway it is "highly ornithokoprophilous" (GRØNLIE 1948, p. 207), in the Faroes it is found generally on the bird-cliffs (RASMUSSEN 1946, p. 65) and on Iceland it inhabits "islands, especially at the hatching places of birds" (GRÖNTVED 1942, p. 368). I can add that I found it growing profusely at the bird-cliff on Carrickcarade Island, west of Ballycastle, northern Ireland, which I visited on the 8th June 1964. The island was inhabited by numerous *Rissa tridactyla*, *Larus argentatus*, *L. marinus*, *Uria aalge*, *Alca torda* and *Fulmarus glacialis*. *Matricaria inodora* was predominant in a community which was extremely luxuriant and consisted of the following species:

Matricaria inodora (var. *maritima*)
Anthyllis vulneraria
Lotus corniculatus
Sonchus oleraceus
Heracleum sphondyleum
Armeria vulgaris (var. *maritima*)
Plantago maritima
– *lanceolata*
Silene maritima

At the Murman Coast, northern Russia, *Matricaria inodora* is found on breeding-places of gulls (BRESLINA & KARPOWITCH 1967, p. 109) and on those of *Fratercula arctica* (TATARINKOVA 1967, p. 111). In Greenland it is found partly in the southernmost West Greenland, where it chiefly inhabits manured ground near settlements (ROSENVINGE 1898, p. 186, PEDERSEN 1972, p. 25), and partly in the middle part of the East-coast, where its distribution to some extent matches that of *Chrysosplenium tetrandum*. GELTING (1934, p. 137) says about *Matricaria inodora* in Northeast Greenland that it is found "on Eskimo sites and on sandy sea-shores which barnacle geese often visit, and the plant is most probably dispersed through the barnacles." This may be correct, but the principle thing is that presence of manured ground is an absolute condition for the existence of this species under an arctic regime. It applies to all the species mentioned in this passage that their occurrence in the

northernmost part of their distributional range would be impossible without the presence of a habitat characterized by an excess of nitrogen compounds, as found in bird-cliffs or "bird-places" of various kinds.

Seed-production

It has been emphasized above that areas of dense growth of grass are generally developed in the coprophyte vegetation of the bird cliffs, while such gramineous associations usually are rare elsewhere in the arctic region. The existence of these extensive grass-fields gives rise to a very large seed-production in the autumn, and this fact attracts seed-eating birds to the bird-cliffs. Even in the breeding-time the seed-eating Snow-Bunting, *Plectrophenax nivalis*, is much more common in the large bird-cliffs than in the adjacent coast-cliffs. I have commented on this at a previous occasion as follows: "Favourable nesting-sites (of *Plectrophenax nivalis*) are also provided by the bird-colonies on steep cliffs on the coast, particularly those of the auks. In such localities there are plenty of cracks and holes in the cliffs, and the terraces are covered with a luxurious carpet of nitrophilous grasses and other plants, on the seeds of which the Snow-Bunting feeds." (SALOMONSEN-1950, p. 541).

In the autumn, especially in September, a large number of seed-eating birds, partly on migration, are found in the bird-cliffs when the coprophytes are mostly withered. I have not been able to study this subject particularly well, but in 1976 I had the opportunity to make some excursions in late September in Godthåb District. On the 19th September I visited the so-called Ikerasak fairway, leading to the north to the numerous islands and skerries between Godthåb and Sukkertoppen and situated slightly east of the outpost Kangeq, now deserted. In the Ikerasak there are three bird-cliffs, all being now abandoned. This abandonment has probably taken place on account of exaggerated shooting owing to their situation very near places inhabited by man until recently. These former bird-cliffs have still kept their luxuriant coprophyte vegetation, of which now the profuse grass vegetation is especially striking. In September 1976 I had only the opportunity of visiting the southernmost one of these bird-cliffs, on which I discovered a number of Redpolls, *Carduelis flammea rostrata*, feeding in the dense vegetation. These birds were migrants now, and Redpolls do not at all breed in the exposed western area of Godthåb District. Redpolls were not encountered on any other places during this excursion.

Still more interesting were observations made on an excursion 29th September 1976 to the large bird-cliff Ivnajuagtoq in the interior of Godthåbsfjord. The luxuriant coprophytic vegetation was now completely withered and difficult to identify from the motorboat (no landing was

made), but it was still possible to recognize *Angelica archangelica*, *Chamaenerion angustifolium*, *Oxyria digyna*, *Sedum rosea*, and *Cerastium alpinum*. There was a surprisingly large activity of *Plectrophenax nivalis*, no doubt on migration now. Some dozens of birds were seen, but it was difficult to ascertain how many birds there were present, because the greater part of them were hidden in the tall and profuse grass vegetation. The Snow-Buntings were seen only when they took off and shifted to other foodplants not far away. However, this rising and alighting of birds took place continuously and gave the definite impression that many birds were present and had spread all over the grass-fields. Further observations in September-October are needed in order to elucidate the importance of the seed-production in the bird-cliffs for the migrating granivorous birds.

Coprozoans

The invertebrates living in the soil grown with coprophytes and in one way or another being dependent on the high level of nitrogen, are in this paper called *coprozoans*. Although not much is known about these organisms, it appears that the micro-fauna of the manured soil in bird-cliffs or in other "bird-places" is very distinctive and much richer than in other habitats of the arctic landscape. This was to be expected, according to the experience gained from work with cultivated fields in the temperate region. The effect of the nitrogen manure in the arable field puts up the population of the soil fauna considerably, especially the number of collembolans, various larvae of insects, mites, nematodes and oligochaetes (Russell 1961, p. 174). This conclusion appears to hold good also in the soil rich in guano of the arctic bird-cliffs.

Summerhayes & Elton)1928, p. 240) studied in Spitsbergen the coprozoans of a bird-cliff, a "skua-hummock" and (p. 245) of an island inhabited by *Sterna paradisaea*, and found in the grass-turf a community of invertebrates which was considerably better developed, both in species and individuals, than those of the ordinary, surrounding fell-field. The authors identified a number of mites and spiders in the manured places, mentioned above, and found these organisms to be numerous. They also discovered that one species of the collembolans, one of the mites and one of the land-flies, did not occur at all in the surrounding fell-field.

In N. E. Greenland Haarløv (1942, p. 12) examined the soil around a "bird-stone" used by *Nyctea scandiaca* and other birds as a watching and resting place. The dense coprophyte vegetation consisted mainly of *Alopecurus alpinus*, with scattered individuals of *Cerastium alpinum*, *Draba daurica*[1] and *Melandrium triflorum*. He found (p. 54) a rich fauna

[1]) = *D. glabella*

in the soil around the stone, including a coleopteron (*Bembidion grapei*) not found elsewhere in the neighborhood, a thysanopteron (*Aptinothrips rufus*) new for Greenland, and an oribatid (*Pediculoides sp.*), present in great numbers, also new for the Greenland fauna; also the oribatid *Phyllocoptes sp.* was numerous at the bird-stone, but nowhere else in the environment. These examples, and those mentioned above, indicate that certain organisms of the microfauna in the manured soil are capable of existing in these northern regions only on account of the presence of guano, just as it was the case with a number of coprophytes (p. 135).

RUSSELL *et al.* (1940, p. 276) investirated the soil on the scree of some bird-cliffs on Jan Mayen and found the number of protozoans, within the groups of flagellates, rhizopods and ciliates, to show a correlation with the amount of guano. There were especially a great number of ciliates, for the development of which a large bacterial population is necessary.

Finally the soil fauna of the bird-cliffs on Bear Island was studied by BERTRAM & LACK (1938, p. 39). They showed that several diptera were not found away from the bird-cliffs, and apparently did not break away from them, although they could occasionally be found some distance inland from the cliffs. Typically they are much more generally distributed, but on Bear Island conditions were presumably too severe except on the bird-cliffs. In some insects, like *Olophrum boreale*, it appeared that the specimens from the bird-cliffs were markedly larger than those from various localities inland, a development which should be compared with the excessive size of the coprophytes (cf. p. 123). It was also found that three species of Staphylinidae, present in the bird-cliffs, were feeding mainly on decaying matter. The restriction of these beetles to the coprophyte vegetation of the bird-cliffs may have been directly correlated, through food supply, with the general scarcity of decaying matter in usual arctic habitats. It is noteworthy that even in the soil of gull colonies in England was found an increase in the number of burying beetles, Staphylinidae and Carabidae (GILLHAM 1964, p. 26).

Investigation of the soil fauna in areas covered with coprophyte vegetation in the bird-cliffs is a very promising field of research. Little is known about this biome and the ecological balance of the coprozoans, and further studies are urgently needed.

THE SEA-BIRD COLONIES OF FREDERIKSHÅB DISTRICT

Each sea-bird colony is described according to the schedule on p. 82 and the methods on p. 83. All breeding-places enumerated in the following are supplied with consecutive numbers and the letter F (for Frederikshåb) in order to make comparison, references and comprehensive studies easier. The description begins with the north, at the boundary towards Godthåb District, and then moves to the south, ending with the Julianehåb District border, although the southernmost breeding place dealt with actually is situated on the other side of the border, in Julianehåb District proper. All the breeding places described are shown on the map Fig. 34.

F. 1

Ikermiut archipelago and adjacent islands, including:

A. The westernmost island in Ikermiut, 62°23′N, 50°16′W.

B. The southernmost island in Ikermiut, 62°23′N, 50°15′W.

Kujatdlît, 62°22′N, 50°13′W.

Agpat, 62°21′N, 50°09′W.

Examined on 30th June 1971. The situation of these islands is shown on the map Fig. 35. On this map is also given the breeding range on these islands of three species of birds, namely *Fulmarus glacialis*, *Larus hyperboreus* and *Larus marinus*.

Island A in the Ikermiut archipelago

This small island has an altitude of about 30 m, and to the north and northwest the coast is steep, forming a vertical cliff about 20 m high. The vegetation is exclusively coprophytic, the dominant species being *Cochlearia officinalis*, which was growing densely almost everywhere, interspersed with *Sedum rosea*, growing more sparsely, and some *Stellaria humifusa*, found only in a few places. Apart from these plants only mosses and grasses were found but not identified. No development of *Caloplaca elegans* was observed.

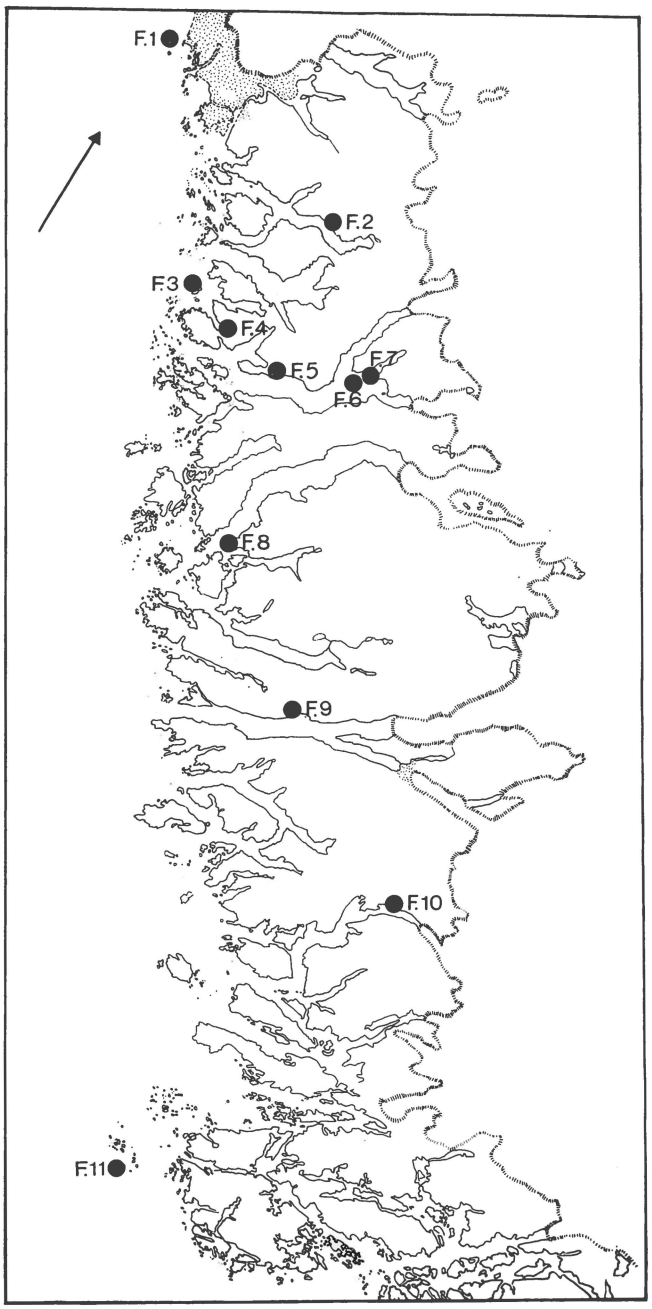


Fig. 34. Map of Frederikshåb District with its sea-bird colonies shown as solid circles and marked with consecutive numbers and the letter F (for Frederikshåb).

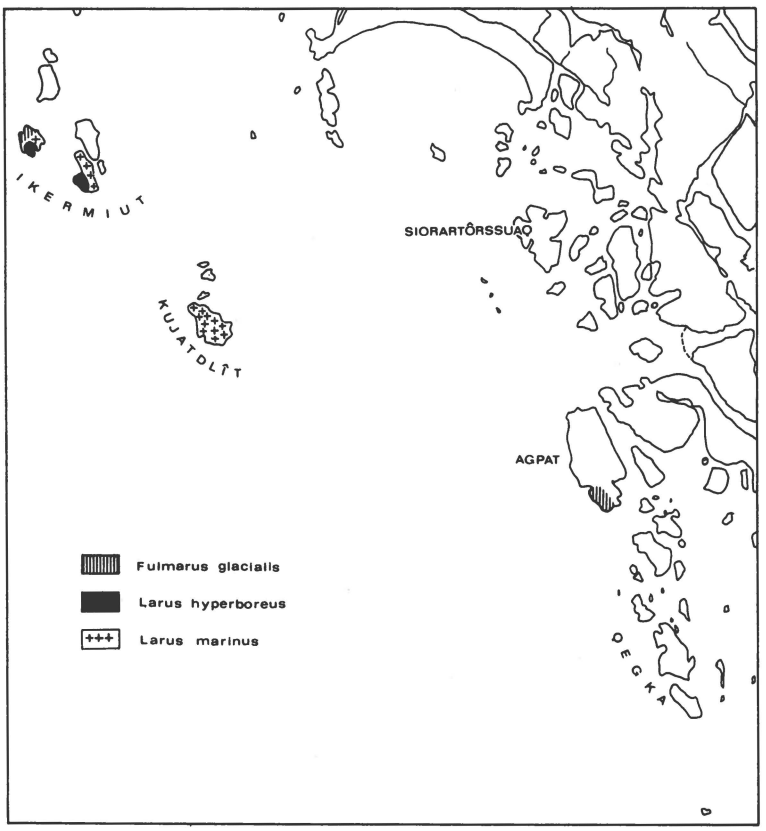


Fig. 35. Map of Ikermiut archipelago, off Frederikshåb Isblink, on 62°20′–62°24′N, giving breeding-range in 1971 of *Fulmarus glacialis*, *Larus hyperboreus* and *Larus marinus*.

Breeding Birds

Fulmarus glacialis. Nothing more can be said about the breeding place of this species than was mentioned on p. 26 above.

Larus hyperboreus. A colony of about 50 pairs were breeding on the southern side of the island, in a large, lavishly overgrown valley. Our crew collected all the eggs they could find, and obtained more than 30, mostly quite fresh, because other people had recently collected here.

Larus marinus. One pair was breeding on the eastern part of the island, quite isolated from the large breeding population of *Larus hyperboreus*. It appeared that the two gull-species were completely segregated on the breeding place. A single individual of *marinus* which ventured to come into the territory of the large *hyperboreus*

colony when all the gulls were in the air, was roughly driven away, but was later tolerated to fly around freely.

Cepphus grylle. Eleven pairs were breeding.

Plectrophenax nivalis. A few pairs breeding on the island.

Island B in the Ikermiut archipelago

This locality does not essentially differ from the island A in structure or vegetation.

Breeding Birds

Larus hyperboreus. Four or five pairs were breeding on the southwestern part of the island.

Larus marinus. On the eastern part of the island four pairs were breeding, completely isolated from the *hyperboreus* population breeding on the southwestern part of the island.

Cepphus grylle. Two pairs were found at the coast.

Alca torda. Eight pairs were found breeding in holes and crevices in the rock up to an altitude of about 10 m. Patches of white guano made the breeding places visible far away.

Kujatdlît

This island is isolated from the Ikermiut archipelago and is slightly larger than the two islands "A" and "B", dealt with above (Fig. 35).

Breeding Birds

Larus marinus. A big colony, numbering about 40 pairs was found on this island. I did not go ashore because a boat from Frederikshåb was anchored at the coast and the crew was occupied with collecting eggs of *marinus.*

No other breeding birds were observed.

Agpat

This island is much bigger than the other islands, described above, and is situated close to the coast of the mainland. In structure and vegetation it differs from the islands situated further out to sea by the presence of heath-vegetation, which indicates that Agpat is closer to the mainland. The heath-vegetation consisted of only few species. The dominant plant was *Empetrum nigrum*, which was found everywhere, often mixed with *Salix herbacea* and with scattered specimens of *Vaccinium uliginosum* and *Silene acaulis.* Coprophytic vegetation was developed only on the breeding place of the Fulmar and on a few *pingut* (see p. 112).

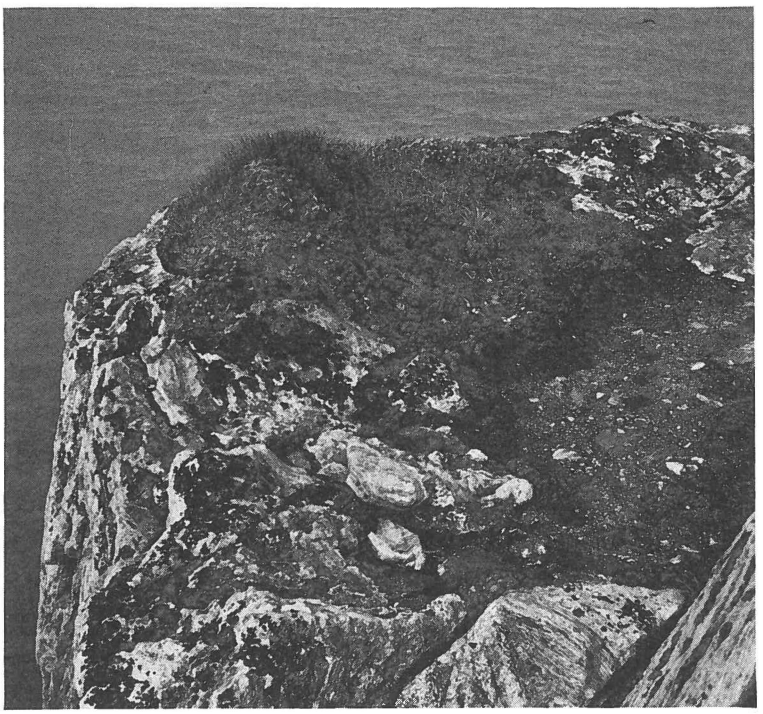


Fig. 36. *Pingo* of *Larus marinus* on top of perpendicular cliff on the west-coast of the island Agpat, Frederikshåb District. Notice profuse vegetation of *Sedum rosea* and various gramineae. (Phot. 30th June 1971 by F. SALOMONSEN).

