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STUDIES ON THE FLORA OF THE NORTH BLOSSEVILLE KYST AND ON THE HOT SPRINGS OF GREENLAND

BY

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WITH 13 FIGURES AND 6 TABLES IN THE TEXT,
AND 1 PLATE

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Abstract

The vascular plants and bryophytes found by recent expeditions to the north Blosseville Kyst, East Greenland, are recorded. Four species, all occurring by the hot springs in Knighton Fjord (69°22′ N. lat., 24°43′ W. long.), are new to the flora of Greenland: *Archidium alternifolium* (HEDW.) MITT., *Fossombronia wondraczekii* (CORDA) DUM., *Ophioglossum azoricum* C. PRESL and *Geum rivale* L. Several species found at these springs and also at those in Rømer Fjord here reach their northern limits in East Greenland.

The vegetation around these hot springs and at Ûnartoq, in South Greenland, is described. All the known hot springs in Greenland are mapped and data, where available, are given on their temperatures and physical and chemical characteristics.

The four species new to Greenland all occur in Iceland and the hypothesis of dispersal by migrating wildfowl is regarded as very plausible.

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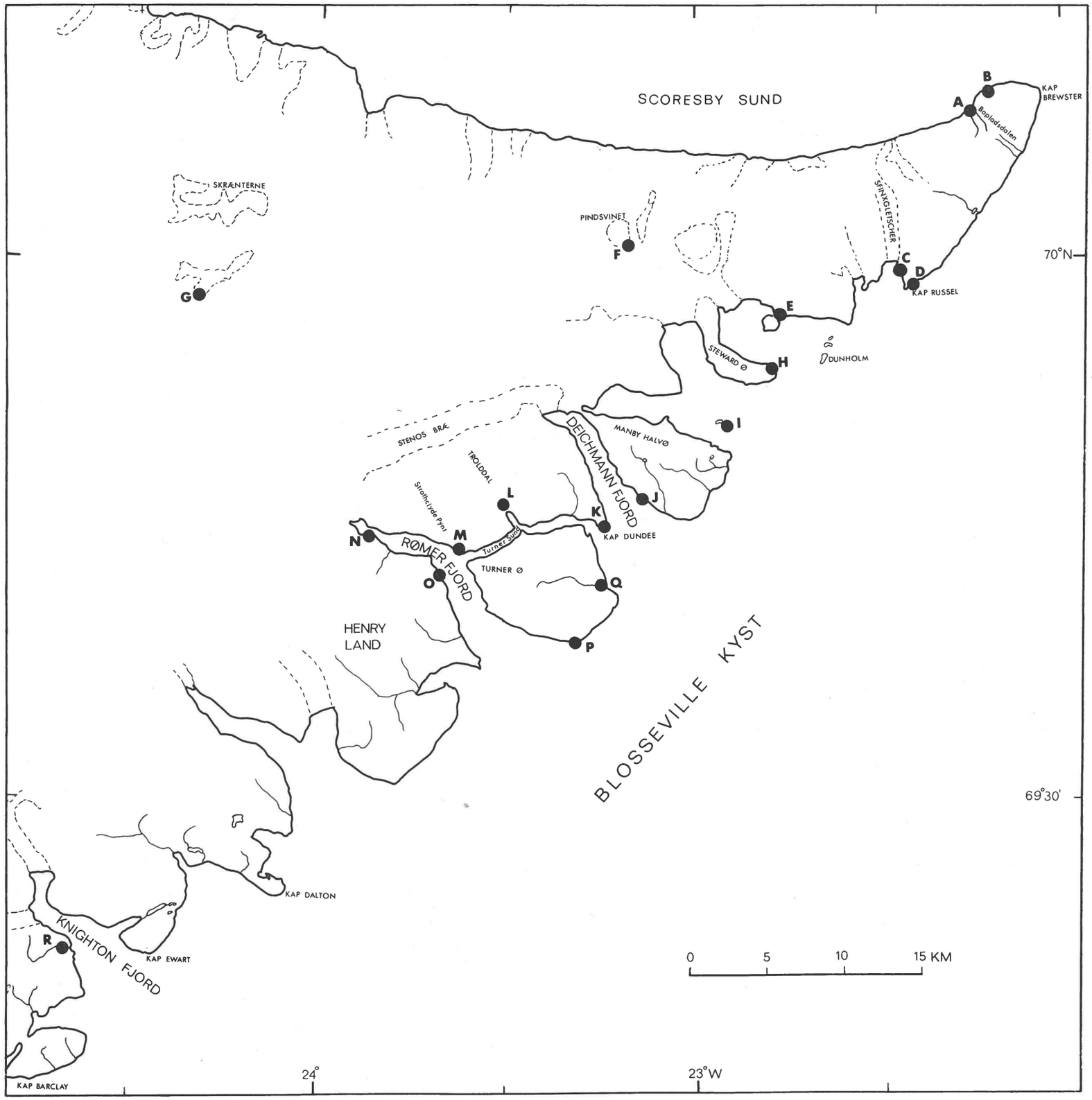

Map of the localities A–R. (L. KLIIM-NIELSEN).

INTRODUCTION

Very few botanical collections have been made along the northern part of the Blosseville Kyst (Fig. 1 and Plate 1) between Scoresby Sund (70°00′ N.lat.) and Knighton Fjord (69°20′ N.lat.). The persistence of the off-shore ice and its unpredictable behaviour have combined to give this coast its reputation of virtual inaccessibility; in fact it has been visited by professional botanists on only three occasions. HARTZ and KRUUSE, members of AMDRUP's expedition of 1900 (KRUUSE, 1905; HARTZ & KRUUSE, 1911), visited Turner Ø on the northward voyage and called briefly at Dunholm, a small island lying midway between Turner Ø and Kap Brewster. This island was later visited by HAGERUP in 1924. His botanical results are unpublished but a number of records based on herbarium material at Copenhagen are cited by BÖCHER (1938).

BÖCHER (1933a, b) himself travelled down the coast in 1932 on the Scoresby Sound Committee's 2nd East Greenland Expedition led by EJNAR MIKKELSEN (MIKKELSEN, 1933). He landed first at Kap Dalton and then in a small fiord a little to the north. Travelling southwards he visited, within our area, Kap Ewart and Knighton Fjord. At the latter locality his observations were supplemented by a collection made by SPENDER, an English cartographer, from the vicinity of the hot springs.

There appear to have been no further collections from this coast until 1965 when Mr. D. C. REX, a member of an Oxford University geological expediton, collected near Kap Brewster and from a nunatak by Torvgletscher, a large glacier which descends from the inland ice to the coast opposite Dunholm. Dr. J. C. RUCKLIDGE, another expedition member, made a small collection from a nunatak on the south side of Torvgletscher about 50 km inland.

In 1967 and 1972 Mr. T. I. HAUGE ANDERSSON, a member of the Copenhagen Geodetic Institute's Survey Expedition to the Blosseville Kyst, paid brief visits to the Knighton Fjord areas of hot springs and made a fairly comprehensive collection of vascular plants and some bryophytes.

Finally, one of us (I.H.M.S.) collected from 14 coastal sites during a boat journey of 120 km down the coast from Scoresbysund as a member of the International Mount Mikkelsen Expedition 1969. Heavy ice

Fig. 1. Typical view of the Blosseville Kyst at Kap Garde (68°16′ N.lat.) showing the characteristic basalt cliffs. (L. KLIIM-NIELSEN, 19.7.1971).

prevented the expedition from proceeding south of Turner Ø and Rømer Fjord, but they visited two very interesting groups of hot springs. At the time they were unaware that these springs in Rømer Fjord had earlier been discovered in 1963 by K. EKHOLM (1973 pers. comm.), the leader of the Copenhagen Geodetic Institute's Survey Expedition to the Blosseville Kyst; no botanical collections, however, were made in 1963.

These four recent collections, together with observations on the hot-spring flora, are the subject of this paper. We have included information on the hot springs of Greenland, and particularly on the ecology of the Knighton Fjord springs, which has in part already been published by KLIIM-NIELSEN & PEDERSEN (1974). Accounts of the Oxford Expedition have been published by RUCKLIDGE & BROOKS (1966) and FAWCETT, RUCKLIDGE & BROOKS (1966). The official report (SMART, 1971) of the Mount Mikkelsen Expedition unfortunately and inadvertently includes in the records a number made by the Oxford Expedition.

Localities

The following list of localities relates to the botanical collections of the 1965, 1967, 1969 and 1972 expeditions mentioned above (Plate 1). The following maps have been used: 1. For latitudes south of 70°00′ N.lat.—U.S. Army Topographic Command map AMS, NR 27, 28–7, series C 501, scale 1:250,000. 2. For latitudes north of 70°00′ N.lat.—Greenland, Scoresbysund 70 Ø. 1 the Geodetic Institute, Copenhagen 1965, scale 1:250,000.

A: (i) Bopladsdalen, the valley 3 km west of the Kap Brewster hut, 70°07′ N.lat., 22°17′ W.long., D. C. Rex, 27.7.1965.
(ii) Above the Kap Brewster hut, 70°08′ N.lat., 22°15′ W.long., alt. 150 m, D. C. Rex, 22.7.1965.

B: 4 km west of Kap Brewster, 70°09′ N.lat., 22°09′ W.long., I. H. M. Smart, 7.8.1969.
(i) Unconsolidated north-facing screes below steep cliff, also from floor and sides of rocky gully, alt. 0–250 m.
(ii) Upper part of gully and fell-field plateau.

C: Small bay on eastern shore of the fiord below Sfinxgletscher, about 5 km north of Kap Russel, 70°00′ N.lat., 22°27′ W.long., I. H. M. Smart, 12–15.8.1969.
(i) Herb-slopes, fell-field and banks of small stream, alt. 0–100 m.
(ii) Fell-field, alt. over 100 m.

D: Kap Russel, 69°59′ N.lat., 22°23′ W.long., I. H. M. Smart, 7–12.8.1969.
(i) South-facing slopes and fell-field above rocky bay immediately east of Kap Russel, alt. 0–100 m.
(ii) From higher ground, alt. 100–150 m, mostly from fairly luxuriant herb-slope on steep bank in valley behind the bay.

E: The northern shore of the fiord north of Steward Ø, 69°57′ N.lat., 22°45′ W.long., fell-field and outflow fan of small stream, I. H. M. Smart, 23.8.1969.

F: Pindsvinet, basalt nunatak on north side of Torvgletscher, 70°01′ N.lat., 23°20′ W.long., level area about 50 m above the glacier on south side of nunatak, alt. 820 m, D. C. Rex, 3.8.1965.

G: Nunatak south of the nunatak Skrænterne, 69°57′ N.lat., 24°19′ W.long., south-west-facing basalt cliff, alt. 1700 m, J. C. RUCKLIDGE, 4.8.1965.

H: North side of tip of Steward Ø, 69°53′ N.lat., 22°48′ W.long., heathland with rocky outcrops, alt. 0–10 m, I. H. M. SMART, 22.8.1969.

I: The largest island in the group of small islands 2 km north from tip of Manby Halvø, 69°51′ N.lat., 22°55′ W.long., undulating heath, I. H. M. SMART, 16.8.1969.

J: South-west side of Manby Halvø opposite Kap Dundee, 69°47′ N.lat., 23°11′ W.long., heathland and banks of small stream 1 km from sea, alt. 0–30 m, I. H. M. SMART, 21.8.1969.

K: Kap Dundee, 69°46′ N.lat., 23°15′ W.long., herb-slopes and fell-field within 1 km of sea, alt. 0–30 m, I. H. M. SMART, 21.8.1969.

L: Trolddal, 69°46′–69°47′ N.lat., 23°30′–23°32′ W.long., herb-slopes, heath and fell-field, I. H. M. SMART, 17–19.8.1969.

M: (i) Strathclyde Pynt, 69°44′ N.lat., 23°37′ W.long., heath and fell-field, alt. 0–30 m, I. H. M. SMART, 19.8.1969.
(ii) Hot springs on north side of Rømer Fjord, about 500 m west of Strathclyde Pynt, 69°45′ N. lat., 23°38′ W.long., alt. 60 m, I. H. M. SMART, 19.8.1969.

N: 5 km stretch along south side of inner Rømer Fjord almost to its head, 69°46′ N.lat., 23°48′–23°55′ W.long., rocky hillside, scree, fell-field, herb-slopes and a tarn, alt. 0–100 m, I. H. M. SMART, 20.8.1969.

O: Hot springs on south side of Rømer Fjord opposite locality Mii, 69°43′ N.lat., 23°42′ W.long., I. H. M. SMART, 20.8.1969.

P: South-west point of Turner Ø, 69°38′ N.lat., 23°20′ W.long., gravel terraces on steep cliff, alt. 30 m, I. H. M. SMART, 17.8.1969.

Q: Mouth of broad valley at eastern corner of Turner Ø, 69°41′ N.lat., 23°15′ W.long., heathland, I. H. M. SMART, 17.8.1969.

R: Hot springs on west side of Knighton Fjord, 69°22′ N.lat., 24°43′ W.long., T. I. HAUGE ANDERSSON, 23.8.1967 and 22.8.1972 (Fig. 10).

Plant Records

Table 1 lists all the vascular plants collected or noted at each locality; earlier records are not included. The names and sequence are those of Böcher, Holmen & Jakobsen (1968). As mentioned above, none of these collections or observations was made by a professional botanist and on all three expeditions botanising was only a secondary consideration. Consequently, the lists for any locality cannot be considered by any means exhaustive; the material collected was often scrappy and poor specimens of common species have in fact been discarded. The very poor weather encountered by the 1969 expedition, together with the fact that the collection had to be sent back to Britain by sea, meant that much of the material was affected by fungus.

The 1965 and 1969 collections have been worked up at Lancaster University by G. Halliday. Those from the 1967 and 1972 expeditions were identified at the Botanical Museum, University of Copenhagen, by L. Kliim-Nielsen (vascular plants), K. Holmen (mosses) and K. Damsholt (liverworts).

Remarks on the more interesting species

Selaginella selaginoides (L.) Link (Fig. 2)

Until recently this species was unknown on the east coast north of Jættefjorden (63°36′ N.lat., Trollefjordeidet, Devold & Scholander, 1933). In 1966 it was found in the Angmagssalik area (65°35′ N.lat.) by Daniëls & de Molenaar (1970), in 1971 at Tugtilik (66°20′ N.lat.) by one of us (Kliim-Nielsen, 1971), while the Knighton Fjord find represents its known northern limit. The other finds in the Skjoldungen and Angmagssalik areas are due to the expeditions of the Greenland Botanical Survey (G.B.U.) in the years 1969–71, led by L. Kliim-Nielsen.

Ophioglossum azoricum C. Presl

Locality: Knighton Fjord, 69°22′ N.lat., 24°43′ W.long., alt. 150 m, leg. T. I. Hauge Andersson, 23.8.1967 (Plate 1, locality R; Fig. 10).

This is a most remarkable find of a fern new to the Greenland flora. This species is very rare in central Europe but occurs scattered in oceanic

Table 1. *The vascular plants recorded from localities A–R. Where sites have been subdivided, + refers to the first subdivision, * to the second. C and L respectively indicate that herbarium material is in the Botanical Museum, Copenhagen* (**C**) *and the Arctic Herbarium, Lancaster University* (**LANC**).