Breeding Birds

Fulmarus glacialis. Remarks on the small breeding population was given on p. 26. The breeding place was a perpendicular cliff, about 40 m high (see Fig. 5), in the southwestern part of the island, facing west. The breeding place was completely lacking *Caloplaca elegans*, probably on account of the continuous sprinkling with sea-water. The vegetation on the breeding place did not differ from that on Ikermiut. There was a profuse growth of *Cochlearia officinalis* on the ledges and a much more scarce vegetation of *Sedum rosea.* Other species could not be identifled from the motorboat in the agitated sea.

Larus marinus. A few pairs were breeding on Agpat. Their activity had given rise to the formation of some *pingut*, which were placed on especially high points of the coast or other eminences commanding a fine view over the surroundings. One of these *pingut* is shown on Fig. 36. It is placed on an about 40 m high perpendicular cliff at the coast. The surroundings were bare rock, only covered with scattered

patches of lichens. It is distinctly to be seen on Fig. 36 that the *pingo* is covered with grasses and voluminous tussocks of *Sedum rosea*. Elsewhere, in the heath-land of the island this plant could be found only rarely and then in very small specimens, only a few cm high. The inhabitants of Frederikshåb District are aware of the significance of these gull-hummocks, which they call by the name *pingo* that also is the name which I, years ago, have chosen as the scientific international designation for this phenomenon.

Cepphus grylle. About 15 pairs were found breeding at the coast of the island.

Plectrophenax nivalis. Several pairs breeding on Agpat.

Other Bird-Species Observed

Historionicus histrionicus. Rather common around the islands. At the island "A" in Ikermiut five specimens were seen in the surf near the coast, at the sialnd "B" a flock of 18 specimens and at some skerries south of Agpat a flock of three.

Somateria mollissima. Some flocks were observed among the numerous islands between Avigait outpost (at 62°14′N) and the islands in question, mostly adult males and immature birds. The Eider is said to breed here sparingly, but we did not find any nests on the islands "A" and "B" in Ikermiut in spite of a thorough search.

Gavia stellata. Three specimens observed, separately.

Stercorarius parasiticus. One pair seen at Ikermiut, both birds of the light phase, and one more specimen observed, probably also belonging to the light phase.

Corvus corax. One or two seen in the air, passing over the islands, where they apparently did not breed.

Other Remarks

It should here be noted that *Sterna paradisaea* does not breed here, nor at any other localities in Frederikshåb District. It breeds a few places in Julianehåb District south of Frederikshåb District, and it begins again to breed in the southernmost Godthåb District, on the islands Tulugartalik (62°28′–30′N, 50°20′–25′W) which are situated a few miles outside the glacier Frederikshåb Isblink and form the southern boundary of Godthåb District. I notice that DAVID BOERTMANN, the leader of an ornithological excursion in West Greenland in 1974, reports (*in litt.*) that there were many large colonies of Arctic Terns on the islands off Frederikshåb Isblink, when they passed this area by ship on the 3rd August 1974. The "islands off Frederikshåbs Isblink" must have

been Tulugartalik. I am also quite sure that it must have been these islands on which EKLUND (1944, p. 648) studied the Arctic Tern in 1944. According to him there were about 300 nests on the small island (300 yards × 100 yards) which appeared to be the only one in the immediate vicinity where the terns were nesting. The island was said to be situated "a few miles off the Frederikshåb Glacier" (*i.e.* Frederikshåbs Isblink), and this is the case with the islands Tulugartalik. However, the geographic position of the islands is stated by EKLUND to be 62°09′N, 50°21′W, and this is a locality much to the south of Frederikshåbs Isblink and far out in the Davis Strait, where there are no islands at all. There is no doubt that his geographical position of the island has been misprinted. The correct position is undoubtedly 62°29′N, 50°21′W, which is the exact spot for one of the islands in the Tulugartalik group.

The Great Black-backed Gull, *Larus marinus*, was commonly breeding on the numerous skerries and small islands situated along the coast between Ikermiut and Avigait outpost. The birds were often seen, standing or resting on the skerries, during our passages with the motorboat through this area. Numerous *pingut* were observed also, and it was distinctly to be seen that the Great Black-backed Gull was breeding with one pair on each small island. The Glaucous Gull, *Larus hyperboreus*, was not breeding on these islands.

The main thing is that the gulls are segregated in the area in such a way that each islet is inhabited by only one pair. This is the usual ecological distribution of the Great Black-backed Gull along the southern parts of the West Greenland coast. On the other hand, it has been shown above that on the Ikermiut Islands as well as on Kujatdlît both species of gulls (*L. marinus* and *L. hyperboreus*) form colonies of about 40–50 pairs on each island. The result of this piling up of birds on these islands is an accumulation of edible eggs, easily accessible to man. Collecting of eggs is for the Greenland inhabitants an important subsistence activity, and I mentioned that our own crew collected eggs on these islands, and also other boats from Frederikshåb District were active there in this way. Since such egg-collecting is done continuously during the summer only a few young will be developed on the islands with big gull-colonies. This means that a selective premium is paid to those gulls which breed isolated on small islands. The fact is that the Greenlanders do not take the trouble to collect eggs on the islands on which only one pair of gulls is present. It would imply that too much effort should be spent if a crew on a motorboat should pay numerous visits to various islands in order to collect a few dozens of gulls' eggs. JAKOB PETERSEN, the motorman on our boat, who was well acquainted with the local hunting and egg-collecting, told me that the inhabitants collected gulls' eggs only on the Ikermiut and adjacent islands, but not on the numerous islands with a

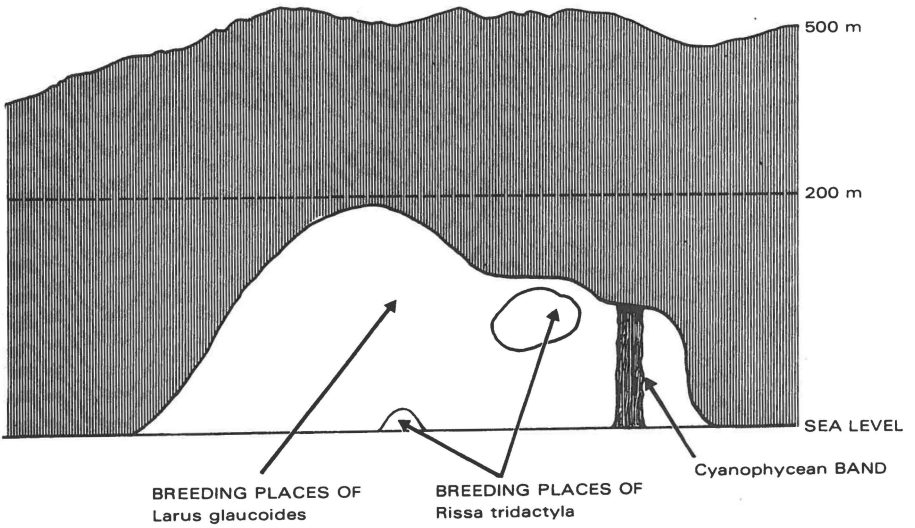


Fig. 37. Diagrammatic representation of the bird-cliff F.2, Qagssit fjord.

single pair of gulls. This agrees with the general situation everywhere in Greenland. Easily accessible gull colonies are, on the other hand, usually wiped out or drastically reduced in number, and remain only if they are situated in remote areas, too far from inhabited places to be harvested regularly. I am sure that Ikermiut must be regarded as one of these remote islands, at least before the modern fast speedboats were introduced into Greenland. This development has taken place all along the West Greenland coast, where I know of several gull islands which are now totally deserted. An instance is given below, p. 155.

The problem of the selective premium paid to seabirds breeding at well spaced-out localities touches upon a general problem to which ethologists have paid only minor attention. The experiments on spacing-out as a defence against predation carried out by TINBERGEN *et al.* (1967, p. 307) deal with a similar phenomenon, namely Carrion Crows (*Corvus corone*) searching for eggs presented in different densities. The authors claim this work to be the first step in the study of this problem. The results obtained by the procedure used by egg-collecting man in Greenland may very well give an impetus to future ethological studies of this interesting subject.

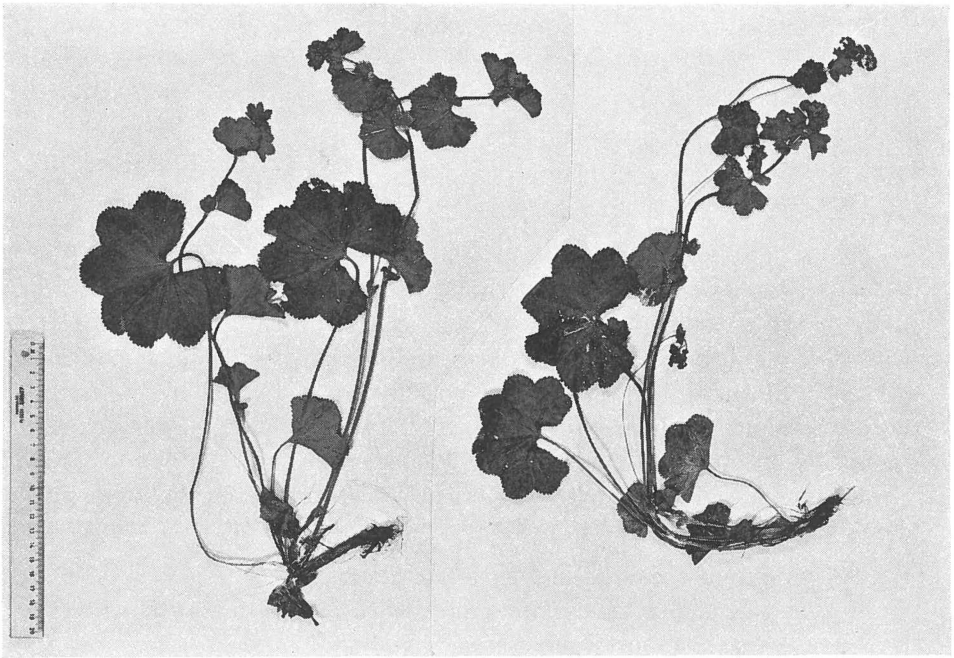


Fig. 38. Specimens of *Alchemilla glomerulans* from the coprophyte zone of the bird-cliff Qagssit fjord (F. 2), collected 29th June 1971. Large size; length 50–54 cm, greatest diametre of leaves 12 cm. Notice patches of bird manure on leaves. (Phot. Zool. Mus. Copenhagen).

F. 2

Qagssit, 62°15′30″N, 49°26′W.

Examined on the 29th June 1971. The cliff is directly south-exposed, it is inhabited by birds to an altitude of about 180 m, and the mountain itself is at least 500 m high. The breeding place is a very steep wall, virtually perpendicular, without any talus below but in its lower part with numerous crannies and projections, giving possibilities for a varied plant-growth, to the right a very broad, black cyanophycean band (Fig. 37) and here there is much water seeping and trickling down and forming small downward passing streams or flows. The guano is dense in the area where *Rissa tridactyla* breeds and colours this part whitish, while the area in which the *Larus* species breed is naked cliff with practically no whitish guano. There is a dense sprinkling of white fecal patches on the vegetation below, which is to be seen on the plants in Fig. 38. The growth of *Caloplaca elegans* is restricted to scattered patches, which are particularly well developed around the area of breeding *Rissa tridactyla.*

Breeding Birds

	Number of Pairs	Altitude (in m)
Rissa tridactyla	ca. 1500	80–120[1]
Larus glaucoides	ca. 200	50–150[2]
Larus hyperboreus	ca. 10	170–180
Cepphus grylle	5	2–50

Vegetation. The plant-growth was found particularly on the protruding projections on the lower part of the bird-cliff. The life-conditions were good, owing to south-exposure (much sunlight), optimal fertilization (with bird-manure) and in many places well-watered soil. The vegetation was as a rule luxurious, and was especially characterized by excessive size of the plant specimens (cf. p. 123). There were differences between the vegetation on moist soil and that on drier localities.

On moist soil often with seeping or trickling water the following plants were found:

Sedum annuum. Found in only a few places.

Sedum rosea. Extremely numerous, with a dense growth of very large tussocks almost everywhere.

Angelica archangelica. Numerous and with large specimens.

Salix glauca. Common.

Alchemilla glomerulans. Very common, appearing in enormous specimens, as shown in Fig. 38. The specimens attained a length of 50–54 cm, the leaves a diameter of up to 12 cm. On Fig. 38 can be seen white dots and patches of bird-manure on the leaves, indicating the easy access of guano on this locality.

Saxifraga stellaris. Found in only a few places.

Saxifraga caespitosa. Scattered specimens, measuring up to 13 cm.

Epilobium palustre. Scattered specimens.

Stellaria longipes. Rather rare, very scattered, of ordinary appearance.

Stellaria calycantha. Rather big tussocks, measuring in length 25–33 cm, compared with a usual size of 15–25 cm (BÖCHER *et al.* 1966, p. 149).

Cerastium alpinum. Rather common in occurrence. The specimens were very large, with long internodes, more glabrous, not so hairy as ordinarily. The length of the specimens were 25–27 cm. Some of my herbarium specimens from Qagssit are shown on Fig. 39, compared with specimens of ordinary size and structure.

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[1]) Some pairs separated below, on 3–20 m; cf. Fig. 37.

[2]) Some pairs breeding further down, one pair as far down as 3 m; many breeding in the areas inhabited by *Rissa tridactyla.*

Fig. 39. Specimens of *Cerastium alpinum*, to the right large ones from the bird-cliff Qagssit fjord (F. 2), collected 29th June 1971, to the left specimens of ordinary size, collected at Narssarssuaq, Julianehåb District, 14th June 1971. (Phot. Zool. Mus. Copenhagen).

Poa nemoralis. Very common, growing in large tussocks. Greatest height measured: 67–69 cm. (Other species of grass were observed, but not collected nor identified.)
Cystopteris fragilis. Common.
Dryopteris filix-mas. Rather common.

On drier localities the following species were found:

Cerastium alpinum. Rather common.
Viscaria alpina. Many, often gathered in clusters of up to 20 plants. The flowers were red; no specimens belonged to var. *albiflora.*
Campanula gieseckiana. Scattered specimens.
Taraxacum sp. Scattered tussocks. The specimens were rather large, with a length of up to 35 cm.
Chamaenerion angustifolium. Qery common, formed extensive growths.
Potentilla crantzii. Rather common, many tussocks, My herbarium specimens are difficult to identify and look similar to *P. ranunculus*,

because they are much less hairy than in usually the case. It appears that hairy species of coprophytic plants tend towards more glabrous types, as shown already, above, in the case of *Cerastium alpinum.*

As mentioned already (p. 00), this sea-bird colony was known as early as about 1770, when it was mentioned by the naturalist OTHO FABRICIUS. Since his time nobody has ever mentioned it.

Other Bird-Species Observed

Anas platyrhynchos. In the head of Qagssit fjord (Qíngua), where the water is silted up with mud from the rivers, a flock of eight Mallards was observed.

Clangula hyemalis. A flock of three individuals in the sound east of the island Iterdlak.

Larus marinus. Very common among the numerous skerries outside Qagssit and one observed at Avigait outpost, but no one seen further inside the fjord.

Larus glaucoides. The inhabitants of the bird-cliff were searching for food by fishing a couple of miles from the sea-bird colony but did not transgress 49°35'W. That means that they were not observed in the outer part of the fjord. A flock of about 50 birds were seen on the clayey beach of the Qíngua (head of the fjord), of which half were adult birds and half immatures.

Rissa tridactyla. Unlike *Larus glaucoides* the Kittiwakes inhabiting the bird-colony searched for food in the entire fjord and moved as a rule much further away from the breeding-place than *glaucoides.* Numerous birds, gathered in flocks of up to 15 individuals, were observed flying to and from the colony, and were seen the whole distance north of Iterdlak right to Avigait outpost.

Uria lomvia. A single bird observed at the entrance of Sarfâ sound north of Frederikshåb.

Other Remarks

The inner parts of the fjord-country, around the Qíngua, is covered with a lush and varied vegetation, and large stretches form extensive thickets. No sheepfarming takes place here, and the plant-life, therefore, can develop undisturbed. In order to show how different the vegetation of such a heath-land is in comparison with the coprophytic association in the Qagssit bird-colony, the following list of the most important plants of the Qíngua country shall be given: *Salix glauca*, *Betula glandulosa*, *Juniperus communis*, *Ledum groenlandicum*, *Rhododendron lapponicum*, *Vaccinium uliginosum*, *Silene acaulis*, *Saxifraga oppositifolia* (a few), *Bartsia alpina*, *Alchemilla alpina*, *Pedicularis labradorica.*

F. 3

Qeqertarssuârag, 62°3′N, 49°45′W.

Examined on the 29th June 1971. This largish island, reaching an altitude of 244 m, is situated right out to the sea, facing the open Davis Strait. The rocky coast is naked, exposed to the wash of the waves. There is no vegetation except a few *Sedum rosea*, which are small and scrubby. *Caloplaca elegans* is completely lacking.

Breeding Birds

Cepphus grylle. A colony of about 50 pairs were breeding along the rugged northcoast of the island.

F. 4

Ungilak, in Sarfâ, 62°01′N, 49°32′30″W.

Examined on the 29th June 1971. A high and steep mountain, the peak reaching an altitude of 691 m, the bird-cliff being west-exposed with scattered fields of debris below, rather moist with dripping water on various places, *Caloplaca elegans* completely lacking.

Breeding Birds

	Number of Pairs	Altitude (in m)
Cepphus grylle	15	3–15

Vegetation. The plants were growing in wet soil, often with seeping water, and consisted primarily of the following species: *Sedum rosea*, *Oxyria digyna*, *Cerastium alpinum*, *Taraxacum sp.*, *Cochlearia officinalis*, *Polygonum viviparum*, *Ranunculus pygmaeus*, *Salix glauca*, *Cystopteris fragilis* and various gramineae. It should also be mentioned that there were many moss-covered places. All plants appeared to be of the ordinary size; there were no examples of excessive growth as was the case at Qagssit (F. 2).