Species	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Huperzia selago	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Selaginella selaginoides	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Equisetum arvense	+	*	+*	+	•	•	•	+	•	•	+	+	*	+	•	•	•	+C
Equisetum variegatum	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Ophioglossum azoricum	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Botrychium lunaria	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	+C
Cystopteris fragilis	*	•	+*	•	•	•	•	•	•	•	•	•	*	•	•	•	•	+C
Ranunculus confervoides	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Ranunculus glacialis	•	*	*	*	+	+	+	•	•	•	+	•	•	+	•	•	•	•
Ranunculus pygmaeus	+	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•
Ranunculus sulphureus	+L	cf+	•	cf+	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Thalictrum alpinum	•	•	•	•	•	•	•	•	•	•	•	+	*	+	+	•	•	•
Dryas octopetala	*	•	+*	+*	•	+	•	•	•	•	+	+	+	+	•	+	•	•
Geum rivale	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Potentilla pulchella	•	•	•	•	•	•	•	+C	+	•	•	•	•	•	•	•	•	•
Potentilla nivea	•	*	•	+C	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Potentilla hyparctica	+*L	*	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•
Potentilla crantzii	•	•	+*	•	•	•	•	•	•	+	+	+	*	•	•	•	•	+CL
Sibbaldia procumbens	•	•	*	+	+	•	•	+	•	•	+	+	*	•	•	•	•	+CL
Alchemilla filicaulis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Alchemilla glomerulans	•	•	•	•	•	•	•	•	•	•	•	•	*	•	+	•	•	+C
Sedum rosea	+	+*	•	+	+	+	•	+	+	•	+	•	+	•	+	•	•	+C
Saxifraga nivalis	+L	*	*	+	+	•	+	+	•	•	•	+	•	•	•	+	•	•
Saxifraga tenuis	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Saxifraga foliolosa	•	•	•	•	•	+L	•	•	•	•	•	•	•	•	•	•	•	•
Saxifraga cernua	+L	+*	+*	+	•	+	+	+	•	+	+	+	+	+	•	•	+	•

Saxifraga tricuspidata	•	•	+	+	+	•	•	+	•	•	+	+	+L	+	•	+	+	•
Saxifraga oppositifolia	•	*	+*	+*	+	•	•	+	•	+	+	•	•	+	•	+	+	•
Chamaenerion latifolium	•	•	+	+	+	•	•	•	•	•	•	+	•	•	•	+	•	•
Epilobium anagallidifolium	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Epilobium lactiflorum	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Epilobium palustre	•	•	•	•	•	•	•	•	•	•	•	•	*L	•	+C	•	•	+C
Hippuris vulgaris	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Papaver radicatum	+	+	+	+	+	•	•	+	•	•	•	+	•	+	•	•	•	•
Draba nivalis	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Draba arctica	•	*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Draba norvegica	•	•	•	•	•	•	•	•	•	•	•	+L	•	•	•	•	•	•
Draba glabella	•	•	•	•	•	•	•	•	•	•	•	+L	•	+	•	•	•	•
Draba alpina	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Draba sp.	•	+	*	•	•	•	•	•	•	•	+	•	•	•	•	+	•	•
Cochlearia groenlandica	+L	+	+	•	+	•	•	+	+	+	•	•	•	•	•	•	•	•
Subularia aquatica	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C	•	•	•
Cardamine pratensis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C	•	•	+C
Arabis alpina	•	•	+	•	•	•	•	•	•	•	•	+	*	+	•	•	•	•
Salix herbacea	•	•	*	+	•	•	•	•	•	•	+	+	+	+	+	•	+	+
Salix arctica	+	*	+*	+*	+	+	•	+	•	+	+	+	+	+	•	+	+	•
Salix glauca	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Betula nana	•	•	•	•	•	•	•	•	•	+	•	+	*	+	•	•	+	•
Oxyria digyna	+	+*	•	+	+	+	•	+	•	•	•	+	+	+	•	+	+	+
Polygonum viviparum	+L	*	+	+*	+	+	•	+	•	+	+	+	+*	+	+	•	+	+C
Cerastium cerastoides	•	*	•	•	•	•	•	•	•	•	•	+	*	•	•	•	•	•
Cerastium arcticum s.l.	+	+*	•	•	•	+	+	•	+	•	+	•	*	+	•	•	•	•
Sagina procumbens	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Sagina saginoides	•	•	•	•	•	•	•	•	•	•	•	•	*L	•	+C	•	•	•
Sagina intermedia	•	•	+*	+	•	•	•	+	•	•	+	•	•	+	•	•	•	•
Stellaria longipes s.l.	+	•	+*	+	•	+	•	+	•	•	•	+	•	•	•	•	•	•
Stellaria humifusa	•	•	•	+	•	•	•	•	+	•	•	•	•	+	•	•	•	•
Arenaria pseudofrigida	•	•	+*	+	•	•	•	+	•	•	•	+	•	•	•	•	•	•
Minuartia rubella	•	•	*	•	•	•	•	•	•	+	•	•	•	+	•	•	•	•

(continued)

Table 1 (cont.).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Minuartia biflora	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	•
Honckenya peploides	•	•	•	•	•	•	•	+	+	•	+	•	•	+	•	•	•	•
Melandrium apetalum	+	*	+*	+	•	+L	•	•	•	•	+	•	•	+	•	•	•	•
Silene acaulis	+	•	+*	+*	+	+	•	+	+	+	+	+	+	+	•	+	+	•
Armeria scabra	•	•	•	•	•	+L	•	•	•	•	•	•	•	•	•	•	•	•
Armeria maritima	•	•	•	•	+CL	•	•	+L	+	•	+C	•	•	+	•	•	+	•
Pyrola grandiflora	•	•	•	+	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Pyrola minor	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Arctostaphylos alpina	•	•	•	+	+	•	•	+	+	•	•	+	+	+	•	+	+	+C
Cassiope tetragona	+	•	*	*	•	+	•	•	•	•	+	+	+	+	•	•	+	+
Harrimanella hypnoides	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	+	+
Phyllodoce coerulea	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Rhododendron lapponicum	•	•	•	•	•	+	•	•	•	•	•	•	•	+	•	•	•	•
Vaccinium uliginosum	*	•	•	+*	+	+	•	•	•	+	+	+	+	+	•	•	+	+C
Empetrum hermaphroditum	•	•	+	•	•	•	•	•	•	+	+	+	+	+	+	•	•	+C
Diapensia lapponica	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Gentiana nivalis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Limosella aquatica	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Veronica alpina	•	•	+	•	•	•	•	•	•	•	+	•	*	•	•	•	•	+CL
Pedicularis hirsuta	+	•	•	+	•	+	•	•	•	•	•	+	•	•	•	•	+	•
Pedicularis flammea	•	+	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Euphrasia frigida	•	•	•	•	•	•	•	•	•	•	•	•	*	•	+	•	•	+CL
Pinguicula vulgaris	•	•	•	•	•	•	•	•	•	•	•	•	*	•	+	•	•	+
Campanula gieseckiana	•	•	*	•	+	•	•	•	•	•	+	•	*	+	•	+	•	+C
Campanula uniflora	•	•	+	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•
Erigeron compositus	•	•	*C	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Erigeron humilis	•	•	•	+	•	+L	•	+	•	•	+	•	+	+	•	•	•	•

Arnica alpina	•	•	•	•	•	+	•	•	•	•	+	•	•	•	•	•	•	•
Hieracium alpinum	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•	•	•	+C
Taraxacum arcticum	+L	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Taraxacum croceum	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Taraxacum brachyceras	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•
Taraxacum sp.	•	•	*	*	•	•	•	•	•	•	+	+	+*	•	•	•	•	•
Tofieldia pusilla	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Platanthera hyperborea	•	•	•	•	•	•	•	•	•	•	•	•	*C	•	•	•	•	+C
Juncus castaneus	•	•	•	•	•	+L	•	•	•	•	•	•	•	•	•	•	•	•
Juncus ranarius	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Luzula spicata	•	•	•	•	•	+L	•	•	•	•	+	•	•	•	•	•	•	•
Luzula confusa	•	+	*	+	•	•	•	•	•	•	•	+	•	+	•	•	•	•
Eriophorum scheuchzeri	•	•	*	•	•	•	•	•	•	•	•	+	*	+	•	•	•	+C
Scirpus quinqueflorus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+CL
Carex maritima	•	•	*L	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Carex bigelowii	•	•	•	•	•	+	•	•	•	•	•	•	•	+	•	•	•	+C
Carex capillaris	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Carex saxatilis	•	•	•	•	•	•	•	•	•	•	•	•	•	+	•	•	•	•
Poa glauca	•	•	•	•	•	+	•	•	•	•	•	•	•	•	•	•	•	•
Poa arctica	+L	•	•	•	•	+	•	•	•	•	•	•	•	+	•	•	•	•
Poa pratensis	+L	+*L	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Poa alpina var. *vivipara*	+	•	+	+	•	•	•	•	•	•	+	•	•	•	•	•	•	•
Trisetum spicatum	+	*	•	+	•	+	•	•	•	•	•	•	•	+	•	•	•	•
Agrostis borealis	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Alopecurus alpinus	+L	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Triglochin palustre	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Festuca brachyphylla	+	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Festuca rubra	+L	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Festuca vivipara ssp. *hirsuta*	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C
Triglochin palustre	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	+C

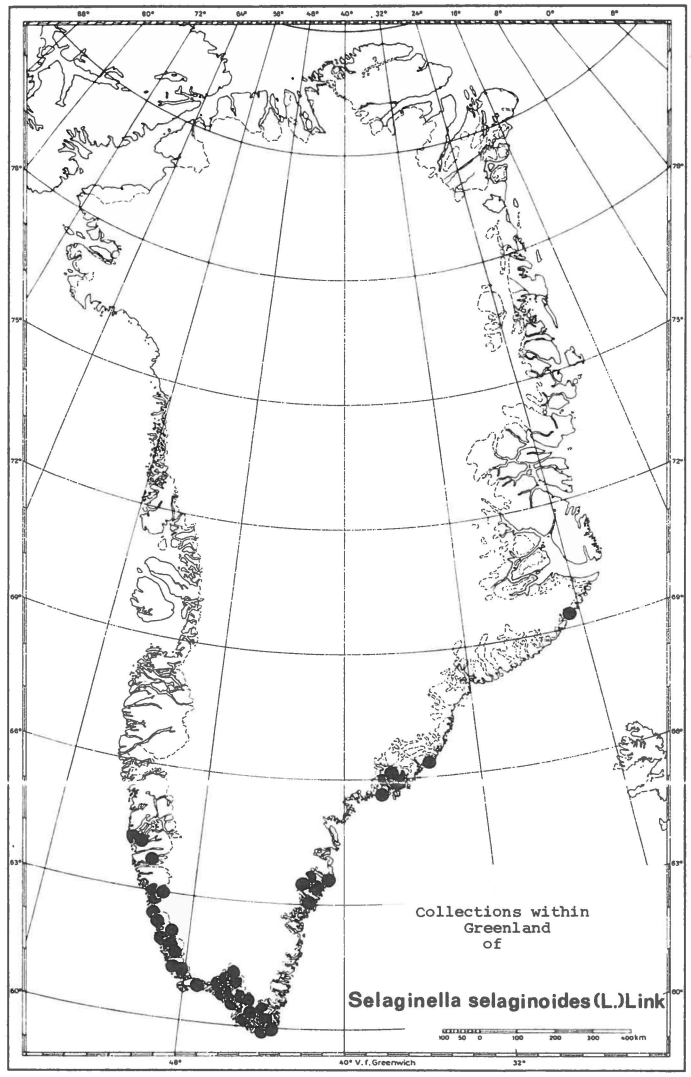

Fig. 2. Collections within Greenland of *Selaginella selaginoides* (L.) LINK
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localities from the Azores to Iceland (ROTHMALER, 1964). In Iceland it is rare and apparently restricted to the vicinity of hot springs (OSTENFELD, 1899: 243; GRÖNTVED, 1942: 102). A drawing of a herbarium specimen is shown in Fig. 4.

Ophioglossum azoricum occurred sporadically in two habitats near the outlets of the hot springs. The principal one was on warm, desiccated and almost bare areas of clay. Here *Ophioglossum* grew together with *Sagina procumbens*, *Limosella aquatica*, *Euphrasia frigida*, *Juncus*

Fig. 3. *Ophioglossum azoricum* growing in a tuft of *Festuca vivipara* from the habitat described below. A few leaves of *Polygonum viviparum* are visible. (Photographed in Copenhagen).

ranarius and **Fossombronia wondraczekii.* The second habitat was a warm, thick moss carpet, with much vegetative *Festuca vivipara*, by the stream close to the outlets (Fig. 3). In one place about 20 vigorous plants were counted. Both habitats, including the species mentioned, are in striking agreement with the habitats of *Ophioglossum* described from Iceland (OSTENFELD, 1899: 239–240).

Botrychium lunaria (L.) Sw.

In his distribution map, BÖCHER (1938: 47) shows only a few very isolated localities for this species between Southeast Greenland and its northern limit on Traill Ø (72°32′ N.lat.). It is now known from several localities in Scoresby Land and the interior of Scoresby Sund, while the gap between the Angmagssalik area and Kruuse Fjord is bridged by

*) OSTENFELD (1899) lists *Fossombronia dumortieri* (HUB. & GENTH.) LINDB. but his material has been redetermined by K. DAMSHOLT as *F. wondraczekii* (CORDA) DUM.

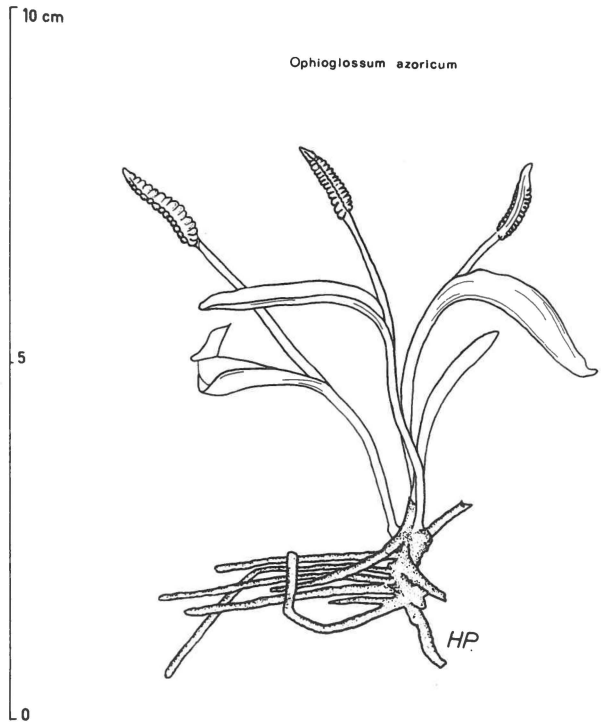

Fig. 4. *Ophioglossum azoricum* C. PRESL. Drawn from one of the herbarium specimens (**C**). The spores are tuberculate and c. 150 μ in diameter. (H. PEDERSEN).

the Nigertuluk—Tugtilik finds reported by ELSLEY & HALLIDAY (1971). The latest finds, from the Knighton Fjord and Rømer Fjord springs, lie between BÖCHER's Kap Ravn (68°27′ N.lat.) locality and those in Scoresby Sund.

Ranunculus confervoides (FR.) ASCH. & GRAEBN.

This species was collected in a small tarn at the head of Rømer Fjord. It is the only record between Scoresby Sund and Angmagssalik.

Thalictrum alpinum L.

This species was found in several places along Turner Sund and in Rømer Fjord; it was previously unrecorded between Kap Dalton and Scoresby Sund.

Potentilla pulchella R. BR.

KRUUSE (1905: 149) noted this species at Turner Sund. This is still its southern limit in East Greenland but the new finds from Steward Ø

and the island off Manby Halvø are the only ones between Turner Sund and Kap Stewart, on the north side of Scoresby Sund (70°26′ N.lat.).

Geum rivale L.

Locality: Knighton Fjord, 69°22′ N.lat., 24°43′ W.long., alt. 150 m, leg. T. I. HAUGE ANDERSSON, 23.8.1967 (Plate 1, locality R; Fig. 10).

This species, which is new to the Greenland flora, was found at the Knighton Fjord hot springs where it was scattered over the whole of the drier herb-mat of *Festuca vivipara* and *Alchemilla glomerulans* (Table 4). The specimens were about 15–25 cm high, flowering profusely. Like *Ophioglossum azoricum* it occurs in Iceland where it is relatively common in the lowlands.

Alchemilla glomerulans BUS.

The new records from Knighton Fjord and Rømer Fjord are the only ones between Kap Ravn and its northern limit in the interior of Scoresby Sund.

Saxifraga cernua L.

This species was unexpectedly rare along parts of the coast. Although common at Kap Brewster it was not found at Manby Halvø and Turner Ø while at Kap Dundee and Trolddal it was infrequent, stunted and usually non-flowering. However, in inner Rømer Fjord it was found growing vigorously and flowering profusely, especially in sites above about 100 m.

Saxifraga tricuspidata ROTTB.