Other Remarks

The differences between the vegetation of west-exposed Ungilak and south-exposed Qagssit are noteworthy. The latter possessed patches of *Caloplaca elegans*, while *Cochlearia* and *Qxyria* were lacking. At Ungilak the situation was just the opposite. Ungilak is a *Cochlearia* cliff, Qagssit a *Caloplaca* cliff; cf. definition of these two types on p. 86. It should be added, however, that the differences between these two types of vegetation are not particularly pronounced so far to the south in the low-arctic region. The *Caloplaca* vegetation on the bird-cliffs does not begin to develop to its lush climax until in the northern part of Godthåb District; see also p. 97 and p. 175.

F. 5

Kuánersôq, 62°0′N, 49°17′W.

Examined on the 1st July 1971. The cliff is situated on the north-side of the large fjord Kuánersôq or Kvanefjord, and is almost directly south-exposed. It is inhabited by birds to about 400 m, and the posterior mountain is 923 m high. The breeding-site of the birds is an almost perpendicular cliff-wall and is placed at a big cleft which is several hundred m high and cleaves almost the entire cliff-wall. There are two large densely overgrown talus' below and several ledges also with much vegetation. Some horizontal springs in the cliff at about 200 m altitude form ledges and constitute the main breeding-places of the Kittiwake. A small rivulet runs down the cleft and moistens the vegetation. In a similar cleft just east of the bird-cliff there is also a rivulet with a small water-fall and with much mossy vegetation around. *Caloplaca elegans* is comparatively well developed and can be seen rather far away, but there is no *Caloplaca* arch.

Breeding Birds

	Number of Pairs	Altitude (in m)
Rissa tridactyla	ca. 300	150–200
Larus glaucoides	ca. 700	200–400
Larus hyperboreus	10	ca. 400
Cepphus grylle	6	2–5

Vegetation. The two talus-formations sbelow the bird-cliff were carefully studied. The following species of plants were found:

Salix glauca. Scattered growth.
Angelica archangelica. Rather many observed.
Alchemilla glomerulans. Big specimens, almost as in Qagssit (F. 2; see also Fig. 38).
Sedum rosea. Very common; large specimens.
Taraxacum sp. Scattered tussocks of large specimens, with a length of up to 35 cm.
Cerastium alpinum. Common.
Arabis alpina. Very common, large vegetations.
Cochlearia officinalis. Only very few, medium sized or rather small specimens, growing in shadowy and moist fissures and crannies.
Oxyria digyna. Scattered, particularly to be found on moist ground at the rivulets. The specimens are not specially large or numerous, but it is nevertheless noteworthy that this species as well as *Cochlearia officinalis* are found at all on this south-exposed locality.

Saxifraga caespitosa. Scattered specimens, not particularly large.
Saxifraga nivalis. Scattered specimens, of normal size.
Saxifraga rivularis. Rather rare, on moist ground.
Campanula gieseckiana. Comparatively few, growing on drier soil.
Veronica alpina. A few specimens on dry ground, together with *Campanula gieseckiana.*
Cystopteris fragilis. Common.
Dryopteris filix-mas. Scattered.

This bird-cliff, which formerly was much bigger and with a greater bird population, is situated so close to Frederikshåb that it has been known by the inhabitants for centuries. It has been mentioned by RABEN in 1823 as a breeding-place for thousands of Kittiwakes and numerous "Glaucous Gulls" (undoubtedly Iceland Gulls) and it was mentioned also by JØRGENSEN in 1842; cf. WINGE 1898, p. 194.

Other Remarks

The inhabitants in Frederikshåb and in the small outpost Kangilineq, situated not far from Kuánersôq bird-cliff (but now abandoned) have hunted sea-birds at the bird-cliff for many hundred years. This has resulted in the fact that the sea-birds have placed their nests very far up on the cliffs. Apart from a few Black Guillemots all breeding birds are restricted to the upper parts on the cliff, no bird breeding lower than 150 m altitude. This height is so excessive that it is not possible for the Greenlanders to disturbe the breeding-birds there, and this is the reason for the continuous existence of this bird-colony. If all breeding-birds had been accessible and it had been possible to reach them by shooting, the bird-cliff would have been completely abandoned by the sea-birds, in the same way as has been the case with many other sea-bird colonies near the cities in Greenland. Needless to say, shooting close to bird-cliffs has been prohibited for many years in Greenland, and it is possible, therefore, that the situation will improve.

F. 6

Qeqertaq, Kuánersôq, 62°03′N, 49°04′W.

Examined on the 1st July 1971. This small, but rather high island (highest point 90 m) is situated in the inner part of the Kuánersôq. About 30 pairs of *Cepphus grylle* breed at the northwest-exposed side of the island, low down above the water, between blocks and boulders, produced by frost-erosion. *Caloplaca elegans* was completely lacking at the breeding-place, but numerous *Sedum rosea* were growing on the sloping cliffs above the breeding-place.

F. 7

Island off Nûgârssuk, Kuánersôq, 62°4′N, 49°01′W.

Examined on the 1st July 1971. This little, flat island, situated between Akugdleq and Nigerdlikasik, the southern arms of Kuánersôq, and only a few hundred m from the promontory Nûgârssuk, is a typical "gull island" and was formerly inhabited by a large number of *Larus glaucoides*. A number of old nest-cups and scrapes were still present, but no gulls were seen. There was a luxurious growth of *Sedum reosa* and *Taraxacum sp.* besides a profuse grass vegetation, these coprophytes being remnants from the days when the island was inhabited by birds. The island is easily accessible, and the number of gulls have greatly attracted the inhabitants. Although the island is far removed from inhabited places modern speedboats soon bring visitors to the island, and incessant egg-collection and shooting has then finally wiped out the birds. Such situations were discussed also on p. 147.

Other Bird-Species Observed

Larus marinus. A floock of about 50, consisting of exclusively immature birds, one to three years old, stayed on the island F. 7, just described, but disappeared when we approached them.

Larus glaucoides. Common in Kuánersôq and frequently met with. In the northern branch of the fjord, called Sermilik avangnardleq, there is an active glacier at the head, and the inner part of the fjord is crowded with icebergs. A great number of Iceland Gulls were found here, more than 100 birds, many resting on the icebergs.

Cepphus grylle. Many specimens, belonging to the colony on F. 6, were found feeding on the water in Sermilik avangnardleq, rather far away from the breeding place. It was interesting that the birds habitually were feeding on the water very close to the icebergs.

Other Remarks

In Sermilik avangnardleq was previously found a small colony of *Rissa tridactyla*, situated on the western bank slightly south of the place called Qangmik. It has been abandoned by the birds many years ago, due to persecution by man. At present only one pair of *Larus glaucoides* was breeding there. According to information from the Greenlanders, another little Kittiwake colony is now found at the head of the Sermilik avangnardleq, practically inaccessible on account of the dense packing of ice. We could not approach this place but had to keep many km from it, due to the ice, and could not even discover the breeding-place in our binoculars.

F. 8

Ivnaq, Sermilik, 61°43′N, 49°10′W.

Examined on the 3rd September 1975. The Sermilik has a very productive glacier at its head, and it is absolutely impossible to visit the bird-cliff Ivnaq, although it is situated in the outer part of the fjord. The ice-production is less in the autumn, and I succeeded in investigating the bird-cliff in the autumn 1975, because at this point it was possible with some caution to approach Ivnaq with motorboat.

The bird-cliff is situated just north of the large island Neria, and is placed on a promontory jetting out in the ice-fjord. The part inhabited by birds is about 70 m high and 200 m broad, the mountain above and behind it reaching an altitude of about 150 m. It is almost directly south-exposed (or better, S.S.W.-exposed), is absolutely perpendicular and without any talus whatsoever. The cliff appeared to be dry, without any rivulet or water-dripping, but there were a few cyanophycean bands, although not particularly conspicuous. No *Caloplaca elegans* is developed at all, the whole bird-cliff being bare, of a pale greyish colour, without lichens. There were no birds present at the cliff at this time of the year, but about 10 individuals of *Larus glaucoides* were observed in the fjord, evidencing that they were the former breeding-birds. Remnants of nests of this species could be seen on the bird-cliff, but there cannot have been more than at most 25 pairs breeding. No nests of *Rissa tridactyla* were found on Ivnaq, and no specimens were seen in the fjord. It can be concluded that the Kittiwake does not breed here, at least not at the present time. The vegetation was partly withered, but it was possible to see a great number of *Sedum rosea* on all ledges. I could not discover any *Cochlearia officinalis*, but I must stress the fact that the ice prevented our boat from landing at the bird-cliff; it was possible only to study it from a distance of about 50 m. There were other species of plants on many ledges, but they were impossible to identify at a distance so late in the autumn. Still, I could recognize some blue flowers of *Campanula gieseckiana* at some places.

This bird-cliff was mentioned as early as 1770 by Otho Fabricius (Winge 1898, p. 194), but in those days this locality was known as a breeding place for the Kittiwake. In the meantime this species has disappeared, probably owing to persecution by man. The outposts Narssalik and Neria (now both abandoned) are situated rather near to the bird-cliff and the inhabitants pursued the birds her to a great extent. After Fabricius nobody has mentioned the bird-cliff.

F. 9

Ivnarssuaq, Sermiligârssuk, 61°31'N, 48°40'W.

Examined on the 4th July 1971. The cliff is situated on the north side of the long and broad fjord Sermiligârssuk, which has a productive glacier at the head and, therefore, is more or less filled with icebergs. Ivnarssuaq (meaning the "large, steep cliff") is an about 3 km long, almost perpendicular cliff wall, about 200 m high, with the mountain behind it, the mighty Sitdlisigssap qáqâ, attaining a height of 690 m. The bird-cliff is south-exposed, with a tendency towards west, and is inhabited by birds to about 150 m altitude. There is no talus at all, but there are a number of ledges with scattered vegetation. The cliffs are stained orange by *Caloplaca elegans* over large expanses, which is surprising when bearing in mind how slight the *Caloplaca* is usually developed in Frederikshåb District. The breeding area is mostly bare rock, of a greyish-whitish colour, while the surrounding parts of the cliffs are more or less blackish, due to lichen vegetation. The breeding-place is divided into four sections, of which the biggest one is to be seen on Fig. 40 and described below. In all four sections there was a broad cyanophycean band and much trickling and seeping of water as well as very moist ground. It is evident, therefore, that the presence of moisture or seeping water is of importance for the breeding seabirds. Cf. also the other large seabirds colonies in Frederikshåb District which possess the same feature.

Breeding Birds

Of the four sections in which the breeding-site is divided the biggest is shown in Fig. 40. In this section there were the following breeding birds:

	Number of Pairs	Altitude (in m)
Rissa tridactyla	ca. 400	3–40
Larus glaucoides	ca. 200	10–100

It is to be seen on the figure that the two species of gulls are partly separated and are independent of each other, and that their breeding sites are divided into several parts, two mainly with Kittiwakes and two with Iceland Gulls. The latter species breed partly in these two breeding-sites, partly with scattered pairs all over the steep cliff walls and, finally, also with a few pairs in the two Kittiwake breeding-sites; cf. Fig. 40. The same structure was found in all the four divisions of the breeding place.

Altogether the following breeding-birds were found in this colony:

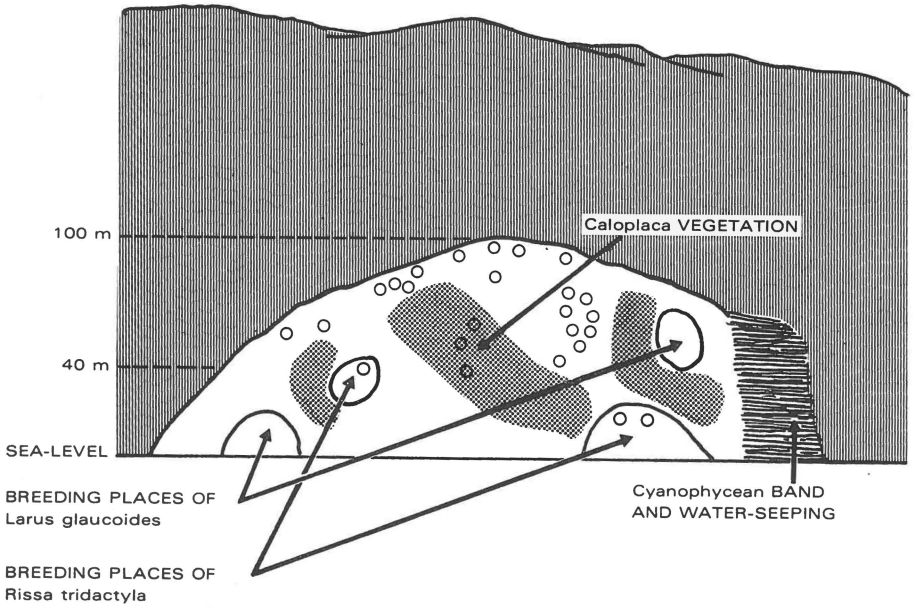


Fig. 40. Diagrammatic representation of the biggest of the four sections of the bird-cliff Ivnarssuaq (F. 9). The small open circles indicate nests of *Larus glaucoides*.

	Number of Pairs	Altitude (in m)
Rissa tridactyla	ca. 1200	3–50
Larus glaucoides	ca. 800	10–150
Larus hyperboreus	3	150
Cepphus grylle	5	2–10

Vegetation. Most localities with vegetation were moist, and the following species of vascular plants were identified:

Sedum rosea. Very common.
Cerastium alpinum. Common; small tussocks, specimens of normal size.
Angelica archangelica. Common.
Alchemilla glomerulans. Common; very big specimens, like those at F. 2 (Fig. 38).
Taraxacum sp. Common.
Oxyria digyna. A few small tussocks.
Poa alpina. Very widespread and common.
Saxifraga caespitosa. Rather scarce.
Saxifraga nivalis. A few, not particularly big specimens.
Veronica fruticans. Rather uncommon.

Salix glauca. Scattered bushes.
Cystopteris fragilis. Rather common. Particular large specimens were found growing closely against the cliff walls, probably because they then receive a maximum of heat, reflected from the cliffs. For the same reason particularly dense and high vegetation of *Chamaenerion angustifolium* or *Elymus arenarius* are found in similar localities in other bird-cliffs; cf. p. 114.

Most characteristic for the vegetation of this bird-cliff is the profuse development of *Sedum rosea*, *Cerastium alpinum*, *Angelica archangelica*, *Alchemilla glomerulans*, and *Taraxacum sp.*, as well as the complete absence of *Cochlearia officinalis* and of *Polygonum viviparum.* This bird-cliff is a typical *Caloplaca* cliff, as was to be expected.

Above 100 m east of the bird-cliff there was a very extensive field with a rich vegetation, in the form of a herb-mat on dry ground. Here the coprophytes were still present, but the concentration of guano, on the other hand, was so low that a number of ordinary, non-coprophytic heath-plants had colonized the locality, like *Betula glandulosa* and *Vaccinium uliginosum.* There was a lush growth of *Salix glauca* and of the following coprophytes:

Polygonum viviparum. Common.
Leucorchis albida. Common.
Hieracium alpinum. Scattered.
Erigeron uniflorus. Scattered.
Poa alpina. Common.
Alchemilla alpina. Common, forming extensive vegetations.
Cerastium alpinum. Scattered.
Veronica fruticans. Common.
Draba aurea. Scattered.
Bartsia alpina. Common. This species is not a coprophyte, but must have occupied this locality together with the heath-plants mentioned above; cf. also p. 120.

Further to the east there were only steep cliffs without any vascular plants, and on the other side of this section there was only ordinary heath-vegetation.

The most characteristic feature of this herb-mat was the extensive vegetation of *Alchemilla alpina* richly interspersed with *Leucorchis albida.* It is noteworthy, however, that species like *Potentilla crantzii* and *Campanula gieseckiana*, which usually are found in coprophytic vegetation on dry ground, here are completely lacking. It is also interesting that *Stellaria longipes* is absent from the coprophytic associations in almost the entire Frederikshåb District (found only at Qagssit, F. 2, in

the north of the district) while it is commonly found both north of the district (in Godthåb District) and south of it (in Julianehåb District). In the most recent study of this species (BÖCHER 1951, p. 405 and Fig. 1) it appears to be absent from Frederikshåb District. It has been collected or observed only at Ivigtut in the far south of the district.

Ivnarssuaq has never been mentioned in the litterature about Frederikshåb District, as stated already (p. 82). It is situated far from inhabited places, also in the old time, and the Sermiligârssuk may further be difficult of access owing to the production of ice. However, the relative modest number of breeding-birds on the vast expanses of usable cliff appears to show that the colony must have been much larger previously, but has deminuished, probably owing to persecution by man. This view is correct, according to statements from various Greenlanders, whom I have asked. On the other hand, we do know nothing about this seabird-colony in former days.

The Sermiligârssuk displays very distinctly the interesting phenomenon, discussed on p. 84–87, namely the importance of the different exposition to the sun of the two fjord-sides. The south-exposed north-side had a lush green vegetation and snow had entirely disappeared, while the north-exposed south-side was still partly brownish with old, withered vegetation and possessed many snow-drifts on comparatively low altitudes.

Other Bird-Species Observed

On the 2nd July and 4th July 1971 the coastal waters off the southern parts of Frederikshåb District (between Narssalik and Arsuk) were investigated. Only the sea-birds observed are mentioned, while terrestrial birds are left out.

Rissa tridactyla. Often seen flying in and out of Sermiligârssuk searching for food, and in the same way it was observed in small numbers just outside the fjord, in the open sea, south to the waters off the promontory Kangeq South. All birds observed were adult ones, undoubtedly coming from the colony Ivnarssuaq (F. 9) in the fjord. On the other hand, no *Larus glaucoides* were observed except within the fjord near the breedingplace. This appears to show the same difference in life-habits of the two species as that noted in Qagssit at F. 2.

Larus hyperboreus. A few specimens were observed along the coast, but the species was much inferior in number to *Larus marinus.*

Larus marinus. Extremely numerous at the countless skerries along the coast, and *pingut* were observed in great numbers. On the island Oqûtalik at the entrance of the Tôrnârssuk fairway there were

three pairs breeding at the western end and four pairs at the eastern end, while a single pair of *Larus hyperboreus* occupied the middle part of the island.

Stercorarius parasiticus. Only one specimen of the light phase and one specimen of the dark phase observed. It appears to be very scarce here.

Cepphus grylle. Common along the entire coast, often swimming close to icebergs, which are numerous here, originating from the great ice-fjords Sermilik and Sermiligârssuk. At the small Isugdlît islands, just north of the entrance to Sermiligârssuk, there were no less than about 100 pairs breeding. The water is very low around these islands and the tide must produce much current. There is also a tremendous current around the island of Oqûtalik where the Tôrnârssuk fairway begins, and here about 40 pairs were observed, many gathered around icebergs.