This western saxifrage is without doubt the speciality of the coast from Kap Brewster southwards, at least as far as d'Aunay Bugt (69°07′ N.lat.), where it was discovered by T. I. HAUGE ANDERSSON in 1967. Although there are two old records on the north side of Scoresby Sund neither has subsequently been confirmed. It was found by the 1969 expedition flowering profusely at nearly all the localities visited from Kap Russel southwards. KRUUSE (1905) describes the Turner Sund and Kap Dalton plants as "about 10 cm high, strong and with a few flowers". This contrasts with BÖCHER's (1938: 121) comments that the plant has "a wretched existence (in most places it was vegetative and quite small)".

Epilobium palustre L.

This species is largely restricted in Greenland to the south and south-west. Apart from a single record in Lindenows Fjord (60°33′ N.lat.), in the extreme south, the only previous record on the east coast is that

cited by BÖCHER (1933b: 5) from Knighton Fjord. The two new finds are from the hot springs on both the northern and southern sides of Rømer Fjord. In the latter locality it was growing in a mat of the moss *Philonotis fontana.*

Hippuris vulgaris L.

The discovery of this species in a tarn at an altitude of 100 m at the head of Rømer Fjord is the only record between Scoresby Sund and the Angmagssalik area.

Papaver radicatum ROTTB.

Although not previously recorded between Turner Sund and Scoresby Sund, it was found at all the sea-level localities as far south as Steward Ø. South of this it was noted growing sparingly in inner Rømer Fjord (above 80 m) and in upper Trolddal (above 150 m). In the Turner Sund area, HARTZ & KRUUSE (1911) record it onlyfrom nearly 1000 m in Henry Land.

Subularia aquatica L. (Fig. 5)

A few small pieces of this species were found in moss (*Anisothecium* sp.) collected from one of the hot springs on the south side of Rømer Fjord. This is a most remarkable find as the species is otherwise known in Greenland only from the Angmagssalik area, South Greenland and a few localities in West Greenland.

Cardamine pratensis L.

The new records from Knighton Fjord and Rømer Fjord are the only ones between Kap Daussy (68°42′ N. lat.) and Scoresby Sund.

Sagina procumbens L.

This is a surprising find from Knighton Fjord as this species was previously thought to be restricted in Greenland to the extreme south and was not previously known in East Greenland north of Danells Fjord (Ivingmiut 60°50′ N. lat.).

Sagina saginoides (L.) H. KARST.

The new finds for this species by the hot springs on both sides of Rømer Fjord represent an appreciable extension of its known northern limit on the east coast from Johan Petersen Bugt (68°48′ N.lat.), where it was found by H. WAGER in 1932 also by a warm spring, the temperature being 38°C (BÖCHER, 1933b: 7 as Kap Beaupré, but see the present paper Fig. 8, no. 10 and Table 2).

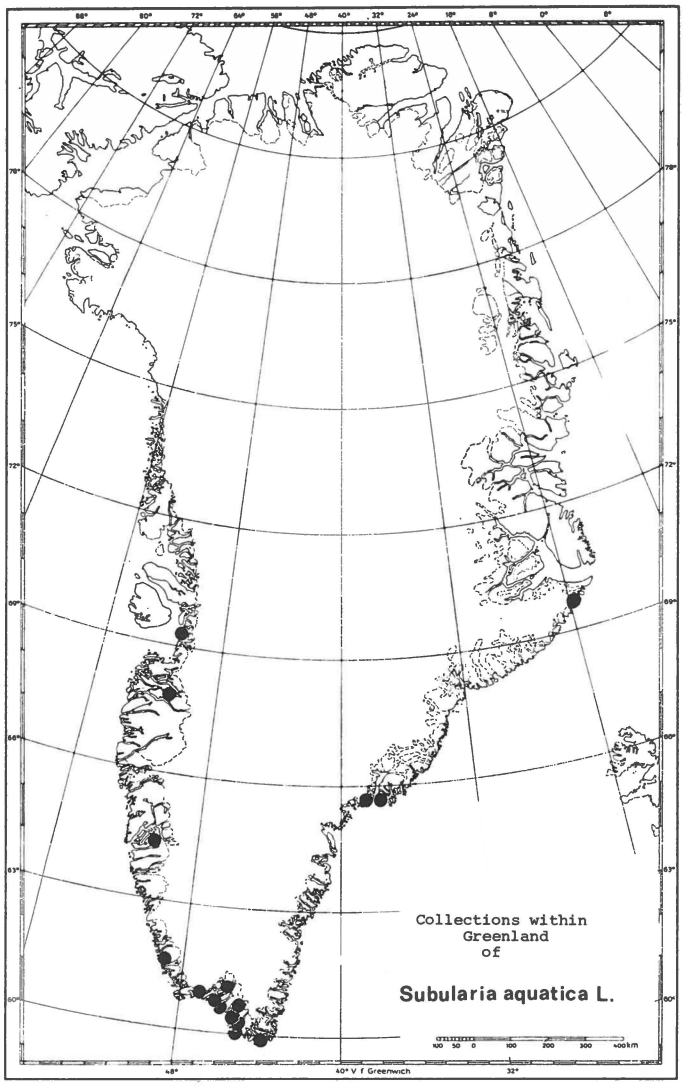

Fig. 5. Collections within Greenland of *Subularia aquatica* L.
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Stellaria longipes GOLDIE coll.

BÖCHER (1951) records two members of this complex from the Blosseville Kyst: *Stellaria edwardsii* R. BR. (syn: *S. ciliatosepala* TRAUTV.), collected by KRUUSE from Turner Sund, and *Stellaria crassipes* HULT. found by himself at Kap Dalton. Both finds were said to represent the southern limits for these taxa on the east coast. Of our material, only that from Turner Sund and Kap Russel was flowering and both collections clearly belong to *S. edwardsii*. However, this taxon is now known from

Table 2. *Table showing the distribution of hot springs in Greenland and of their recorded temperatures. Most of the localities have several springs.*

No. in Fig. 8	Locality	*	Co-ordinates N.lat., W.long.	Temperature (°C)	Reference (including author's name for locality where different)
1.	Vaigat				
	Ûnartoq		69°54′, 52°37′	6	Steenstrup, 1900:265
				1.2	M. P. Porsild, 1902:117
	Ûnartuarssuk		69°58′, 52°50′	2	M. P. Porsild, 1902:117
2.	Mellemfjord				
	Ûnartukavsak	*	69°46′, 54°37′		
	Puilassoq	*	69°40′, 54°25′	18.8	Steenstrup, 1900:287
3.	Kuánerssuit suvdluat				
	Angujârtutit	*	69°34′, 53°28′	4	M. P. Porsild, 1902:191; 1920:113
	opposite Qârusuit		69°33′, 53°37′		Steenstrup, 1900:294, Tarajungitsok
				12	M. P. Porsild, 1902:188, Tarajungitsok; 1920:138
4.	Disko Fjord				
	Ûnartoq		69°26′, 53°52′	7–12.5	Steenstrup, 1900:299
5.	Godhavn				
	Engelskmandens Havn		69°16′, 53°35′	2°R = 2.5°C	Rink, 1852:78
				17	M. P. Porsild, 1902:181; 1915:254, Ûnartorssuaq
				15–17	Reisinger & Steinböck, 1927:41
					Lettevall, 1962:5(+ map)
	Lyngmarken		69°16′, 53°32′	2°R = 2.5°C	Rink, 1852:78
					M. P. Porsild, 1915:253, Ûnartuarssuk

				4–5	A. E. Porsild, 1925:4, Vandelven
				1–7.8	Lettevall, 1962:18(+ map), Vandelven, Østerdalen
				6–8	Lægaard, 1971:352
6.	Disko Bugt		69°00′, 51°07′	1.5°R = 1.9°C	Rink, 1852:77, Lerbugten
7.	Sarqardlîp nunâ		68°41′, 52°46′	4.5°R = 5.6°C	Rink, 1852:77, Tessiursak-Bugten
8.	Ûnartoq		60°31′, 45°20′	40	Hartz, 1894:19
				35–41.9	Persoz *et al.*, 1972:7 (with full bibliography)
					The present paper
9.	Ikâsartivaq		65°50′, 37°28′		Kruuse, 1912:98(+ map)
	Ûnarteq			25	Holm & Petersen, 1921:565
10.	Johan Petersen Bugt		68°48′, 26°15′	101°F = 38°C	Wager, 1934:32(+ map), ". . . and the one in the bay to the N of Kap Tupinier . . ."
					Böcher, 1933b:7 (as Kap Beaupré)
11.	Kap Coster		68°59′, 25°30′	105°F = 40.5°C	Wager, 1934:32(+ map)
12.	Knighton Fjord		69°22′, 24°43′		Böcher, 1933b:5, Knighton Bay
					Mikkelsen, 1933:18, Knighton Bay
				50	Spender, 1933:10, Knighton Bay
					Wager, 1934:32(+ map), "The hot springs in the fiord between Kap Ewart and Kap Barclay . . ."
				52–54	The present paper
13.	Henry Land		69°33′, 23°41′	38	Hartz, 1902:159(+ map)
					Nordenskjöld, 1907:221

(continued)

Table 2 (cont.).

No. in Fig. 8	Locality	*	Co-ordinates N. lat., W. long.	Temperature (°C)	Reference (including author's name for locality where different)
14.	Rømer Fjord				
	north side		69°44′, 23°38′	21–30	SMART, 1971:28(+ map)
					The present paper
	south side		69°43′, 23°42′	48–58	SMART, 1971:29(+ map)
				40–57	W. S. WATT, 1973 pers. comm.
					The present paper
15.	Kap Hope		70°28′, 22°22′	6	A. PEDERSEN, 1926:254
				2	T. B. PEDERSEN, 1929:294(+ map)
				15	ROSENKRANTZ, 1933 "moskilden"
					(W. S. WATT, 1973 pers. comm.)
16.	Kap Tobin				
	Ûnarteq	*	70°24′, 21°57′	45.5–62.0	A. PEDERSEN, 1926:253
				61.8	T. B. PEDERSEN, 1929:296(+ map)
				61.5	W. S. WATT, 1973 pers. comm.
	Ûnarterajik	*	70°25′, 21°53′	34.7–41.8	A. PEDERSEN, 1926:254
				30–33	W. S. WATT, 1973 pers. comm.
17.	Emmanuel Gletscher	*	70°51′, 21°44′		
18.	Janus Ø				
	north	*	70°52′, 21°41′		
	south	*	70°51′, 21°40′		
19.	Randers Fjord	*	70°58′, 21°42′		
20.	Storefjord				
	south side		71°04′, 21°54′	60	BACKLUND, 1955:331
				60.2	A. NOE-NYGAARD, 1973 pers. comm.
				54.2	I. D. FREDERICHSEN, 1971 (W. S. WATT,

	Kildedal	*	75°15′, 20°55′	1,5	T. JOHANSEN, 1933 (unpublished notes in archives of the Geodetic Institute, Copenhagen)
A.	Marrait Kangigdlît just east of "Geologhus"		70°31′, 54°10′		K. JAKOBSEN, 1973 pers. comm.
B.	Iterdlâ between Angnertuneq and Saviarqat, Nûgssuaq		70°45′, 53°23′		K. JAKOBSEN, 1973 pers. comm.
C.	Suvdlua Iviangernat		72°03′, 54°40′		K. HOLMEN, 1973 pers. comm.
D.	". . . the interior of Granville Bay . . ."		c. 77°01′, 69°30′		KOCH, 1929:200
E.	". . . the northern portion of Hold-with-Hope, especially west of Cape James . . ."		c. 73°52′, 20°25′		KOCH, 1929:200–201. According to prof. A. NOE-NYGAARD (W. S. WATT, 1973 pers. comm.) these are not hot springs.

The co-ordinates for localities 10–14 are taken from the U.S. Army Topographic Command maps AMS, NR 25, 26–12 and 27, 28–7, series C 501, scale 1:250,000. The rest are from the 1:250,000 maps of Greenland published by the Geodetic Institute, Copenhagen. Springs marked as such on the latter maps are asterisked (*).

Comments on springs A–E:

Springs with a winter temperature of just above zero are often incapable of maintaining an area free of ice and snow with the result that a conspicuous cone of ice builds up over the outlet (A. E. PORSILD, 1925). Depending on latitude and local topography, this may be slow to melt in the summer, the ground below therefore supporting a late snow-patch flora. It is possible that the springs referred to by PORSILD (1925) on Nûgssuaq and Svartenhuk Halvø are of this type. Three such springs on these peninsulas (A–C) have been localized by K. HOLMEN and K. JAKOBSEN (1973 pers. comm.). It may be that the springs referred to by KOCH (1929:200–201) (D & E) also belong to this category.

considerably further south having been found by R. G. SWAINSON in 1967 from the north side of the Glacier de France above the head of the fiord Kangertitivatsiaq (Kangerdlugssuatsiaq, 66°31′ N.lat.).

Arenaria pseudofrigida OSTF. & DAHL

The new records from Steward Ø and the fiord below Sfinxgletscher help to fill the gap between Scoresby Sund and Turner Sund; its southern limit is Kap Dalton.

Honckenya peploides (L.) EHRH.

Previous to the four new localities, this species was known between Scoresby Sund and Angmagssalik only from Kap Dalton.

Melandrium apetalum (L.) FENZL ssp. *arcticum* (FR.) HULT.

This species had previously been recorded south of Scoresby Sund only from Turner Sund and Kap Dalton.

Armeria scabra PALL. ssp. *sibirica* (TURCZ.) HYL.

The Pindsvinet nunatak locality is the only one between Scoresby Sund and the isolated occurrence at Angmagssalik.

Armeria maritima (MILL.) WILLD.

The only previous record of this species from the east coast is that of HAGERUP's from Dunholm. It was cited by BÖCHER (1938: 165) under *Armeria scabra* but subsequently it was transferred to *A. maritima* (BÖCHER, HOLMEN & JAKOBSEN, 1968). It was found on the 1969 expedition to be not uncommon locally between Dunholm and inner Rømer Fjord. BÖCHER *et al.* (1968) state that the Dunholm material has very hairy scapes only 1 to 2 cm high. Our collections are similar, the capitula being scarcely exserted above the leaves. The scapes are hairy above, rather more so than in material from southern Greenland. *A. scabra* has scapes which are glabrescent to moderately hairy, at least above. There are two good characters by which at least the Greenland material may be separated from *A. maritima*. *A. scabra* has leaves which are quite glabrous and the calyx is pubescent, not only on the veins but also between them.

Diapensia lapponica L.

The discovery of this species in inner Rømer Fjord helps to fill a major gap in its east coast range between Kangerdlugssuaq (68°15′ N.lat.) and Scoresby Sund.

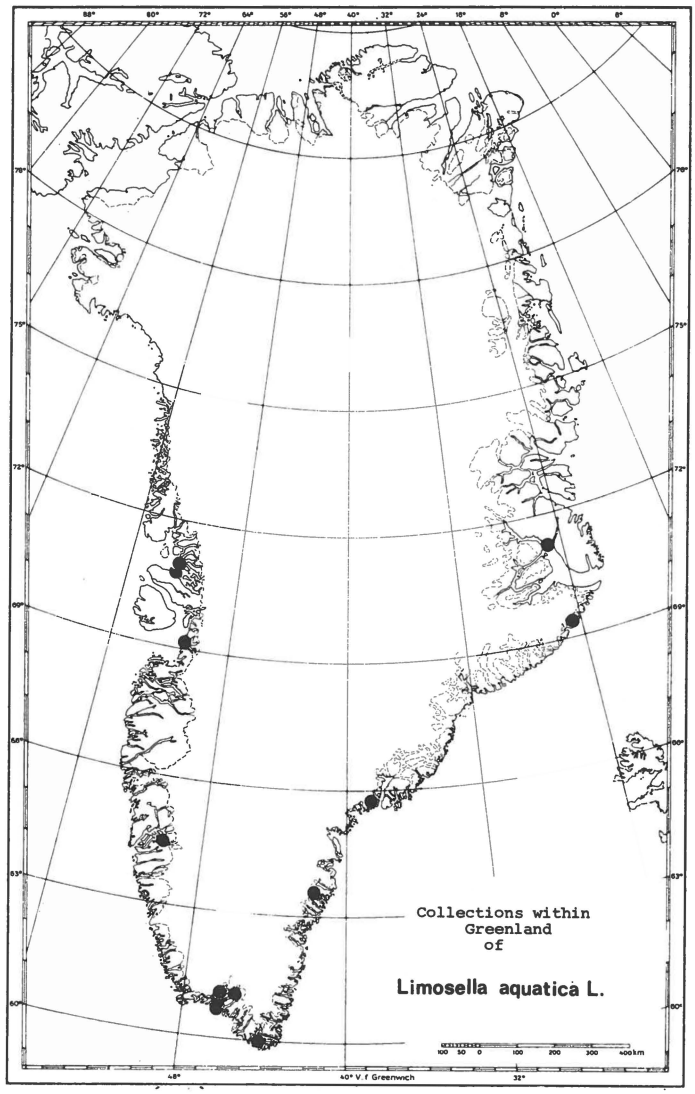

Fig. 6. Collections within Greenland of *Limosella aquatica* L.
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Limosella aquatica L. (Fig. 6)