Uria lomvia. Occasionally seen in small flocks, altogether only about 20 birds.

Somateria mollissima. THOMAS THOMSEN, the manager of Narssalik Outpost and a keen ornithologist, informed me that the Eider bred on the Isugdlît islands, but no other places in Frederikshåb District. We saw about 50 specimens around the Isugdlît islands, most of them in flocks, but no ducklings were observed. Elsewhere the Eider was uncommon and was seen only a few places. In the Tôrnârssuk fairway 3–4 birds were seen, and at the southwestern point of Sermersût island, which jets far out to sea in a mighty promontory, a flock of 25 immature birds and one adult male were observed.

Histrionicus histrionicus. Several small flocks, altogether about 50 specimens, were observed among the Isugdlit islands (mentioned above), and a few were seen at Sermersût.

Fulmarus glacialis. We had dense fog while sailing from the promontory Kangeq North to Sermersût, and in these wsters quite a few Fulmars were seen. There was even much ice here coming from Sermiligârssuk Altogether the following birds were observed: 26 *Fulmarus glacialis*, 12 *Rissa tridactyla*, 2 *Larus hyperboreus*, and about 10 *Cepphus grylle* feeding near the icebergs. All the birds were foraging in spite of the dense fog.

Other Remarks

There were formerly two colonies of *Uria lomvia* in these waters, but they have both disappeared in recent years, undoubtedly owing to strong human persecution. The birds have then moved to other places (F. 10

and F. 11), as shall be further dealt with below. Very little is known of these two breeding places. In my book on Greenland birds (SALOMONSEN 1950, p. 366) I said the following about these colonies: "In Frederikshåb District there is a small rookery on the promotory Kangeq South (61°25′) and another on a small islet just off Sermersût island (61°15′), numbering about 4000 and 1000 pairs, respectively, according to the Greenlanders of Arsuk. HELMS also mentions these two colonies, based on reports from the Greenlanders." (HELMS visited Arsuk in 1890–93). The information stated above was delivered to me in 1949 by JON FREDERIKSEN and ABEL KRISTIANSEN, inhabitants of nearby Arsuk outpost and both keen ornithologists. There is no doubt, therefore, that in these years the colonies still existed, although probably rapidly decreasing. I could, personally, a few years previously, get a glimpse of the colony on the islet off Sermersût, when on the 25th June 1946 our steamer "Disko" tried to find a usable lead in the dense ice off Arsuk Fjord and moved up and down the coast, less than half a mile from the islands. In 1971 I visited the place with my motorboat. The islet is called Agpat ("The Guillemots") and is situated due west of Sermersût Island, very near to its coast, on 61°16′N, 48°3′W. The island is completely deserted by *Uria lomvia*, and the only seabirds breeding there now is one pair of *Larus marinus* and three or four pairs of *Cepphus grylle*.

According to information from JON FREDERIKSEN and ABEL KRISTIANSEN the other former colony of Brünnich's Guillemot was situated on the promontory Kangeq South, at 61°21′N, 48 59′W. This may, however, not be correct, for somewhat north of the nearby promontory Kangeq North there is a locality, on 61°24′30″N, 49°01′W, still called Agpârssuit inât ("The home of the many Brünnich's Guillemots"), which may have been the former breeding-site of *Uria lomvia*. Needless to say, both Kangeq North and Kangeq South are now totally vacated by the guillemots.

The same informants told me that a colony of *Rissa tridactyla* had formerly inhabited the place not far from Qaersutsiaq on the north side of the fjord Tigssaluk, at about 61°21′N, 48°22′W. This colony has been abandoned many years ago. On the other hand, ORLA BORGEN HANSEN of Godthåb tells me that in 1971, while working on the radio station at Kangeq South he found that a new seabird colony was building up at the bay of Sitdlisit only 2–3 km east of the promontory. He found 20 pairs of *Rissa tridactyla* and 9 pairs of *Larus glaucoides* breeding. In 1975 members of the local council in Frederikshåb informed me that the number of *Rissa tridactyla* breeding at Sitdlisit was steadily increasing.

F. 10

Tâteraerûnerit (Fox Fald), Arsuk Fjord, 61°19′10″–40″N, 48°04′–47°55′W.

This is a very well-known seabird colony. In Arsuk Fjord the Cryolite Qarry, erected more than a hundred years ago, as well as the Naval Station Grønnedal, are situated, and numerous visitors and tourists from these places make each year excursions to the bird cliff to admire the beautiful scenery. According to WINGE (1898, p. 192) the Fox Fald colony was first mentioned by JØRGENSEN in 1842. HAGERUP observed it in 1886–88 and gave the number of Kittiwakes breeding there as about 2000 birds. In 1893 HELMS stated the number of breeding-birds to be about 5000. Judging from the descriptions it appeared, however, that the number of breeding Kittiwakes must have been much greater, and it also appeared that the Kittiwake must have bred in other places than those existing now, but the information is very scanty.

Unfortunately, I have usually been able only to visit the colony late in autumn, when the greater part of the breeding birds had left the bird-cliff. My first visit took place on the 15th September 1925, when the entire breeding-place was deserted. On the 4th September 1936 there were still a few nestlings left, but not until my third visit, on the 21st August 1954 I got some information, although I took part only in a transitory tourist excursion. The bird cliff is south-exposed and can be divided into several smaller sections. It is situated slightly eastwards of the magnificent waterfall, the Fox Fald, and stretches almost as far as to the glacier at the head of the fjord. There are several other waterfalls, but they are not situated on the breeding-places proper. There is no scree and very little vegetation on the steep cliff, but on the slopes on the sides of the breeding-place there is a lush vegetation of *Angelica archangelica* as well as several other coprophytes, of which only *Campanula gieseckiana* could be identified from the boat at some distance. There was rather much *Caloplace elegans*, but it appeared to grow irregularly and did not form any real arch. I estimated the number of breeding *Rissa tridactyla* to be about 8000 pairs, and to these should be added a modest number of *Larus glaucoides*.

The military leader of Grønnedal, Rear-Admiral H. L. PRAUSE and his staff have been kind enough on my request to carry out a thorough and painstaking census of the Fox Fald colony in 1973. They arrived at the following results. There are five sections of the colony which can be described as follows, moving from west to east:

(a) A small area not far from the Fox Fald with about 50 pairs of *Rissa tridactyla*.

(b) A bigger area, about 3 nautical miles from the glacier, with about 500 pairs of *Rissa tridactyla* and a few *Larus glaucoides*.

(c) The largest section of the bird-cliff, about 1–2 nautical miles from the glacier, is inhabited by about 4000 pairs of *Rissa tridactyla* apart from about 5–10 % of this figure being *Larus glaucoides* and *Larus hyperboreus*.

(d) The next section is situated about one nautical mile from the glacier and is inhabited by about 1000 pairs of *Rissa tridactyla* and 100 pairs of *Uria lomvia*.

(e) Less than half a nautical mile from the glacier there is a small colony of *Rissa tridactyla*, amounting to 50 pairs.

In addition to these seabirds a *Falco peregrinus* had its nesting place near the Fox Fald, not far from the section (a) of the bird-cliff. In September 2–3 Falcons were seen here simultaneously, which appeared to show that they raised some young.

I was especially interested in the *Uria lomvia*, which invaded this bird-cliff in 1972. They had never bred here before, so far as known, and they probably settled here now because persecution was too heavy at the two colonies in Frederikshåb District, where they had been before; cf. above p. 162. Rear-Admiral Prause was kind enough to continue the census of Brünnich's Guillemot in the following years. In 1972 there must have been only a few Guillemots in the Fox Fald colony, but we do not know the exact number, in 1973 there were 100 pairs, as described above, in 1974 there were about 300 breeding pairs, in 1975 there were at least 2,000 individuals and in 1976 5,000–10,000 birds. This shows that numerous birds must have joined the pioneers, perhaps coming from the big colonies on outer Kitsigsut (F. 11) where shooting and egg-collecting is quite uncontrolled. In 1976 the Falcon breeding at the bird-cliff got 3 young.

As far as the Kittiwake is concerned there were in about 1890 ca. 2,000–5,000 birds (pairs?) present, in 1954 8,000 pairs and in 1973 about 5,600 pairs. Altogether, the population has not changed essentially, but it must be admitted that no proper census has been undertaken. It appears that the breeding-birds here are left in peace, because the Danish inhabitants of Ivigtut and Grønnedal keep an eye on the colony and prevent shooting near the bird-cliff as far as possible. It should be added that the new Greenland game-act forbids to shoot or make unnecessary noise within a distance of 2 km from any bird-cliff inhabited by Kittiwakes or Brünnich's Guillemot. This law went into force the 1st January 1978; cf. Nalunaerutit (The Greenland Statute Book) 1977, ser. A, nr. 2, p. 195–200.

F. 11

Ydre Kitsigsut, 60°43′–47′N, 48°21′–29′W.

Ydre Kitsigsut have been described earlier in this paper (p. 23–25), because the Fulmar has bred here since about 1945. It was also mentioned that my excursion to these very remote islands on the 3rd July 1971 was hampered by bad weather, strong wind and heavy sea which prevented landing on most of the islands, much ice, heavy fog and icy cold. These obstacles must be kept in mind when considering the following description. However, the excursion was a success and a number of hitherto unknown seabird colonies were discovered. As mentioned above (p. 24) good information was received about the bird-life on these islands in 1949 by JON DAVIDSEN and RAME NIELSEN in Qagssimiut, and in 1971 by JULIUS JAKOBSEN in Arsuk. My observations agreed very well with what was said by these gentlemen, only appeared the whole bird-life more varied and rich than it was described for me.

Somewhat north of Ydre Kitsigsut some other islands are situated, the so-called Indre Kitsigsut, which differ distinctly from Ydre Kitsigsut. The majority of these islands are low and bare, without vegetation, and in storm quite flooded by the waves. There were very few birds among these islands, and the only ones observed were quite a few *Somateria mollissima* (non-breeding), some *Cepphus grylle*, a single *Alca torda*, a few flocks of *Uria lomvia* (non-breeding), and finally 10 specimens of *Larus hyperboreus* hanging poised over one special rather high island where they probably bred.

The Ydre Kitsigsut are higher than the inner ones, many of them being more than 50 m high and the biggest island, "Thorstein Islænder", reaching an altitude of 116 m. Many of the islands possessed some vestigial vegetation, but generally they were naked, due to the direct exposure to the mighty waves or heavy swell of the Davis Strait.

All islands were examined, but those with only a single pair of *Cepphus grylle* or *Larus hyperboreus* are not mentioned in the following, but only those with genuine sea-bird colonies are described. It has been mentioned already (p. 24) that both *Fulmarus glacialis* and *Uria lomvia* had occupied the islands recently, in the years about 1945.

The islands are shown in Fig. 41, and those with seabird colonies are marked with a letter, from A to J. The following is a thorough review of these island.

A.

The island is quite bare without vegetation, with a rather steep cliff wall to the west.

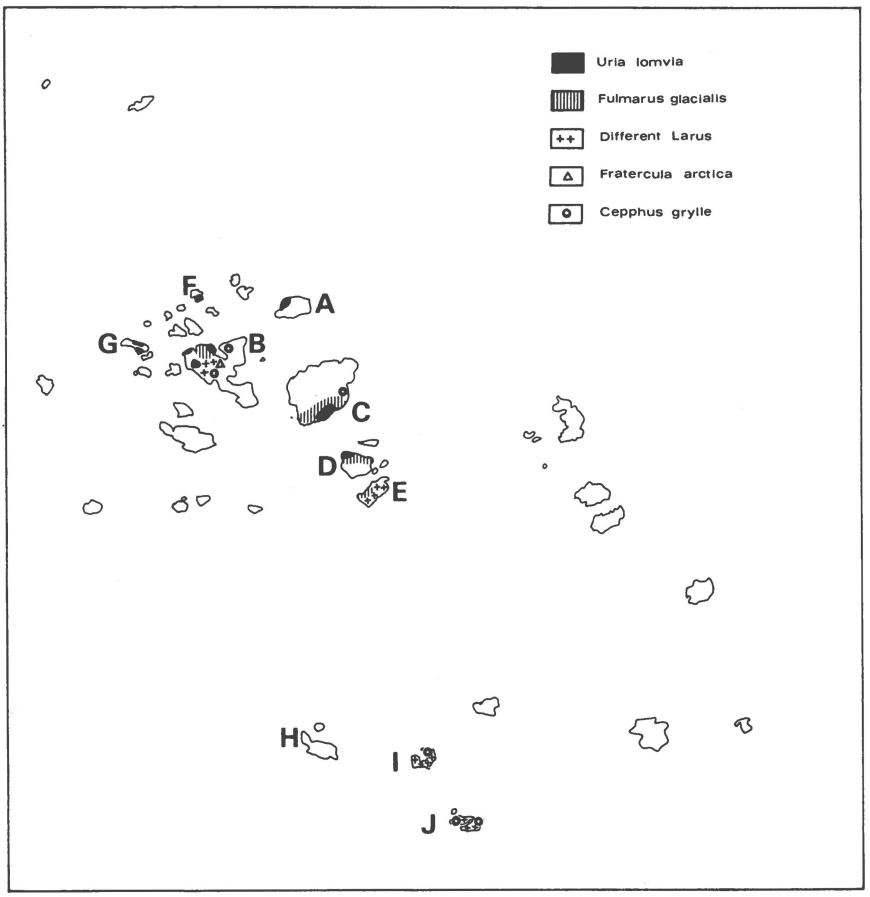


Fig. 41. Map of the islands Ydre Kitsigsut (F. 11) on 60°43′–47′N, giving situation in 1971 of breeding sea-birds, the islands with sea-bird colonies marked with the letters from A to J.

Breeding Birds

Uria lomvia. About 5000 pairs bred on the northwest-exposed side of the island, quite from the water's edge (about 2 m above the tidal movement) to about 10 m. The breeding-place is lighter, greyish-white, due to the avian guano, than the rest of the island.

B.

A big island with numerous seabirds breeding. On the higher parts of the island there was some vegetation, mostly in the form of grass-covered areas.

Breeding Birds

Uria lomvia. At the entrance of a little bay on the northside about 5000 pairs were breeding, from 2 to 10 m altitude, north-east exposed.

The cliff was here naked, without vegetation, the breeding place easily accessible, although very slippery, and our crew collected easily 15 eggs from the lowest ledge. Another colony, only amounting to 200 pairs, was found on the northwest corner of the island; it was due north-exposed. A third breeding-place, counting about 1000 pairs was found on the west side of the island (west-exposed); see Fig. 41.

Alca torda. Two were seen flying from the island; must undoubtedly have bred.

Fratercula arctica. Only one bird seen, flying from an extensive grass-covered area at the head of the small bay on the north-side of the island, in an altitude of about 12 m. There were a few holes in the peat, but only this single bird was observed. JON DAVIDSEN and RAME NIELSEN in Qagssimiut informed me in 1949 that there were only "a few pairs" breeding on Ydre Kitsigsut, and JULIUS JAKOBSEN in Arsuk said in 1971 that there were three or four pairs on the island B. Apart from the grass-vegetation on the breeding-place there was a profuse growth of *Cochlearia officinalis*, but no other plants could be discovered from the boat situated at some distance.

Fulmarus glacialis. On the northern side of the island, west of the small bay, 11 pairs were breeding, in an altitude of 10–15 m. The breeding-place was north-exposed. The birds were breeding on small grass-covered ledges and prominences, but viewed from below, from the boat, it appeared as if some of the birds were breeding on the bare rock.

Larus hyperboreus. On the western side of the island two pairs breeding, on the northern side one more bird seen, probably breeding.

Larus marinus. On the western side there were two specimens, probably representing breeding birds.

Cepphus grylle. Scattered around the coasts of the island, altogether eight pairs breeding.

C.

This is the main island, the biggest and the highest island, reaching an altitude of 116 m. The island is called "Thorstein Islænder" og Umánaq and is a well-known landmark for shipping. The greater part of the south-exposed coast is inhabited by numerous Brünnich's Guillemots and some Fulmars, as to be seen on Fig. 42. Another photograph of the same scenery but reduced to scale, is to be seen on Fig. 4.

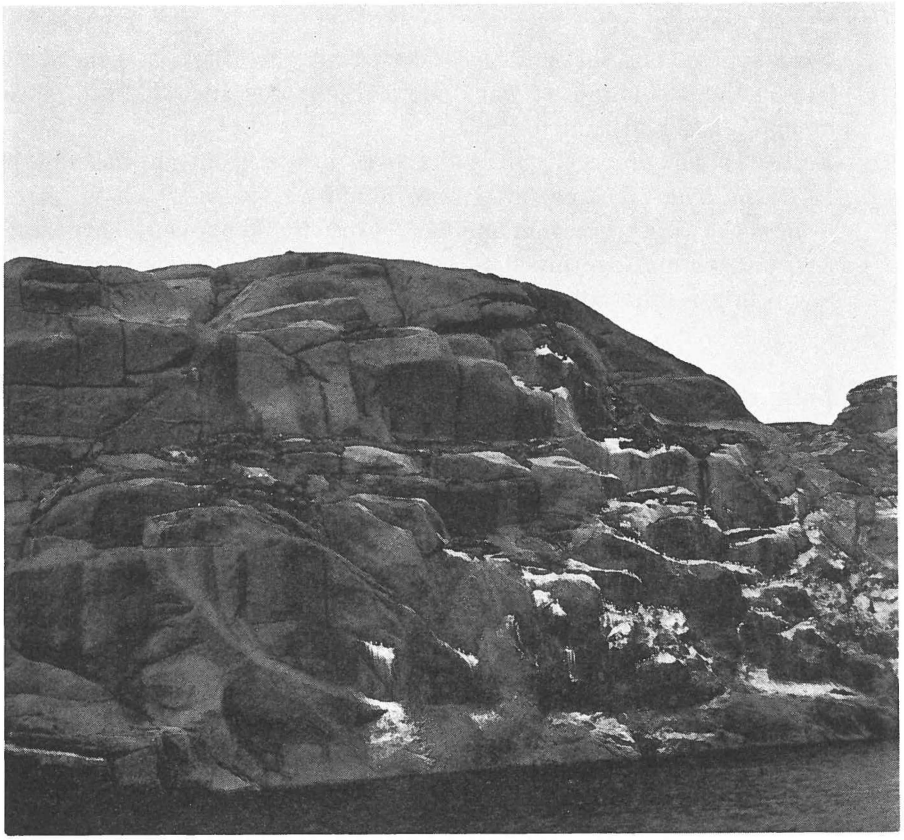


Fig. 42. The island "Thorstein Islænder", marked C on the map Fig. 41, in Ydre Kitsigsut (F. 11) showing breeding *Fulmarus glacialis* (small white dots to the left) and *Uria lomvia*. (Phot. 3rd July 1971 by F. SALOMONSEN).