Until recently this species was known in Greenland only from the extreme south, and two isolated localities in West Greenland, its northern limit on the east coast being in the Skjoldungen area (63°35′ N.lat.). In 1969 it was found at Tâsílálik (65°39′ N.lat.) by L. KLIIM-NIELSEN and O. HAMANN, members of the Greenland Botanical Survey Expedition to the Angmagssalik area. Its known range was further extended by its

discovery in 1967 at Knighton Fjord, while in 1970 it was found by one of us (I.H.M.S.) in rocky pools on a bird-island off Sydkap in Scoresby Sund (71°16′ N.lat.).

Pinguicula vulgaris L.

These new records from the Knighton Fjord and Rømer Fjord hot springs are the only ones between Scoresby Sund and just north of Kap Ravn.

Erigeron compositus PURSH

Only a few non-flowering pieces of this high-arctic species were brought back from the fiord below Sfinxgletscher. Although BÖCHER (1938: 190) shows a gap in its east coast distribution between Scoresby Sund and Skjoldungen, it is now known from the west side of Kangerdlugssuaq, where it was found by Mrs. L. R. WAGER in 1936, from Tugtilik (ELSLEY & HALLIDAY, 1971), and from several localities in the mountains behind Angmagssalik (HALLIDAY, 1967; GRIBBON, 1968).

Taraxacum arcticum (TRAUTV.) DAHLST.

The locality near Kap Brewster is the first record from the south side of Scoresby Sund and is a new southern limit.

Platanthera hyperborea (L.) LIND. (Fig. 7)

BÖCHER, HOLMEN & JAKOBSEN (1968) give the northern limit of this species on the east coast as Angmagssalik. However, it was discovered in 1967 by R. G. SWAINSON at the head of Kangertítivatsiaq (ELSLEY & HALLIDAY, 1971) and in an Addendum to their paper the later find by the hot springs on the north side of Rømer Fjord was reported. The authors were unaware at that time of its discovery in 1967 by T. I. HAUGE ANDERSSON at Knighton Fjord. Finally, in 1971 one of us (KLIIM-NIELSEN, 1971) found it at Mikis Fjord (68°10′ N.lat.).

Juncus castaneus SM.

The surprising discovery of this plant on the Pindsvinet nunatak is the first record on the south side of Scoresby Sund and a marginal extension southwards from its localities in inner Scoresby Sund. It does not materially affect the very large discontinuity between the species' northern area in East Greenland and the very isolated occurrences in the Angmagssalik area.

Juncus ranarius PERR. & SONG.

This species was found by the hot springs in Knighton Fjord growing with *Ophioglossum azoricum*, *Sagina procumbens* and *Limosella aquatica*

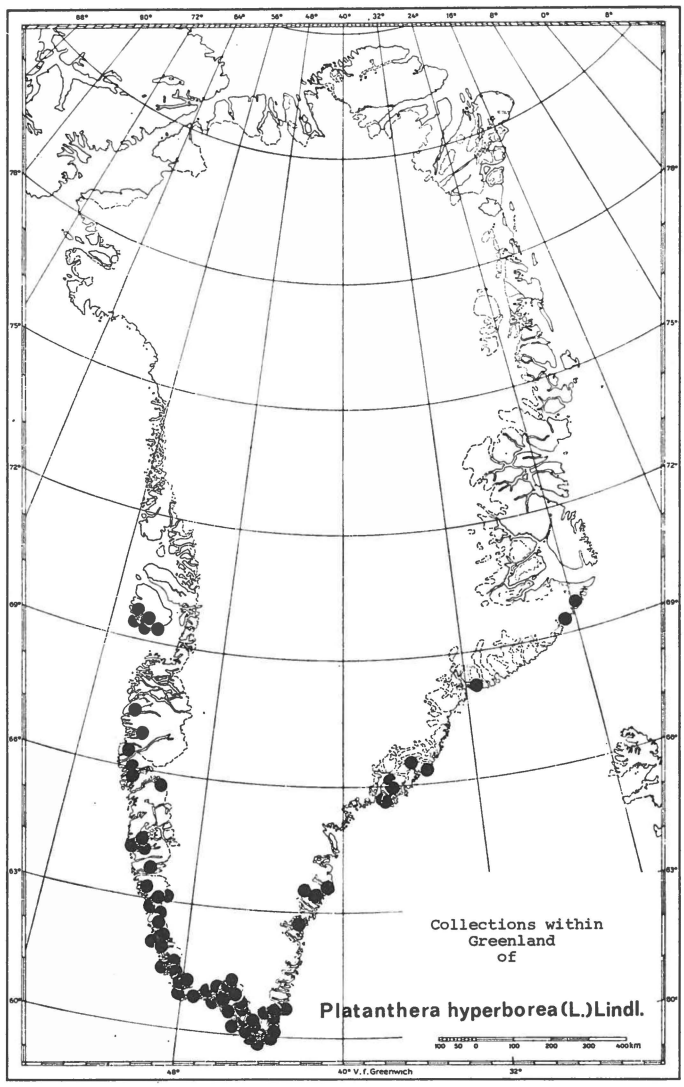

Fig. 7. Collections within Greenland of *Platanthera hyperborea* (L.) LINDL. Reproduced with the permission (A 67/71) of the Geodetic Institute, Copenhagen.

on almost bare areas of clay. Only one specimen was collected; it is about 1 cm high and has a single capsule with ripe seeds.

Juncus ranarius is very rare in East Greenland having only previously been found at Storefjord in Liverpool Land (71°04′ N.lat.) by A. NOE-NYGAARD in 1933 (SEIDENFADEN & SØRENSEN, 1937: 165), who (1973 pers. comm.) considers it likely that his specimen was collected from the vicinity of the hot springs on the south side of the fiord (Fig. 8, no. 20).