Breeding Birds

Uria lomvia. A big colony of about 10.000 pairs, breeding in an altitude of 3–50 m. Part of the colony is to be seen on Fig. 42.

Fulmarus glacialis. Altogether 40 birds were breeding, in an altitude of 10–50 m. Some breeding-birds can be seen on Fig. 42. They bred on ledges and narrow terraces covered with green vegetation, among which big tussocks of *Sedum rosea* could be identified.

Cepphus grylle. Only three pairs observed.

D.

Only two species were breeding on this medium-sized island.

Breeding Birds

Uria lomvia. On the northwest-corner of the island a colony of 5,000 pairs was found. It was due north-exposed and the birds were breeding in an altitude of 3–40 m.

Fulmarus glacialis. Only 18 pairs were breeding, in an altitude of 20–25 m. The breeding birds were found on ledges which all were overgrown with vegetation and which were found above the breeding *Uria lomvia* and continued to the east, where 12 of the birds were found breeding isolated from all other birds.

E.

This island is of about the same size as D and is situated due south of it. On this island begins the concentrations of big gulls which breed to the south in the archipelago, apart from this island also on island I and J. It was a surprise that the colonies of breeding whitish gulls here were not Glaucous Gulls, but Iceland Gulls, which usually do not move so far out on the outer skerries, but prefer more quiet surroundings at the coast or in the fjords. However, the weather was so bad, with great movements of the boat in the agitated sea that it was very hard to identify these gulls. Their smallish size, length of the wings, short bill and the colour of the nestlings to be seen in many places on the breeding-areas convinced me that these gulls were Iceland Gulls.

Breeding Birds

Larus glaucoides. About 20 pairs breeding, scattered over the greater part of the island. They had large nestlings now.

Larus marinus. Two pairs were breeding on the uppermost part of the island, isolated from the main-population of *Larus glaucoides* and in no way interfering with the other gulls.

Fulmarus glacialis. Only five pairs, inhabiting the northwest corner of the island, breeding on ledges covered with vegetation.

F.

This is a very small island, but it is high, about 50 m, and of a form almost like a sugarloaf. There was no vegetation whatsoever and no development of *Caloplaca.*

Breeding Birds

Uria lomvia. At the south-exposed side of the island at least 20,000 birds were breeding. These were sitting densely packed from 5 m above sea-level up to the top of the "sugarloaf", an altitude of about 50 m. Our crew collected about 35 eggs from the lowest ledges, but could have taken many more. According to the new Greenland game-act, put into force 1st January 1978, it is forbidden to collect

eggs of *Uria lomvia* everywhere along the west-coast, except in Upernavik and Thule Districts.

G.

This island is as high as F and with similar steep sides. It is almost as small as F, but it is of a longish form.

Breedish Birds

Uria lomvia. There were two colonies of this species on this island. On the north-exposed side there was a large colony, in which about 10,000 pairs bred in an altitude from 5 m up to 50 m. On the other side, south-exposed, there was a colony of about 5,000 pairs.

H.

No sea-bird colony was found on this medium-sized island, but in the area between the island and a small skerry north of it there was a large stretch of low water with much submarine vegetation, and at present with a very heavy surf. In this area there were large flocks of *Somateria mollissima*, of which about 30 were flushed, when we passed. Among them were a number of adult males. Also a flock of about 15 *Histrionicus histrionicus* were flushed.

I.

This island is comparatively small but about 30 m high. It is almost bare, only with very little vegetation. The gull colony, which was found on island E, continues on this and the next island (J.).

Breeding Birds

Larus glaucoides. About 20 pairs, breeding scatteredly over the whole island. There were large young now.

Larus marinus. One pair breeding on the top of the island, above all the Iceland Gulls.

Cepphus grylle. Four pairs were breeding.

J.

This small island resembles somewhat I. It is even slightly higher and steeper than I and has a deep valley almost cleaving the island and supplied with some vegetation. The bird life was surprisingly large on this island.

Breeding Birds

Larus glaucoides. About 50 pairs were breeding on the steep sides of the island, but the greater part was concentrated in the central valley. Also on this island big nestlings were seen everywhere. It appeared that there were some *Larus hyperboreus* between the many *Larus glaucoides*, both on this island and on the preceeding one (I),

but the icy wind and the rough sea gave few opportunities for distinguishing the two species.

Larus marinus. One pair breeding.

Cepphus grylle. Very numerous, at least 70 pairs breeding.

Table 1. *Number of pairs of various sea-birds breeding at Ydre Kitsigsut islands.*

	A	B	C	D	E	F	G	I	J	Total
Fulmarus glacialis		11	40	18	5					74
Alca torda		2								2
Fratercula arctica		1								1
Uria lomvia	5,000	6,200	10,000	5,000		20,000	15,000			61,200
Cepphus grylle		8	3					4	70	85
Larus marinus		1			2			1	1	5
Larus hyperboreus		2								2
Larus glaucoides					20			20	50	90
Total										61,459

Nobody has ever referred to these islands as a breeding place for sea-birds. It was stated above that the two most prominent species, the Fulmar and Brünnich's Guillemot, are newcomers to the islands. The Fulmar has immigrated from Iceland (cf. p. 26), and the flourishing population of Brünnich's Guillemot has undoubtedly been built up by refuges from the now abandoned old colonies in Frederikshåb District, mentioned above p. 162. The remote situation of the islands, the rough weather usually prevailing in these waters and the presence of more or less impenetrable ice and the ensuing dense fog already from April onwards (cf. p. 28 and Fig. 3) makes it ordinarily a tough job to visit the Ydre Kitsigsut in the breeding time. I do not think, therefore, that the birds on Ydre Kitsigsut are particularly persecuted by the Greenlanders. The easily accessible breeding places, being situated just over the water's edge, indicate that the birds are victimized only to a very small extent. Therefore, there is hope for the survival of the bird-colonies here, especially since the new game-act, of the 1st January 1978, has prohibited all commercial trade with bird-eggs and, as said above, also has quite prohibited taking of Fulmar's and Guillemot's eggs in these latitudes.

Apart from the four species of alcids breeding on Ydre Kitsigsut it is very likely that a fifth species breeds there, namely the Little Auk, *Alle alle.* I said previously about this occurrence (SALOMONSEN 1950, p. 399–400): "The Little Auk still breeds, however, in a few places in Julianehåb District, where heavy pack-ice blocks the coast in summer. A breeding place has been known for many years to exist on the skerries Outer Kitsigsut, west of Nunarssuit Foreland, but only one pair breeds there now." The source to this information was JON DAVIDSEN and RAME

NIELSEN in Qagssimiut, who in 1949 told me that a single pair bred on the medium-sized island situated east of the island I on Fig. 41. Another informant, HENNING LUND, stated that on the 26th June 1948 he observed four specimens of Little Auk at the entrance to Torssukátak fairway, only about a dozen km northeast of the supposed breeding-place. On my excursion I did not observe any Little Auks at the Ydre Kitsigsut.

Other Bird-Species Observed

In the waters between Arsuk outpost and Ydre Kitsigsut the following observations were made.

Rissa tridactyla. Numerous birds met with, but only between Arsuk and the island Sánerut, a distance of about 20 km. These birds must have come from the Fox Fald colony (F. 10), and appeared in flocks of up to 20 birds. All specimens observed were adult, only one was a one-year old bird.

Uria lomvia. Small flocks began to appear at Sánerut and increased in number to the south as the Ydre Kitsigsut were approached.

Fulmarus glacialis. Some specimens were observed rather near land from Sánerut southwards to the Ydre Kitsigsut. They may probably have been breeding birds on the latter locality.

Cepphus grylle. Quite a few were observed rather far from land in the ice-filled sea where they were searching for food between the ice-floes.

Falco rusticolus. A beautiful, almost pure white individual was observed, just north of island F in Ydre Kitsigsut. It had a juvenile *Larus marinus* in its talons and was pursued by an adult *L. marinus*, no doubt one of the parents of the victim. The falcon alighted on an ice-floe and began to eat its qarry, the adult Great Black-backed Gull sitting only one metre from it. When the boat approached, the falcon was flushed and disappeared, still pursued by the adult *Larus marinus*. The Gyrfalcon may very well have bred on the Ydre Kitsigsut Islands.

Conclusions

The list of breeding-places for sea-bird colonies in Frederikshåb District, enumerated above, is far from impressive. When comparing with the number of sea-bird colonies in districts further north many more breeding-places should be expected to be present in Frederikshåb District, especially when considering the appreciable size of the district.

The reason for the small population of sea-birds in the district at present is partly the increasing human persecution of the birds in the last 50 to 70 years, which has been the cause to extermination of various sea-bird colonies in other districts of Greenland. However, the greater

part of the sea-bird colonies of Frederikshåb District still exist, although considerably reduced in size. When comparing the status now with that in the 18th–19th century, judging on the basis of the meagre literature statements, it appears that the number of sea-bird colonies were not particularly larger in those days than at present.

In the very thorough and painstaking description of Greenland issued in 1921 BENDIXEN (1921a, p. 320) has given a list of the large bird-colonies of Frederikshåb District in the period preceding 1920. He mentions and shortly describes the following bird-cliffs, which in the list below are given the names and designations of my list, for the sake of comparison:

F. 2, *Qagssit;* "rather big bird-cliff, with Kittiwakes."

F. 5, *Kuánersôq;* "several bird-cliffs, situated closely to each other, where gulls, particularly Kittiwakes, breed in enormous numbers on the northern cliff-wall and in the clefts."
Akugdleq; "a small bird-cliff (gulls)".)Akugdleq is the median branch of the Kuánersôq Fjord; the bird-cliff is now deserted.)

F. 9, *Ivnarssuaq;* "Kittiwakes and a few Brünnich's Guillemots."

F. 10, *Tâteraerúnerit;* "a small bird-cliff with gulls and Kittiwakes."

BENDIXEN mentions only one bird-cliff which has now disappeared, namely the small bird-colony in Akugdleq. On the other hand, he does not mention the bird-cliff F. 8, Ivnaq, which did exist in those days. Neither does he mention the two colonies of Brünnich's Guillemot which we know were present since at least 1890 (cf. p. 162), or the Kittiwake colony of Tigssaluk, mentioned on p. 163. BENDIXEN mentions, on the other hand, "a few Brünnich's Guillemots" breeding on F. 9, which is surprising to me, since no one else has told me that *Uria lomvia* has ever bred there.

Apart from the negative changes, mentioned above, it should be remembered that a small Kittiwake-colony in recent years is found near Sitdlisit (cf. p. 163). Brünnich's Guillemot has begun to breed at new places in appreciable numbers (at F. 10 and F. 11), and the Kittiwakes, at least at F. 5 (Kuánersôq) have withdrawn to the upper parts of the cliff-wall where they cannot be hit by gun-shot (cf. p. 155). Altogether the changes in the number of sea-birds in Frederikshåb District during the last hundred years appear to be modest.

Summarizing, it can be said, that human persecution has reduced the number of sea-birds, but the majority of colonies are still present although diminished in size. However, the number of breeding sea-birds in Frederikshåb District has always been modest compared with the situation in most other parts of the West Greenland coast. The reason for this fact is unknown, but must have something to do with the food

production in the sea. The primary production, measured in mg C/m² per day, appears to be slightly smaller in Frederikshåb District than further north, but too little is known about it. The size of the fishery production cannot be used as a measure either, as it is dependent on the number and dimensions of fishing-vessels, the man-power involved, etc. Therefore, nothing definite can be said about this question.

Altogether, the bird-life in the district appears to be staple, apart from the general reduction due to exaggerated hunting. Noteworthy is the complete disappearance of the two colonies of *Uria lomvia* and the establishment of new colonies in recent years at F. 10 and F. 11 and the immigration of *Fulmarus glacialis* as a breeding-bird, which has been dealt with in detail on p. 23–30. Another fact to be mentioned here, is the complete absence in the district of *Sterna paradisaea*, described on p. 146. It breeds regularly and rather commonly in the greater part of Godthåb District, just north of Frederikshåb District, and is known also to breed several places in the northern part of Julianehåb District, south of Frederikshåb District, namely on numerous islands from Kap Thorvaldsen (on Nunarssuit) and eastwards to Bredefjord. This gap in the distribution in Frederikshåb District has been known for many years and was mentioned by me many years ago (SALOMONSEN 1950, p. 339), although the gap is actually larger than that mentioned by me. The reason for this gap is unknown, but undoubtedly has to do with too small food-production. The extreme scarcity of *Stercorarius parasiticus* in Frederikshåb District is also noteworthy and is probably due to the same reason as the absence of *Sterna paradisaea.*

A certain point in the description of the bird-cliffs needs to be emphasized here, and that is the fact that presence of moisture or seeping water is a character of all large sea-bird colonies, at least those with breeding *Laridae*, like F. 2, F. 5, F. 9. The only exception is F. 8, Ivnaq, which appeared to be completely dry. However, this locality is not a really large colony and was examined in September when the surroundings were extremely dry and when all the breeding birds had left. The presence of water is a feature found at most large bird-colonies and is particularly conspicuous in those places where *Rissa tridactyla* breeds. At such localities there may even be large water-falls flowing over the cliff-walls of the breeding place, as in F. 10. Cf. also what I said about this phenomenon in SALOMONSEN 1950, p. 327, The reason for this presence of water may be the easy access of fresh drinking-water for the breeding gulls or may have something to do with the gull's habit of bathing, especially in the period of the postnuptial moult. It is noteworthy that as early as in 1925, in my first paper on Greenland birds (SALOMONSEN 1925, p. 120) I mentioned that the greater part of the bird-cliffs met with on the expedition this year were situated at water-falls or rivulets.

Another point of importance is the fact that bird-cliffs frequently are situated near a glacier. In Frederikshåb District it is the fact with F. 7 (Kittiwake-cliffs mentioned under "Other Remarks" p. 156), F. 8, F. 9 and F. 10. This attachment to glaciers is found among bird-cliffs everywhere in the Arctic and has to do with certain hydrographical factors of importance for the availability of food. The phenomenon has been explained by SALOMONSEN (1950, p. 324) and there is no reason to go further into the subject here.

As regards the coprophytic plants attached to the bird-cliffs there are several points of interest in Frederikshåb District. The growth of *Caloplaca elegans* is not particularly large, and real *Caloplaca*-arches (cf. p. 94) are not developed at any bird-cliffs. Only at F. 9, Ivnarssuaq, large expanses are stained orange by *Caloplaca* (cf. p. 157). It should also be noted that the differences between the two coprophyte-types of the bird-cliffs, namely the *Caloplaca*-cliff and the *Cochlearia*-cliff, are not particularly pronounced in Frederikshåb District. The reason for this may be the southern position in the Arctic region of Frederikshåb District with its more mitigated climate and its heavy precipitation (cf. p. 11).

Attention should also be drawn to some other details among the coprophytes. It has been described already (p. 160) that *Stellaria longipes* is virtually absent in the coprophytic vegetation of Frederikshåb District. The same appears to be the fact with *Rumex acetosella* and *Elymus arenarius*, all of which are commonly found among the coprophytes of Godthåb District. On the other hand, *Alchemilla glomerulans* (and to a lesser extent *A. alpina*) form extensive vegetations with extremely large specimens (cf. Fig. 38) at almost all the large bird-cliffs, while at the bird-cliffs in Godthåb District and further north they lead a much more unobtrusive existance.

Finally, some details concerning life-habits of the colonially breeding sea-birds should be noticed. At F. 1 was mentioned the segregation of the breeding-places of *Larus marinus* and *L. hyperboreus* on small islands, probably due to competition. In a similar way the breeding places of *Uria lomvia* and *Fulmarus glacialis* were separated from those of *Larus glaucoides* in the island group F. 11. Another point which should be stressed concerns the difference in feeding habits between *Larus glaucoides* and *Rissa tridactyla*, described at F. 2, Qagssit (p. 152), at F. 9, Ivnarssuaq (p. 161) and at F. 11 (p. 172). The former species was searching for food in the fjord quite near to the breeding-place, while the Kittiwake was utilizing the entire fjord and also transgressed the limit of the fjord and was found 20–30 km out to sea. The same difference in life-habit between the two species is found everywhere in West Greenland. It appears that in this way the two species, both common along the entire West Greenland coast, have divided the food resources to avoid competition.

SEA-BIRD MIGRATION IN FREDERIKSHÅB DISTRICT

I have collected a long series of observations of the autumn migration of sea-birds along the West Greenland coast, mainly during voyages about 10–20 miles off the coast. The majority of these observations have been made off Frederikshåb District. It is convenient, therefore, to incorporate these notes in this ornithological survey of Frederikshåb District, although a number of the observations originate from other districts.

The species dealt with are generally pelagic, but some off-shore birds are considered, also, while no in-shore species are discussed.

Puffinus major

The Great Shearwater is a common summer-visitor in the southern parts of Davis Strait, northwards to the southern part of Disko Bugt, arriving in the first days of June and leaving the Greenland waters in September. I have often met with it on voyages in Davis Strait, most often in Frederikshåb District.

In 1936 my expedition was onboard the schooner "Dannebrog", which carried out a non-stop voyage from Godhavn on Disko to Ivigtut in Frederikshåb District, along the coast of Greenland, but far out to sea. This voyage down the Davis Strait took place from the 26th August to 1st September. The first Great Shearwaters began to appear off Holsteinsborg, they increased off Sukkertoppen District and reached their greatest number off Godthåb District, where numerous smaller or greater flocks were seen.

The greatest number of Great Shearwaters that I ever saw was on the 22nd August 1954, when the birds were in moult. The weather was calm, but rather misty, when our ship passed from Arsuk Fjord to the south. About one mile off the coast large flocks of the great Shearwater were observed, from Sánerut (61°N) in southernmost Frederikshåb District to Torssukátaq fairway (60°47′N) in Julianehåb District, a distance of about 9 miles. I estimated the flocks to comprise altogether about 30,000 individuals. The birds, which dotted the surface of the sea everywhere, were very reluctant to rise when the ship passed, owing to the fact that they had not yet finished their wing-moult. I have dealt with this observation elsewhere (SALOMONSEN 1967a, p. 11) and have here also described the moult situation in this and other species of shearwaters and its interesting biological implications.

Another noteworthy observation was made on the 6th September 1975. On my voyage to the north my motorboat passed from Frederikshåb City to the glacier Frederikshåb Isblink, at a distance of about 8–10 km from the mainland, passing somewhat outside the outermost skerries. The weather was rainy and foggy with only a gentle breeze from the south, but with a heavy swell. On the whole stretch, about 50 km, numerous Great Shearwaters were encountered, resting or feeding on the sea. The greater part was gathered in groups, each numbering about 500 birds, and besides four such large flocks there was a number of small groups, as well as flying birds, and altogether about 3,000 birds were seen. Many of them could only fly with difficulty. They remained on the water when the boat approached and were probably still in moult. The greater part, however, rose when the boat come too near to them.

It is a well-known fact that the moulting Great Shearwaters in Greenland approach land in foggy weather. I observed this two years later, the 16th July 1977, when I was sailing in dense fog in Sukkertoppen District. Southeast of the island Talerulik at about 64°56′N, quite near to the mainland, I observed two Great Shearwaters, one in heavy moult, the other in a more light moult. Both birds rose when the boat came near, and it was easy to see that the flying birds had considerable gaps in the row of remiges as well as in the tail. This latter consisted of only 6–7 feathers, evidencing that the moult took place at a very rapid rate. It is easy to understand that the Greenlanders in the old days were able to catch a large number of these moulting, weakly flying birds.

Finally, in 1978 about a hundred individuals of the Great Shearwater were observed on the 24th August on the stretch from Søndre Strømfjord to Sukkertoppen City in the waters a few miles off the coast. The birds were gathered in small flocks, numbering 2–10 individuals each. Many flying birds were observed, and they all appeared to have finished the moult.

In former days it was necessary to go to Greenland by ship, which had great advantages for ornithologists who wanted to study sea-birds. I used the transatlantic ships until 1960, and after that year I travelled by air. My copious notes on sea-birds on the North Atlantic have never been published except for the year 1925 (SALOMONSEN 1926, p. 140). I have never seen any Great Shearwaters in May, only in 1936 I saw about 30 specimens on the 31st May somewhat east of Kap Farvel. The pattern does not change until the midst of June, when the birds begin to move up the Davis Strait as well as eastwards into the Atlantic. In the latter days of June they are commonly found along 60°N all across the Atlantic, almost to northwestern Scotland. In Davis Strait the Great Shearwaters are commonly met with in the greater part of June. As early as

the 1st July (in 1954) I observed 11 Great Shearwaters as far north as off Blåfjeld (69°22:N) on western Disko. However, the Great Shearwater increases in number in Davis Strait in July and reaches a peak in August.

In the autumn they are still met with in the first half of September. In the second half of this month there are sometimes only a few flocks left in the northern part of the Atlantic (on the shipping route at 60°N), either to be seen around Kap Farvel (24th September 1946) or around the Faroe Islands (19th September 1949), but as a rule they may still be observed more or less commonly in flocks along the greater part of the shipping route on the North Atlantic (20th–25th September 1925; 13th–20th September 1936).

Fulmarus glacialis

The Fulmar is extremely common in Davis Strait as it is in the North Atlantic. It frequents the pelagic parts of the sea and is usually not to be seen near the coast. However, in the breeding area it feeds right to the coast and in fjords and sounds nearby. It arrives to the breeding places in West Greenland in April and disappears again chiefly in September. In October-November it slowly moves to the south in the Davis Strait, and it appears that the southern parts of Davis Strait are not entirely deserted in winter. As late as on the 14th October (in 1976) I saw a great number of Fulmars at the islands Kookøerne (at the approach to the Godthåbsfjord), whereas it was scarce in the waters further north, to Sukkertoppen.

In Frederikshåb District the Fulmar is widespread on the ocean stretches some miles off the coast, but in late summer it does not occur as commonly as the Great Shearwater. On the 6th September 1975 only about 150 were counted during two hours of observation, whereas thousands of Great Shearwaters were observed during the same period. Of these 150 individuals about 20 per cent belonged to the dark phase. It is a well-known fact that the Fulmar is dichromatic, varying between a light and a dark form and passing through all intergradations. The geographical variation of these phases, which is particularly interesting in Greenland waters, has been described by Salomonsen 1950, p. 39; Salomonsen 1965, p. 327.

The dark phase is uncommon among the breeding Fulmars in Greenland, constituting 0.1 per cent in the Disko Bay and Umanak District Fulmar colonies, and 1 per cent in Upernavik – Thule Districts. I published these estimates in 1950, and they still hold good. On the other hand, on the Canadian side of Davis Strait (Baffin Island and islands north of it) there is a higharctic climate, and 85–90 per cent of the Fulmars breeding there belong to the dark phase. The birds belonging

to the Baffin Island populations forage all over the Davis Strait and are, therefore, often met with in the Greenland waters. In this way a large number of dark phase birds turn up among the light phase ones off the Greenland coast, but the percentage of dark birds varies greatly. In the southern parts of Davis Strait it usually amounts to 10 to 20 per cent of the population, just as was the case with the birds observed on the 6th September 1975 off Frederikshåb District. Sometimes there may be many more, up to 50 per cent, as in early June 1936, when I on the 2nd June counted about 50 per cent dark birds in the waters off Julianehåb District, and the next day as many dark birds in the waters off Godthåb District. Some few days before (in 1960) I counted even about 75 per cent (50 per cent dark birds and 25 per cent intermediate ones), namely on 17th May 1960 south of Færingehavn in Godthåb District.

I have with particular care studied the occurrance of the two phases in the Fulmar population off the West Greenland coast and have made about fifty censuses. I cannot here go into details but can summarize the situation by giving a quotation from my paper SALOMONSEN 1965, p. 336:

"In May the percentage of dark birds on the fishing banks decreases rapidly north of Godthåb and rarely amounts to more than 2 per cent of the population off the Sukkertoppen – Holsteinsborg Districts. Further north, in the Egedesminde District, only occasional dark birds are met with, because these waters are within the premises of the local breeding population of the Disko Bugt colonies, which consists almost exclusively of light birds. In the summer (June–August), when many non-breeding birds return to sea from cliff-prospecting, the dark birds are met with farther north, and then the population may often consist of 10 to 20 per cent of dark birds, even in the waters north of Holsteinsborg. In the coastal waters north of Disko, right up to Melville Bugt, dark birds are only exceptionally met with, but they appear in increasing numbers to the west, when one approaches the higharctic zone in the western part of Baffin Bay and Davis Strait."

To this summary a few remarks should be added. The percentage of dark birds in a certain area of the sea is far from constant. One day there may be many individuals, the next day only a few ones. The waters off the coast from Holsteinsborg north to Agto outpost, a distance of about 110 km, is very thinly populated by sea-birds and only a few Fulmars occur. On the 22nd May 1960 altogether 14 Fulmars were observed, of which one dark and two intermediate ones. A few days later, on the 27th May 1960 30 Fulmars were observed, but only one intermediate among them and no black ones. Later in the season the number of black birds increases. On the 21st July 1975 20 Fulmars were observed of which 6 specimens were dark.

Another noteworthy fact must be mentioned. In summer, mainly in July and August, the Canadian Fulmars (the dark birds) approach the breeding places in West Greenland rather closely and mix with the indigene population on the feeding grounds. When investigating the phase composition of the local populations it is necessary, therefore, to examine the birds on the nest or in areas where they absolutely do not mix with foreign birds. This is the fact on feeding grounds situated far from the open sea, in closed bays, deep fjords etc. The population breeding on Blåfjeld in western Disko forage to a great extent in the Sydost Bay and in the fjord Kangersuneq. In these areas, more than a hundred km from the open sea, Canadian visitors never venture to come. I have seen many thousands of Fulmars foraging here but have virtually never observed any dark birds. In the same way in Umanak District, where there are four large Fulmar colonies, I have observed a number of dark birds in the open outer (western) part of Umanaq Fjord, whereas virtually no dark birds have been seen in the inner part of the fjord.

Conditions are quite different in the waters off southwestern Disko, which are part of the open Davis Strait, but is situated close to the great Fulmar breeding-colony Mount Blåfjeld (cf. SALOMONSEN 1950, p. 33). In the area from Søndre Laksebugt to Fortunebay, only 20 km east of Blåfjeld, I observed the 11th July 1976 among many hundred Fulmars 4 per cent intermediate and dark birds (only 0.5 per cent really dark birds), whereas three years previously, on the 9th July 1973 I saw in the same area only 2 dark birds among at least a thousand of light ones. This was exactly the same number I saw in the same waters during a census on the 14th August 1946, and it convinced me that the percentage of dark birds in the Blåfjeld population was 0.1. However, the much higher percentage found in 1976 shows the presence of Canadian birds very near the breeding places and at the same time indicates the variability and the complicated composition of the Fulmar populations at sea.

Oceanodroma leucorrhoa

This boreal species does not breed in Greenland, but it occurs as a regular summer visitor in the pelagic zone of the southern Davis Strait. It is fairly common from early May to the end of August, from Kap Farvel northwards to Godthåb District and in rapidly decreasing number north to Disko Bugt. Sometimes it appears to winter in the southern parts of Davis Strait, but probably only quite exceptionally.

In the 19th century when the entire traffic to Greenland went by ship, Leach's Forktailed Petrel was often observed by passengers on the ships, while at present, when everybody travels by air, very few have the opportunity to see this bird. I have encountered the Forktailed Petrel several times in Davis Strait, but only years ago as a passenger

on the Greenland steamers. On the 18th June 1925 I observed three specimens off Julianehåb District, and the following day several individuals off Frederikshåb District. On the 2nd June 1936 I saw one off Frederikshåb District and the next day one off Godthåb District. In the autumn I have met with the species only once in the Davis Strait, *viz.* the 19th September 1925 off Julianehåb, where I observed two individuals. The date for this observation is comparatively late. However, the number of specimens found dead inland in Greenland after storms in late autumn (October–November) has piled up in recent years and evidences that the birds must occur as scarce visitors to the southern part of Davis Strait even far into the autumn.

Phalaropus lobatus

The Red-necked Phalarope is pelagic in its winter-quarter as well as during migration. It arrives to Greenland in the latter half of May and departs from the end of July to the midst of September. I have met with this species on migration numerous times, but only a few times in spring. The 27th May 1960 I observed a flock of altogether 60 birds resting on the water close to floating sea-weed a few miles off the coast at the entrance to Holsteinsborg City. I shall also mention a few observations from the autumn migration in Frederikshåb District. The 5th September 1936 several small flocks rested and foraged in the coastal waters off Arsuk and further south, eastwards of Storøen (Qeqertarssuaq) and even in Kobberminebugt. The following day many were seen in the area further south, from Qagssimiut to Julianehåb. This has no doubt been the main period of the autumn migration. The latest autumn observation of a Red-necked Phalarope that I have ever made was on the 20th September 1925 when a single bird was observed off Kap Farvel.

I have no records of the migration of the Grey Phalarope (*P. fulicarius*) in Frederikshåb District.

Rissa tridactyla

The Kittiwake is even in summer found in a great number in the pelagic zone. The breeding-birds often forage in areas with distances from the breeding place of more than 100 km, as shown by ringing of Greenland birds. In the waters off the great fjords with Kittiwake breeding-cliffs there is everywhere in West Greenland a bustling traffic of Kittiwakes feeding far out to sea. This has also been mentioned above in the description of the Frederikshåb bird-colonies (p. 176). Altogether four categories of Kittiwakes forage in summer in West Greenland.

(1) Adult birds, from the breeding places in the fjords moving out to sea, where they mainly forage on the large fishing-banks stretching

along the coast. The daily movements are more or less regular, the birds passing out, sometimes in larges files, in the afternoon, resting at night on the sea or on icebergs and returning to the fjords in the morning. The adult birds arrive very early to the breeding places in southwestern Greenland, in the last days of March. They desert the breeding-cliffs and their surroundings when the young are fledged, usually in the midst of August, and then retreat to the pelagic zone of the Davis Strait or to the outer skerries and icebergs in the offshore zone. As early as in the beginning of September they give up every connection with land and withdraw completely to the pelagic zone. The autumn migration takes place late in the season, usually in October, but in some birds not until November. The migration takes place far from land, in the pelagic zone, and practically no breeding-birds are encountered along the coast in September or later. A few birds spend the winter in the southern part of the Davis Strait, where they after heavy storms may be seen near the coast, but the overwhelming majority moves to the Atlantic Ocean.

(2) The juvenile birds after fledging. Intensive ringing in West Greenland has shown that the juveniles spend the first month (August) in the surroundings of the breeding-cliffs and do not move farther away than 25 km from the place where they were hatched. In September they move somewhat further about and are usually found within 115 km from the breeding place, although the migration has started already in many young Kittiwakes. There are two recoveries of ringed juvenile Kittiwakes about 200 km south of the breeding-place and far out in the pelagic zone, 70 km from the coast. The main migration takes place in October and moves closer to the coast than that of the adult birds. The migration is over in November, *i.e.* it takes place on an average 2–3 weeks earlier than in the adult Kittiwakes.

(3) The non-breeding, immature birds, one to three years old. These birds spend the summer foraging along the West Greenland coast, but they do not breed until they are at least four years old. The one-year old birds, which are easily recognizable on plumage characters, swarm along the coasts of West Greenland in very large numbers and are of great importance for the hunting of the Greenlanders. These birds usually arrive in Greenland in the month of July, but do not penetrate to the breeding-places. They migrate to the south in September, which means that they leave the coasts of Greenland about a month earlier than the juvenile birds. The two-year and three-year old immature birds arrive to Greenland as early as in May. In summer they usually frequent the waters about 25 to 150 km south of the breeding-places, but about 10 per cent reach the breeding area, where they, however, do not breed. They usually leave the coastal waters in August, already, which is about one month earlier than the one-year old immature birds.

(4) Juvenile and immature Kittiwakes from European breeding-

places, summering in West Greenland waters, where they are found usually from June to October. These visitors occur in almost as great numbers as the young birds of the Greenland populations (category 3, mentioned above), and they are as important as hunting object for the Greenlanders as the immature indigene birds. The ringing recoveries in Greenland of these European Kittiwakes have shown that 93 per cent are juvenile and immature birds, and of these are by far the greater part (67 per cent) one-year old immatures. There are only 7 per cent adult birds, from four to eleven years old, usually to be met with in August to October.

The complicated composition and movements of the Kittiwake populations of the West Greenland coast has been thoroughly dealt with by SALOMONSEN (1967, p. 237–248) on the basis of ringing results, and the representation above is a summary of the conclusions.

The description above shows that the Kittiwake is a numerous bird in the pelagic zone of the Davis Strait in the greater part of the year, being absent only in December–February. In BROWN *et al.* (1975, map c–h) it is to be seen that the Kittiwake in August–October is distributed practically everywhere in Davis Strait. The 7th October 1976 I examined about two dozens Kittiwakes in Godthåb, shot for food, and found them to consist of about 50 per cent one-year old specimens and 50 per cent with adult plumage.

It is my experience that the Kittiwakes appearing in large flocks off the coasts for the greater part belong to the one-year old birds with a smaller or greater minority belonging to juvenile birds or to such with an adult plumage. This rough estimate is, of course, dependent on the locality (closeness of breeding-places) and of the month in question. In the waters west of Disko and further south in the Davis Strait I observed in 1936 that the juveniles had left the colonies and appeared in the pelagic zone the 22nd August and that the majority of Kittiwakes observed then on the 28th–29th August were juvenile individuals. On the 24th August 1978 I passed through Sukkertoppen District in the pelagic zone and found the Kittiwake to be the most numerous bird species in these waters. I have often on excursions passed the entrance to Godthåbsfjord, which is characterized by the enormous upwelling of deep sea water on account of currents and tidal movements. These areas are, therefore, rich in food and well-known for the foraging here of numerous birds of many species. As late as the 14th October 1976 large flocks of Kittiwakes were observed here, consisting of both adult and one-year old birds, the latter apparently being in the majority. Further north, in the pelagic zone of Sukkertoppen District the Kittiwakes were very scarce. One month earlier (14th September 1976) there was a very strong southgoing movement with thousands of Kittiwakes off Sukkertoppen.

In Frederikshåb District I encountered numerous Kittiwakes on the 17th May 1960, in the Davis Strait very far from the coast. They appeared in flocks consisting of from 10 to 60 birds, by far the majority being one-year old birds. Many rested on icebergs, which were passed by the ship. In the remaining two weeks of May I covered the Davis Strait between Godthåb and Egedesminde District, sailing between these places several times. Each day numerous Kittiwakes were observed on the voyage, which took place very far from land. The majority of the birds seen were one-year old immature birds. This time of the year, when the adult birds were busily occupied at the breeding-places, the immature birds have moved to the north and frequented the pelagic parts of the Davis Strait. As said above the one-year old birds do not approach the coastal waters until July. The two-year and three-year old birds move earlier to the coast (in May), as already said, and leave only the one-year old birds in the pelagic zone.

In 1925 I witnessed the southward migration of the Kittiwake in September in Frederikshåb District. On the 13th and 14th September that year enormeous numbers were observed along the coast. As far away as one could see big flocks were seen fishing or swarming over the water. The 6th September 1975 a comparatively great number of Kittiwakes were seen off Frederikshåb District, but by far not so many as in 1925.

It is quite natural that the Kittiwake is so common along the West Greenland coast that a great number is noticed on each day of observation. Several hundred-thousands of pairs breed on both sides of Davis Strait and Baffin Bay and numerous young birds visit these waters from abroad. I have seen the Kittiwake every day I have been at sea in Greenland, and what I know about its marine distribution and its migration has been described above. So, I find it not worth while to go further into details.

Sterna paradisaea

The stupendous migration of the Arctic Tern from Greenland across the Atlantic and south along the European and African coasts to the Antarctic seas has often been studied, most recently by Salomonsen (1967a, p. 3). The Arctic Tern arrives to the lowarctic parts of Greenland between the 16th and 22nd May and departs again in September (Salomonsen 1950, p. 345). I observed this species on spring migration in 1960 when in the last half of May I sailed between Disko Bugt and Godthåb, well off the coast. On the 22nd May flocks of 20 to 50 Arctic Terns were seen fishing and diving around icebergs between Holsteinsborg and Egedesminde. They had obviously just arrived and were still on migration. The following day a number of terns

were observed at Grønne Ejland in Disko Bugt, a well-known breeding-place to which they now had arrived.

In Frederikshåb District I have observed the autumn migration in the pelagic zone, about 10–15 km outside the outermost skerries. On the 13th September 1925 a large number of southgoing Arctic Terns were seen, and on the 6th September 1975 a smaller number, about 30–40 individuals, were observed.

Uria lomvia

The spring migration northwards takes place mainly in March and early April, and in the latter month the birds arrive to the breeding cliffs in lowarctic West Greenland, the date somewhat varying in connection with the climatical situation. The young leave the breeding-cliffs in lowarctic Greenland in the first half of August, and then immediately go to sea, joined by one of their parents, rarely by both of them. The migration moves very leisurely to the south, starting in the end of August or in early September. It takes place in the waters at some distance from the coast, usually 10–20 km, in the off-shore or pelagic zone, and is carried out entirely by swimming. This is due to the fact that in the adult birds the shedding of the remiges is now taking place, making it impossible for the birds to fly for a period, and in the young birds the growth of the remiges is not completed until in September–October, during the postjuvenal moult (SALOMONSEN 1950, p. 375). The swimming migration covers very large distances. The stretch south along the coast from the colonies in Disko Bugt and north of it to Julianehåb District is about thousand km. The migration takes place mainly in September and early October. The Greenland birds winter in Newfoundland, were they arrive from November to January, while the waters along the Southwest Greenland coast constitute the winter quarter of partly European, partly North Canadian populations.

The long swimming migration of Brünnich's Guillemot is a most peculiar phenomenon, but it not particularly well studied. This is understandable, for the birds appear almost to have vanished, once they have abandoned the breeding-places, on account of the large areas and considerable distances in Davis Strait. Still, I have observed this migration a number of times, especially in Frederikshåb District. On the 12th September 1925 I observed a good many birds in Davis Strait south of Godthåb. On the 21st September 1946 on Dana's fishing-bank south of Fiskenæsset, about 20 km out to sea I saw a great number of swimming "couples" (*i.e.* a parent with its young), in small parties of 2 or 4 birds, scattered over a considerable area. The water-depth here is 60–80 m. Birds were seen almost the whole day from the steamer, most of them swimming southwards, only a few on the wing. Although they were very

PLATES

Plate I

Fig. A. North-exposed mountain-side south of "Lake Ferguson", Søndre Strømfjord Airbase. (Phot. 21st July 1968 by SVEND KRISTENSEN).

Fig. B. South-exposed mountain-side north of "Lake Ferguson", Søndre Strømfjord Airbase. (Phot. 21st July 1968 by SVEND KRISTENSEN).

Fig. C. U-shaped valley, with a north-exposed and south-exposed side at Ravneklippen, Søndre Strømfjord Airbase. (Phot. 21st July 1968 by SVEND KRISTENSEN).

(For closer description of Figs. A–C cf. Fig. 22 and discussion on p. 85–86).

A

B

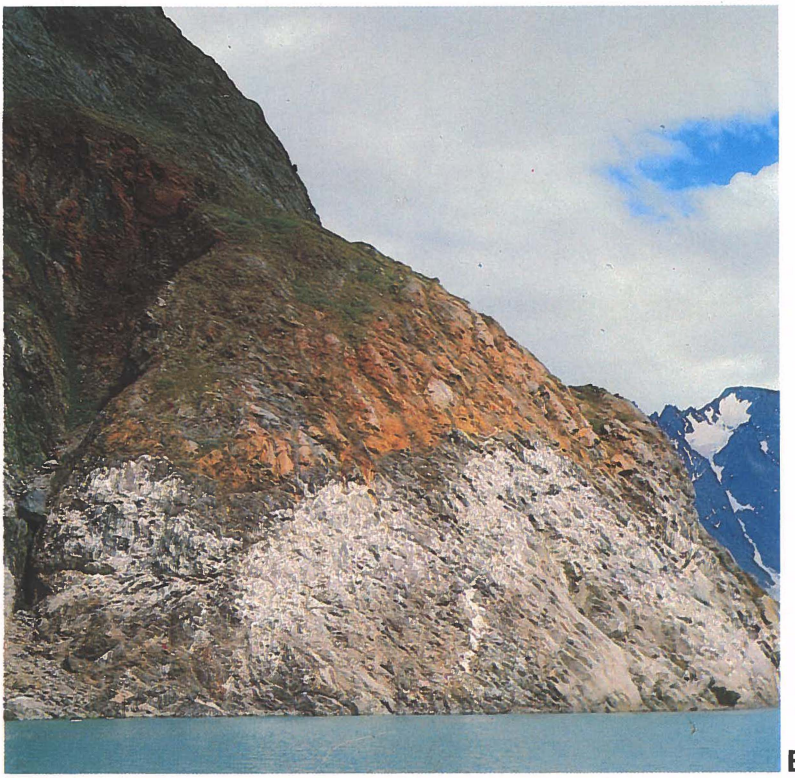
C

Plate II

Fig. A. Part of *Caloplaca* arch between green vegetation (left) and white-washed breeding-site of *Rissa tridactyla* on the bird-cliff Tâterât, 1st section, in the Evighedsfjord, Sukkertoppen District. (Phot. 12th July 1977 by F. SALOMONSEN).

Fig. B. *Caloplaca* arch above breeding-site of *Rissa tridactyla* on the bird-cliff Tâterât, 3rd section, in the Evighedsfjord, Sukkertoppen District. (Phot. 12th July 1977 by F. SALOMONSEN).

A



B

Plate III

Coprophytic flower-meadow in front of the bird-cliff Augpalugtoq in Tasiussaq Fjord, Christianshåb District (69°03′N, 50°27′W). The flower-meadow is about 300 m in length (along the bird-cliff) and 50–100 m broad and its main constituents are *Cerastium alpinum* and *Saxifraga tricuspidata.* (Phot. 6th July 1976 by F. SALOMONSEN).

scattered, there must altogether have been many thousands of birds. Not far from this area, about 8–10 km out to sea I saw on the 6th September 1975 numerous groups of Brünnich's Guillemots, consisting of two birds (a "couple") or a multiple of this number, up to 10–12 birds, but usually only a single "couple" was seen. When the motorboat approached all birds dived, and nobody took off. Altogether several hundred birds were observed in a period of two hours; there were not so many birds as observed 29 years previously.

On the 14th September 1976 when sailing between Sukkertoppen City and Godthåb City I again met with the migration of Brünnich's Guillemot. The weather was calm, with a heavy swell running and with drizzling rain. The distance to land was about 13 km, the water-depth about 300 m. The birds were very scattered, but with my binoculars I could constantly see 10–20 groups each with 2–3 birds (a "couple"). When the ship approached them they all dived and no-one rose. The birds were observed over a distance of about 150 km and I estimated them to amount to 10,000 individuals. When in the afternoon the ship turned towards land, sailing to the entrance of the Godthåbsfjord, the guillemots ceased to occur. This indicates that the migrating "couples" prefer to stay in the waters at some distance from land. Exactly one month later, the 14th October 1976, I carried out the same voyage to Sukkertoppen-Godthåb, at the same distance from land. Now Brünnich's Guillemot was much more scarce. It looked as if the last parts of the migration were now present in these areas. Not only "couples" were seen but also smaller flocks, and the majority of birds were able to fly.

On the 12th August 1978 I passed the northern part of Upernavik District, about 22 km outside the coast, where enormous colonies of *Uria lomvia* (Agpârssuit, Kípako) are situated. In the waters south of these bird-cliffs small flocks of flying individuals were seen, generally consisting of 2–5 birds, probably immature birds. When passing the large bird-colonies (at a distance of 22 km) altogether 20 "couples" of Brünnich's Guillemots were observed, with the juvenile birds being very small, *i.e.* having just left the cliff. All birds dived, when the ship came close to them, and no-one took off. North of the said bird-cliff, there are no further colonies of Brünnich's Guillemot for long distances, and the occurrence of flightless "couples" therefore stopped as the ship moved on to the north. The migration has, undoubtedly, just started in this period. Some days later, on the 24th August 1978, off Sukkertoppen District, only a few flightless (immature?) birds were encountered. The migration of breeding-birds with their young will probably not reach this area until about 3 weeks later.

As said above, the swimming migration of Brünnich's Guillemot in Greenland is little known. However, the results of the ringing activity, at

which more then 50,000 *Uria lomvia* have been ringed, furnish some information. The adult breeding-birds appear to move to the west and leave their offspring when they have regained their power of flight. At least, there are no recoveries at all of adult birds from October–December in Greenland waters. The adult birds keep undoubtedly further out to sea and are, therefore, not shot by the inhabitants in Greenland. However, in the months January–March, when the ice sometimes is very dense in the Davis Strait, there are a few recoveries in Greenland (altogether 5) of adult birds. This may indicate that they spend the first winter-months in Davis Strait, which corresponds with the fact that they usually do not arrive in Newfoundland until January. The juvenile birds stay in the Greenland waters and are hunted to a large extent. Only a minority of them reach as far south as Frederikshåb District. Still in December a number of juveniles are shot, but the recoveries cease, which means that the latest birds now must have withdrawn to the west on their way to Newfoundland. The greater part of the juvenile birds arrive, however, already to Newfoundland in November, some as early as October. The immature birds, *i.e.* the one-year to three-year old birds, as a rule reach the breeding-area in summer, only about 25 per cent spend the summer south of it. They move to the south later than the "couples" of adult birds with their young and do not reach Southwest Greenland until January–February. Many reach as far as Julianehåb District on their migration to the south, but a lesser number of them are shot in winter than of the juvenile birds. This probably shows that a large number of the immature birds move to the west in Davis Strait in the autumn, but not so many as adult birds. In this respect the immature birds apparently are intermediate between the adult and the juvenile ones. The crossing of the Davis Strait takes place rather far to south in order to utilize the westgoing branch of the West Greenland current and in this way facilitate the long migration to Newfoundland by passive floating. The juvenile and immature birds use this migration route one or two months earlier than the adult birds and arrive correspondingly earlier to Newfoundland, as evidenced by recoveries of ringed birds.

The complicated migration pattern of Brünnich's Guillemots in Greenland has been described in details by SALOMONSEN (1967, p. 268–278) and is only set forth here as a summary. No comments have been given here about the occurrence of the populations from abroad (Europe, Canada) which regularly spend the winter-months in the West Greenland waters. Neither has anything been said about the massive mortality of Brünnich's Guillemot taking place during its autumn migration (September–October) in recent years due to the use of gill nets set for salmon.

Alle alle

This higharctic species breeds in countless numbers in Thule District and in a small number a few places further south. Just as Brünnich's Guillemot the West Greenland population winters in Newfoundland, but the migration is different. The Little Auk arrives to the breeding-places in the first days of May and leaves them again in the latter half of August. The adult birds as well as the young ones collect in August in small flocks and move slowly to the south, the majority in September, the latest birds leaving the higharctic region by the freeze-up in October. In summer immature, non-breeding birds are much more common in the ice-filled Canadian side of Baffin Bay than on the Greenland side (SALOMONSEN 1950, p. 402), because the actual habitat of the Little Auk is the drift-ice. It is, therefore, quite natural that the southward migration to Newfoundland takes place in the pack-ice zone of the Canadian current and the Labrador current, as to be seen in BROWN *et al.* (1975, map 34f–h). In this way they avoid the Greenland waters with the broad shelf and fishing-banks. Not until the latter part of October and November Little Auks turn up along the West Greenland coasts, but they are winter visitors from Europe and leave again in February–March (cf. SALOMONSEN 1967, p. 263–267).

In the long period between March and October the Little Auk occurs only exceptionally in the southern part of the West Greenland waters apart from a few breeding-pairs. I have never observed it in the pelagic zone some distance from land in West Greenland in the summertime proper, *i.e.* from the end of June to late August, but in the migration period (from mid-May to late June and from late August to mid-October) I have met with small numbers, at most 10 specimens during one day's observation. Somewhat higher numbers were encountered in areas with much pack-ice or many ice-floes, like the "Storis" (the East Greenland ice) around Kap Farvel. There I observed on the 1st June 1936 a number of small flocks, consisting of up to 8 birds, altogether at least 20 individuals. I have also seen the number of Little Auk increase in the so-called "Vestis" (the winter-ice of Baffin Bay) which in spring floats southwards with the Canadian current and approaches the Greenland coast in the waters north of Disko. On the 5th June 1936 I observed a number of Little Auks in dense drift-ice off the coast of Umanak District. The birds observed during migration time along the West Greenland coast are obviously the remotest offshoot of the strong migration in the area of the Canadian current, and the occurrences in Greenland waters must be regarded as the outermost fringe of this migration. My earliest observation during spring migration was the 17th May 1960 when I in the waters off Frederikshåb observed two birds and later on the day two more. My

latest spring observation was made on the 20th June 1925, also off Frederikshåb District, where I saw a flock of 6 birds and later another flock of 3 birds. During the autumn migration my earliest observation was on 24th August 1936, when I saw some small flocks northwest of Disko, and my latest observation the 14th October 1976 when I noticed one single bird near the islands Kookøerne, Godthåb District.

Other Bird-Species Observed

The number of pelagic sea-birds is not exhausted by mentioning the species above. Numerous other species occur in Greenland, either as breeding-birds or as regular visitors in the migration period. I do not find it worthwhile to enumerate all observations of these species during their migration in the pelagic or offshore zone, since they do not show any particular close connection with Frederikshåb District. Besides, they occur in so small number and there are so few observations of them that they cannot be compared with the widespread and common species dealt with above. I shall in the following shortly mention each species with a few remarks on their frequency.

Morus basanus. An infrequent visitor, observed by me only once, namely on the 1st June 1936 in the Davis Strait off Nanortalik District.

Stercorarius pomarinus. Often seen in migration times, sometimes in small flocks, from 1st to 24th June and from 29th August to 14th September.

Stercorarius parasiticus. Commonly seen, from 16th May to 20th June and from 8th to 20th September, usually single birds or a few birds together.

Stercorarius longicaudus. Only seen by me a single time, off Disko, and this may have been a local breeding bird. Apart from a few birds breeding on Disko the Long-tailed Skua does not breed in lowarctic West Greenland. It moves earlier to the south than the other skuas, the migration being finished before the end of August. These facts account for the rare occurrence of the Long-tailed Skue on migration along the West Greenland coast.

Stercorarius skua. There are many records in recent years of this boreal visitor to the lowarctic part of the waters off Western Greenland. I have personally only seen it once in Greenland, on the 27th July 1975, in the westernmost part of Disko Bugt. On the map in BROWN *et al.* (1975, p. 101) it appears that the Great Skua is comparatively often met with in the open sea of the Davis Strait, frequently in the eastern parts, not far from Greenland, north to Disko.

Xema sabini. Only seen a few times on the southward migration, mainly in August.

Alca torda. Noticed only three times, once in June and twice in September.

Fratercula arctica. I have seen this species only once in the pelagic zone in the Davis Strait, on the 5th June 1936, when a single bird was observed in the drift-ice off Umanaq District. This is a rather late migration record and it is more probable that it is a specimen on food excursion from the population of Upernavik District. The maps in BROWN *et al.* (1975, p. 201–203) show scattered observations of Puffins in the Greenland part of the Davis Strait from August to October. It is noticable that part of the Greenland population remains in winter in the southern part of the Davis Strait (SALOMONSEN 1950, p. 418).

I should add that I have never seen *Pagophila eburnea* in Davis Strait. It is a higharctic species, and in winter occurs mainly in the ice-fields on the Canadian side of Baffin Bay. During western gales it may be blown to the Greenland coast where it is known as a rare visitor (SALOMONSEN 1950, p. 291).

Inshore Species

Many inshore species are found in the offshore and pelagic zone off West Greenland in small numbers, both in summer and in the migration time. I shall not go into this, just mention which species I have seen constantly or irregularly on the fishing-banks off the coast: *Gavia stellata*, *Phalacrorax carbo*, *Cepphus grylle*, *Larus marinus*, *Larus hyperboreus* and occasionally *Larus glaucoides.* Finally, are *Clangula hyemalis* and *Histrionicus histrionicus* observed only as rare visitors.

LOCAL BIRD-NAMES IN FREDERIKSHÅB DISTRICT

A number of birds have received local names in Frederikshåb District, and these names are unknown and not recognized in the remaining West Greenland. However, some of these names are used also in Julianehåb District, and one of them is used even in Fiskenæsset outpost, in the southern part of Godthåb District. The reason for this change of names in Frederikshåb District I do not known, but it may have something to do with the isolated position of the area. It was extremely difficult and dangerous in the old days, with their more primitive means of transportation, to pass the long stretch of open water off the glacier Frederikshåb Isblink, which separates Godthåb and Frederikshåb Districts. This fact may have contributed to the isolation of the latter district and therefore to the possibility of creating new designations for more uncommon phenomena. In primitive and very thinly populated areas the appearance of noa names may also disrupt the well-known pattern and give rise to formation of new names.

The bird-names in Greenland, used since the earliest historical and linguistic sources (in the 18th century), and their meaning have been described by BERTELSEN (1906, p. 69). The modern bird-names, used in my various papers and books on Greenland birds, were determined in cooperation with a number of Greenlanders, first and foremost with the late AUGO LYNGE (1899–1959), a well-known Greenland teacher and author, member of the Danish Parliament. The names decided by LYNGE and me as those to be used are now the official ones in Greenland. However, in the following cases the inhabitants of Frederikshåb District use other designations than the established ones.

Somateria mollissima. Official name *Miteq*. BERTELSEN (1906, p. 75) states that "on the southern part of the West coast the name *Avôq* is used." (This name is an onomatopoetic rendering of the male's voice). The use of *Avôq* has been very much restricted in our days, and this designation is now used in Julianehåb District only with inclusion of the neighbouring town Arsuk, the southernmost outpost in Frederikshåb District. Further north in the district (from Narssalik north) *Miteq* is exclusively used. Although the name *Miteq* is well-known in Julianehåb, *Avôq* is still much used, sometimes as a designation for the adult male only. As a token of the general use of this name one of the small new coasters was recently named "*Avôq*".

Mergus serrator. Official name *Pâq*. BERTELSEN (1906, p. 77) states that "in South Greenland the name *Nujalik* is heard" (meaning "the bird with hair on its head") and that FABRICIUS, as early as in 1780, gives a similar version (*Nujaligssaq*) for the name of *Mergus serrator* used in Frederikshåb District, where he was a missionary. The name *Nujalik* is still in use in Julianehåb District as well as in the entire Frederikshåb District. The inhabitants in most places do not even know what *Pâq* means. Only in Avigait, the northernmost outpost in Frederikshåb District, the inhabitants know the name *Pâq*, but they told me that they did not use it, but preferred *Nujalik*. I was told that the inhabitants of Fiskenæsset, the neighbouring outpost to the north of Avigait, also used *Nujalik*, but this appeared not to be correct, although people there knew the term *Nujalik*. It appeared that they had their own word for this bird, namely *Patsiaq*, meaning something similar as "the bird that is a *Pâq*". The curious thing is that one of the Bohemian Brethren, DAVID CRANZ, who was employed at the missionary station Lichtenfels, erected 1758 at Fiskenæsset, in his description of Greenland in 1770 gave the name of *Mergus serrator* as *Paussoq*, which to my ears appears to be quite similar to *Patsiaq*, the name presently used in Fiskenæsset and, therefore, probably more than 200 years old.

Fulmarus glacialis. Official name *Qaqugdluk*. The official name is used generally in both West and East Greenland, with exception of the northern districts of the West coast, *i.e.* Upernavik and Umanaq, where the Fulmar is called *Tingmiakuluk* (meaning "the inferior bird"). Very widespread is even the designation *Malamuk*, which dates back to the foreign word *Mallemugge*, a name given by the early Dutch arctic voyagers to the Fulmar. The name *Malamuk* was adopted by the Greenlanders in the 18th century and is mentioned as a Greenland name already by CRANZ in 1770. It is noteworthy that the same name has been recently (in 1946) adopted as the Danish name for the Fulmar ("*Mallemuk*"), while the Dutch have given up this name years ago and no other country has adopted it.

The Fulmar is so common along the coasts of West Greenland that it has received several local names apart from those already mentioned, and some of these are still is use. In Egedesminde District (but nowhere else) the name *Qûliuk* is often used. It is of uncertain meaning, but probably onomatopoetic. BERTELSEN (1906, p. 80) gives the spelling as *Qûlioq* and states that it is used generally in Disko Bugt, but this is no longer the case.

Most peculiar is the name of the Fulmar in Frederikshåb District. It was shown above (p. 179) that the Great Shearwater was extremely numerous in Frederikshåb District and in summer much more common

than the Fulmar and, therefore, much better known by the inhabitants than was the Fulmar. Consequently, the peculiar thing happened that the Great Shearwater took over the name of the Fulmar and is everywhere in Frederikshåb District called *Qaqugdluk*, instead of its usual Greenland name *Qaqugdlungnaq* (meaning "not the usual Qaqugdluk"). The Fulmar then needed another name and received the designation *Qaqugdlukuluk* (meaning "the inferior *Qaqugdluk*"). This exchange of names in Frederikshåb District was not only unknown to me but appears to be unfamiliar to everybody outside the district. It has never been discussed in print before, and most likely the name exchange must be a comparatively new invention. I asked a great number of people, not only in Frederikshåb City, but in all the outposts of the district, and all persons confirmed without the slightest doubt that the names of the two species were as scheduled above.

Charadrius hiaticula. Official name *Tûjuk.* This name, having an onomatopoetic meaning, has been known for centuries. BERTELSEN (1906, p. 81) adds that in "South Greenland" the Ringed Plover is called *Tukagfâjôq*, meaning "with curly hair"(!); even this name has been mentioned in the literature from the 18th century already, and must have had a wide distribution in southern Greenland in those days. In present days the official name is used almost everywhere, but it is worth mentioning that in Julianehåb District *Tukagfâjôq* is still the name used in most places, whereas the inhabitants do not know the designation *Tûjuk.*

Fratercula arctica. Official name *Qilángaq.* The official Greenland name is not subject to any change along the entire west coast, so far I know. The only local name I have come across was in Arsuk outpost in Frederikshåb District. In this part of West Greenland the Puffin does not breed, but may occur as a rare visitor in winter. On account of its exceptional occurrence the inhabitants must have forgotten the name of the Puffin and call it now *Sâgîgsukúmak*, according to JON FREDERIKSEN, ABEL KRISTIANSEN and other inhabitants of Arsuk.

Carduelis flammea. Official name *Orpingmiutaq.* BERTELSEN (1906, p. 92) states "a few places in South Greenland the name is *Anâraq*". This name is, quite like the official one, known since the 18th century. Although *Orpingmiutaq* is by far the most well-known name everywhere in Greenland I have heard the designation *Anâraq* still used by many people in Frederikshåb District. This was a surprise to me, because I thought that *Anâraq* was extinct many years ago, but this is evidently not the case.

Plectrophenax nivalis. Official name *Qupaluarssuk.* A similar name, *Qupangnâq*, was known formerly to be widespread in South Greenland, where it appeared to be the commonly used designation (BERTELSEN 1906, p. 93). About 25 years ago AUGO LYNGE told me that *Qupangnâq* was still preferred as the name for the Snow-Bunting by the inhabitants of Julianehåb and Frederikshåb District as well as in Fiskenæsset outpost in the southern Godthåb District. In our days the name *Qupangnâq* is still remembered by inhabitants of Frederikshåb District, but it appears that the official name, *Qupaluarssuk*, has gained ground and is now the ordinary name, generally used in the district. The common teaching of the official bird-names in the schools will, naturally, in the long run wipe out all the old local names.

A VISIT TO DYE II ON THE ICECAP WITH NOTES ON THE TRANSGLACIAL BIRD-MIGRATION

The reason for my interest in visiting the Dye II station on the ice-cap was my intention to obtain some information about the transglacial bird-migration. Formerly nobody thought it possible that any bird-species was able to cross the enormous ice-cap on their migration, but in my book on Greenland birds (SALOMONSEN 1950) I mentioned the possibility or the probability that a number of species moved that way. However, the ringing results and the local observations were too few to decide the issue. In my book on the bird-migration and ringing-activity in Greenland (SALOMONSEN 1967) I could utilize a big material of experience and conclude that there was empirical proof of a transglacial migration, at least in spring, for the following species: *Anser albifrons* (described p. 98–107), *Branta bernicla* (p. 112–118), *Arenaria interpres* (p. 165–169) and *Calidris canutus* (p. 180–182). The case of the two species of geese is absolutely certain, and many recent observations (not published) strengthen the view. As far as the Brent Goose is concerned it complicates the matter that apparently part of the population moves to America in winter and another part to Europe across the ice-cap. Cf. the map of the migration of the Greenland Brent Geese in SALOMONSEN 1958, p. 205. The transglacial migration of the Brent Goose is conclusively proved, but the American migration route was only based on a hypothesis (cf. SALOMONSEN 1967, p. 118) on account of the lack of ringing recoveries. However, the 4th June 1974 a Brent Goose was recovered near Godhavn, Disko having been ringed in Franklin District, near Ellesmere Island (at 73°30′N, 99°00′W) the 30th July 1972[1], showing that the hypothesis was correct.

The two species of waders, mentioned above, had until recently not been observed on the ice-cap, for the good reason that this enormous lifeless desert is not inhabited by man and rarely visited. However, the rather recent erection of the American stations of the DEW-line (Distant Early Warning Line) on the ice-cap has changed the situation as has also the many expeditions with regular habitation on the ice-cap. It is, therefore, not correct when recently MORRISON (1975, p. 299), in his

[1]) Ring no.: 867-77142.

treatise of the migration of the Knot and Turnstone in Ellesmere Island, states that "details of the migration route between Iceland and arctic Canada are unknown." He has, however, completely ignored the Greenland literature and, therefore, made various mistakes.

Some noteworthy observations have been made by members of the "Expéditions polaires françaises" on the "Station centrale du Groënland" situated on 70°45'N, 40°42'W on an altitude of about 3000 m, almost in the centre of the ice-cap. During erection of the station, in the summer of 1949, a specimen of *Arenaria interpres* was caught and photographed, and other individuals of this species were caught at the station in the autumn 1949 and during spring 1950 (BOURLIÈRE 1952, p .57). Even other birds were noticed, and it is very interesting that Rock Ptarmigan, *Lagopus mutus*, were observed on various points, and that a single specimen was seen flying from west to east on the 20th October 1949 at a temperature of −38°C. BOURLIÈRE was unaware of the fact that this year was a peak-year for the Ptarmigan in West Greenland and that the migration from the autumn 1949 to spring 1950 was specially studied (SALOMONSEN 1950, p. 178). The records from the central ice-cap demonstrates how far and wide Ptarmigan move during peak-years. Apart from the Ptarmigan and the Turnstone even *Stercorarius longicaudus*, "geese" and "ducks" as well as a Snowy Owl, *Nyctea scandiaca*, were observed or caught, but unfortunately no ornithologists were present (BOURLIÈRE 1952, p. 57–58 & p. 179).

Returning to the transglacial migration of the Turnstone a remarkable recovery of a ringed bird was made a few years ago. The 28th July 1968 a ringed Turnstone was found dead on the station DYE II on the ice-cap. The ring was sent to SVEND KRISTENSEN at Søndre Strømfjord airbase, who forwarded it to me. It turned out to come from England and was put on the bird at St. Agnes, Isles of Scilly, Cornwall at the 30th September 1960 (SALOMONSEN 1971, p. 12).

As far as the Knot is concerned, an individual was found sick and enfeebled on the 21st July 1968 at DYE II. The weakened bird was sent to the hospital in Søndre Strømfjord, where it recovered and was released. It was photographed in Søndre Strømfjord by SVEND KRISTENSEN, who sent the photograph to me. It was easy to identify the bird as an adult Knot in worn summer-plumage.

The observations of Turnstones and Knots on the ice-cap make it pretty certain that these two species, elsewhere on migration attached to sea-boards, must carry out a transglacial migration. Some other species of birds have also been met with on the ice-cap by various expeditions in the past, and all these records have been enumerated in SALOMONSEN 1950, mentioned under the species in question. There are, however, a few more recent observations on the ice-cap which I should like to mention here.

The Snow-Bunting, *Plectrophenax nivalis*, is one of the species most frequently encountered on the ice-cap (cf. SALOMONSEN 1950, p. 548–549). The explorer Dr. CHRISTIAN VIBE, an experienced dog-sled driver, in 1941 made a sled journey to Inglefield Land from Thule, and has informed me about the following incident (*in litt.*). On the 20th May 1941 on the voyage over the ice-cap between Clements Markham Gletscher and Renselaer Bugt on Inglefield Land (77°55′N, 71°50′W–78°22′N, 71°00′W) flocks of Snow-Buntings were observed four times. The flocks, numbering only a few individuals, came from southeast, moving towards northwest. Probably the migrating birds came from Upernavik District further south the West coast, and moved over the ice-cap east of Melville Bugt and Thule District on their way to Inglefield Land or, possibly, to Ellesmere Island.

Dr. VIBE informed me about another bird-record from the ice-cap (*in litt.*). WILLIE KNUTSEN, major in the Norwegian army, spent some time in 1961 at the ice-cap station DYE III, situated about a 100 miles west of Angmagssalik. He told Dr. VIBE about the migration of small passerine birds at DYE III. The 18th May 1961 he sent by air to Dr. VIBE a Wheatear, *Oenanthe oenanthe*, found dead the same day at DY III. In my book on the bird-migration in Greenland I have commented on this record (SALOMONSEN 1967, p. 311) and conclude that it is very likely that the Wheatear in spring, probably more rarely in the autumn, crosses the southern part of the ice-cap on its migration. I must refer to my book in question for particulars about the reason for this conclusion; it would be too lengthy to go into details here.

The DYE II station is part of the DEW Line (Distant Early Warning Line) and is situated on the ice-cap on 66°05′N, 47°06′W, on an altitude of 2300 m. It is a huge and peculiar building (Fig. 43), erected in the completely lifeless desert. It is 84 m high, has a weight of 3000 tons, has 5 floors and is carried by eight steel-pillars. It has a crew of 15 men and is equipped with everything needed for a pleasant life. Outside the building it is extremely cold the whole year through. In the summer the temperature is usually about 0°C, and is at most 10°C, and in the night it drops to −20°C. It is often blowing and this lowers the temperature considerably. According to the "Equivalent Chill Temperature Chart" a wind-force of *e.g.* 40 miles per hour lowers a temperature of −30°C to −50°C, which may give rise to almost immediate congelation. It is important to bear these extreme temperature relations in mind when discussing the life-conditions for birds crossing this icy desert.

I got permission by the Chief Staff of U.S. Air-Forces to visit DYE II, and I spent there the period 9th–13th July 1971. I was well received by the station chief GEORGE P. YUNG, who showed me the whole station. Apart from the hospitality and kindness of the American officers the stay was a disappointment, as I did not get any idea of the bird-migration

here. There were several reasons for this. Firstly, the situation of the station was much too far south of the area of the main bird-migration, which moves, roughly speaking, from Disko Bugt to Angmagssalik. Secondly, the time I visited DYE II was too early to observe the migration proper, but I could not change the dates. For the third, the light was in day time so intense and the reflections from the ice so strong that it was necessary always to carry sun-glasses in open air. This made it almost impossible to discover flocks of birds passing silently high up inthe air.

Still, I saw something of ornithological interest, which I shall briefly inform about.

Plectrophenax nivalis. An adult male and a female were found dead on the snow in the shelter of the pillars of the station.

Oenanthe oenanthe. Two adult males were found dead not far from the Snow-Buntings.

All the four birds were in nuptial dress (summer dress), somewhat worn, but without any moult whatsoever. They were quite fresh, not at all rotten, since they were kept here as in a refrigerator. The eyes were sunken, which shows that they must have been dead for some days. The occurrence of these birds here cannot be due to any real migration, but must have been a result of random movements from the breeding-area.

Phalaropus lobatus. An individual was found dead in a water-container. These containers, in which hot water is poured over snow for producing drinking and bathing water, are open upwards. The bird must have believed that it had found a pool on the ice-cap and thrown itself into the hot water. It was an adult bird but the sex could not be determined, because the bird must have been dead a couple of days and was somewhat damaged.

I interviewed the staff about their observations of birds, but the result was not satisfactory. The reason for this was that the crew generally worked inside the building which had no windows. Besides, the migration will probably pass at night, when nothing can be seen and when nobody is outside the building to hear the bird sounds, which could betray the presence of migrating flocks. There are no lights to attract nocturnal migrants, only some dim landing lights on the air-field and a red lamp on top of the main building to warn air-crafts. I was for military reasons not allowed to study the radar plots, which may have shown something about the migration.

However, I received some notes of interest. It must be emphasized, however, that nobody was particularly interested in or acquainted with ornithological matters, and the information has to be viewed on this background. For identification I used the well-known work of Peterson *et al.*, A Field Guide to the Birds of Britain and Europe.

It appeared that Snow-Buntings had been observed by everybody. This species must be a common visitor without being a real migrant here.

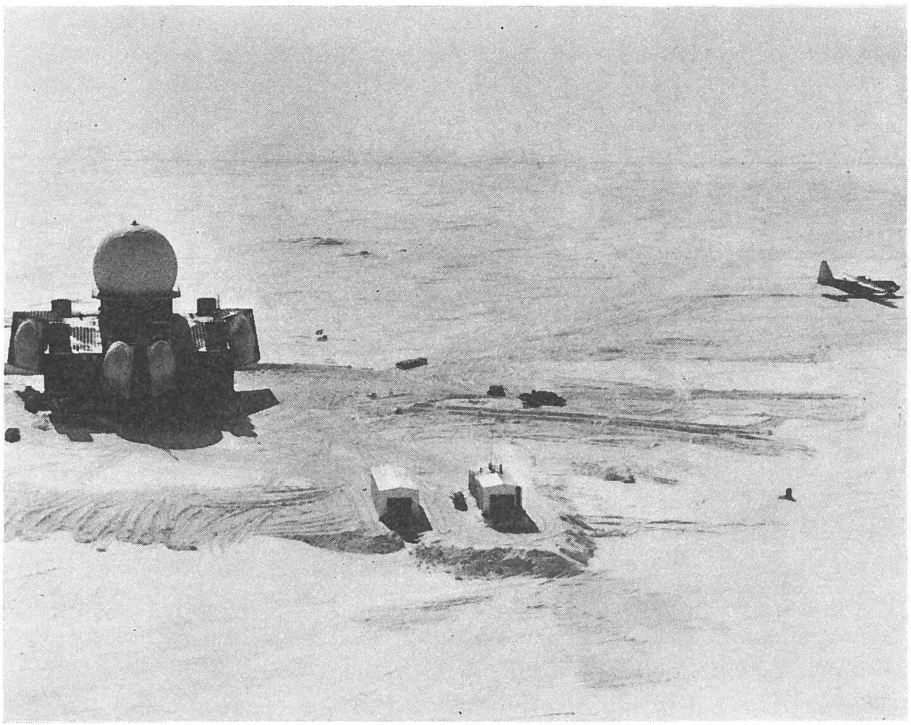


Fig. 43. The DYE II Station, belonging to The Distant Early Warning Line, on the Greenland icecap. (Phot. in July 1971 by LLOYD NAEGELI).

The movement of the Snow-Bunting goes along the coast and does not cross the ice-cap.

Of the staff-members DICKIE MIETH told me that he had seen some long-billed waders with red on their throat, the size of Snow-Buntings. He observed them early in the autumn, once 4–5 birds in a flock; altogether he had seen 15 specimens. They have probably been Sanderlings, *Calidris alba*.

ASGER NIELSEN, another staff-member, informed me that he in July or early in August 1970 after a heavy storm observed a flock of about 20 Purple Sandpiper, *Calidris maritima*. The birds stayed for three days, then left. The identification of this species appeared to be correct. ASGER NIELSEN also informed me about observations of some Mallards, *Anas platyrhynchos* he had made. In May–June 1970 he noticed 3–4 specimens of which one descended on the ice, probably an exhausted or weakened bird. They appeared all to be females (or immature birds).

RICHARD MCCLOUD inspected the meteorological instruments and, therefore, had to go outside the building each night. He told me that he, to the best of his knowledge, had never heard whistling or piping sounds of waders or other bird voices at night.

H. E. HUNTON informed me that he has seen the Snow-Bunting

rather often. In September–October 1969 he saw a flock of at least 12 birds, of which 5–6 went into the house by an open door to get some heat. The other birds were soon found dead in the snow outside. The birds in the house were fed with bread and grain but did not want any food and soon succumbed. In the summer of 1970, probably in the midst of August, he saw a flock of 16 Snow-Buntings, which were very active and alert and stayed around the station a couple of days, especially frequenting the dump. Four days after their arrival they had all left. HUNTON observed Snow-Buntings altogether five times, usually in the autumn. Apart from the two large flocks, described above, the remaining flocks consisted of only 4–6 birds.

As already said, these Snow-Buntings must undoubtedly represent birds roaming about in the autumn before the real movement to the south and their presence here does not indicate actual migration.

Very noteworthy was the observation by HUNTON of Whitefronted Geese, *Anser albifrons*, some time in the spring of 1970. (He did not remember the date for the observation). In four consecutive days he saw flocks pass in the air, but each consisting of only 6–8 birds. They had the direction towards Søndre Strømfjord, which would be the proper one for the migration. The observations were all made during the daytime, and HUNTON saw even that a flock alighted on the ice and continued the flight after a short stay. This observation of White-fronted Geese was the only one I came across which dealt with a species carrying out a regular transglacial migration.

HUNTON was kind enough to send me a specimen of *Oenanthe oenanthe* which he found dead at the station in the autumn 1971. It had flown inside the building during the night before 22nd August 1971. "He was very lively all day the 22nd and ate some bread and drank water, but was dead in the morning of the 23rd. No other birds seen besides this one." HUNTON also states that the wind in the days 19th–22nd August came from the southeast, with a maximum speed of 18 knots, average speed 12 knots. There were no storms during the period 17th–22nd August, but some snowfall and fog.

The bird was a juvenile male in fresh autumn dress, without showing any sign of moult any longer. The wing measured 105 mm.

I refer to p. 44 about HUNTON's observation of Blackheaded Gulls, *Larus ridibundus*, at the station.

Summarizing it may be said that the result of my visit to DYE II was meagre, although I saw a few birds myself and got some interesting notes from others. The main thing was that I did not obtain any satisfactory news on those birds which regularly and in great numbers pass the ice-cap on migration. The interesting question about the transglacial migration in Greenland is still not adequately known, but, admittedly, it is not easy to tackle.

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