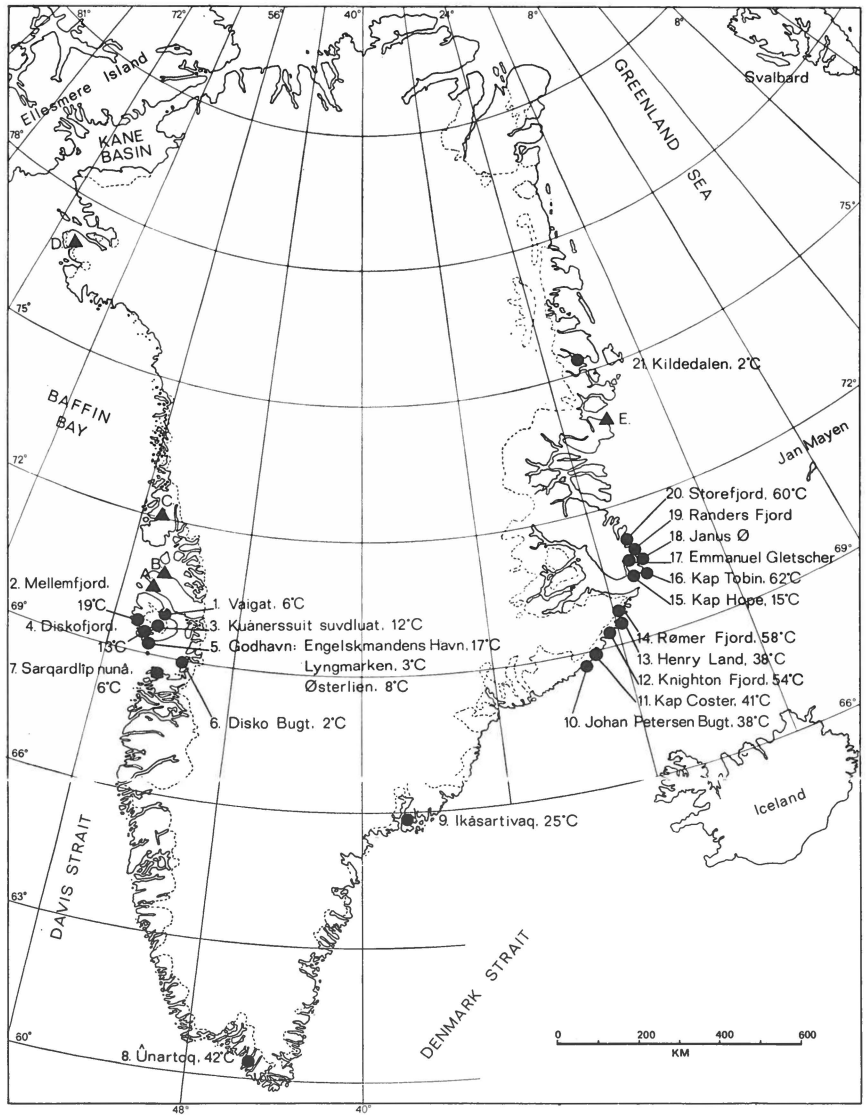

Fig. 8. The distribution of hot springs in Greenland. See also Table 2. Reproduced with the permission (A 511/72) of the Geodetic Institute, Copenhagen.

Scirpus quinqueflorus F. X. HARTM.

This is a surprising find from the hot springs at Knighton Fjord as this species was previously thought to be restricted to South Greenland (chiefly in the interior) and to the head of Søndre Strømfjord (map in BÖCHER, 1950: 33). It is worth mentioning that the southernmost record in Greenland is from the hot springs on Ûnartoq island (HARTZ, 1894: 20).

Carex maritima GUNN.

The new locality for this species by the fiord below Sfinxgletscher appears to be the only one between Scoresby Sund and just north of Kangerdlugssuaq.

Agrostis borealis HARTM.

The record from Knighton Fjord is the only one between Kap Ravn and Scoresby Sund.

Triglochin palustre L.

The discovery of this species at Knighton Fjord helps to bridge the major disjunction of its east coast range between Scoresby Sund and Angmagssalik.

Concluding remarks

Most of the above records fall into one of three categories:

(1.) Species new to the flora of Greenland: *Ophioglossum azoricum* and *Geum rivale.*

(2.) Southward extensions of range, or additional localities towards their southern limits, of continental and northern species such as *Potentilla pulchella*, *Stellaria edwardsii*, *Taraxacum arcticum* and *Juncus castaneus.*

(3.) Northward extensions of range, or additional localities towards their northern limits, of low-arctic, southern species, for example *Epilobium palustre*, *Subularia aquatica*, *Sagina procumbens*, *S. saginoides*, *Limosella aquatica*, *Platanthera hyperborea* and *Scirpus quinqueflorus.*

The predominance of the last category and the existence of the first is due almost entirely to the presence within the area of hot springs.

Hot springs in Greenland

Hot springs may be defined in a number of ways. For our purpose we shall use the term in a rather wider sense than is usual and include all springs with a water temperature always in excess of the mean annual air temperature. Such a definition includes certain springs in West and Northeast Greenland which are usually considered warm rather than hot with temperatures of only 0°–2°C.

The published data on the hot springs of Greenland are scattered and fragmentary. The only publication of which we are aware that purports to cover all the hot-spring areas in Greenland is that of WARING (1965). We have therefore mapped and given references for all the known hot springs (Table 2 and Fig. 8); this map is based on verbal information and what little has been published.

East Greenland

The following accounts of the three groups of hot springs are based on visits by T. I. HAUGE ANDERSSON (Knighton Fjord), W. S. WATT (1971, Rømer Fjord, southern springs) and one of us (I.H.M.S., Rømer Fjord). Gas and water analyses were carried out by the Geological Survey of Greenland (G.G.U.) and have been made available to us by W. S. WATT. The chemical analysis of a metallic deposit from the Rømer Fjord southern springs was made by G. JORDET of Strathclyde University, Glasgow.

Rømer Fjord, northern springs

Two groups of hot springs lie almost opposite each other on the north and south sides of the entrance to Rømer Fjord.

The northern springs (Plate 1, locality M) are situated about 500 m west of Strathclyde Pynt about 60 m above and 200 m from the shore. Two springs emerge from the floor of a gully just below the point where the water course broadens out to form an outwash fan. The water temperature of the westerly spring was 30°C and of the easterly 21°C.

Fig. 9. One of the hot springs on the south side of Rømer Fjord (Plate 1, locality O) with a well-developed crater which is about 25 cm high and 80 cm across. The temperature at the bottom of the crater was 58° C. (Reproduced with the permission of the Geological Survey of Greenland).

The stony floor of the gully was poorly covered in vegetation as it is swept by run-off water each spring. The most interesting spring emerged from the mountain side about 10 m west of the bank of the gully. It was surrounded by luxuriant vegetation noticeable from the fiord as a bright green patch on the hillside. The temperature of the water as it emerged was 25°C and the rate of flow was of the order of 5 litres/minute. The banks of this small stream were covered in thick moss. Growing in the warm moss were *Botrychium lunaria*, *Thalictrum alpinum*, *Veronica alpina*, *Euphrasia frigida*, *Pinguicula vulgaris* and about a dozen specimens of *Platanthera hyperborea*. Further away there were lush growths of *Alchemilla glomerulans*, *Betula nana* and *Campanula gieseckiana*.

Rømer Fjord, southern springs

The springs on the south side of Rømer Fjord (Plate 1, locality O) lie close to the shore, some of them discharging below high-tide level. Discharge points occur along 100 m of shoreline. Towards the western end of the outlet area at high-tide level, one spring has built up a mound of shingle pebbles cemented together with salts. It resembled a pepper pot in form being about 1 m high with several openings at the top from

which gas and water emerged. The lip of one of these openings was covered by a shining metallic deposit. This was chipped off and on subsequent examination by electron-probe microanalysis was found to consist of a silica–and aluminium complex with a high iron and titanium content and spinels (octahedral crystals) containing magnesium, manganese and fluorine.

Lush vegetation surrounds the western outlets which are all near the sea. *Sedum rosea* was particularly profuse and covered the bank above the stream, specimens reaching a height of 25 cm. It was here that the specimens of *Subularia aquatica* were found. The temperature of the water as it emerged was 48°C and the flow-rate of each outlet was small, of the same order as the hot springs on the opposite side of the fiord.

In the eastern part of the spring area the outlets extend inland for 50 m or so and the ground was impregnated by salts and bare of plants. Towards the north-east extremity of this area there was a small crater about 25 cm in depth and 80 cm in diameter, and raised about 25 cm above the summit of a low mound (Fig. 9). Gas and clear water bubbled through a floor of pebbles. The water temperature was 58°C. Gas samples collected from this source were analysed by the Geological Survey of Greenland and found to contain 18 % methane (CH_4).

Further gas samples collected in 1971 similarly showed a high methane content (CH_4 = 30 %) but no traces of the typical volcanic gases CO_2, H_2S and H_2. The water of the Rømer Fjord springs is very pure and slightly alkaline (pH = 9.3).

Blue-green algae grew in all the hot springs.

Knighton Fjord

The hot springs are situated on the west side of the bay just north of a small river (Plate 1, locality R; Fig. 10) and can be seen from a considerable distance out in the bay because of the slender columns of steam. They are found about 500 m inland at the foot of a 150 m high basalt hill which rises abruptly from the flat moraine. The springs emerge from the hillside in about 20 places over a distance of about 250 m and run about 30 m down to the river, their courses being marked by luxuriant tongues of vegetation (Fig. 11). The water usually bubbles gently out of the ground but one spring was seen emerging under pressure out of a hole in the rock.

It was not possible to find the hot springs on the north side of the basalt hill referred to by MIKKELSEN (1933) and mapped by WAGER (1934).

Water temperatures in the hot springs varied from 52° to 54°C. It is worth noting that air temperatures of 8° and 10°C were measured only

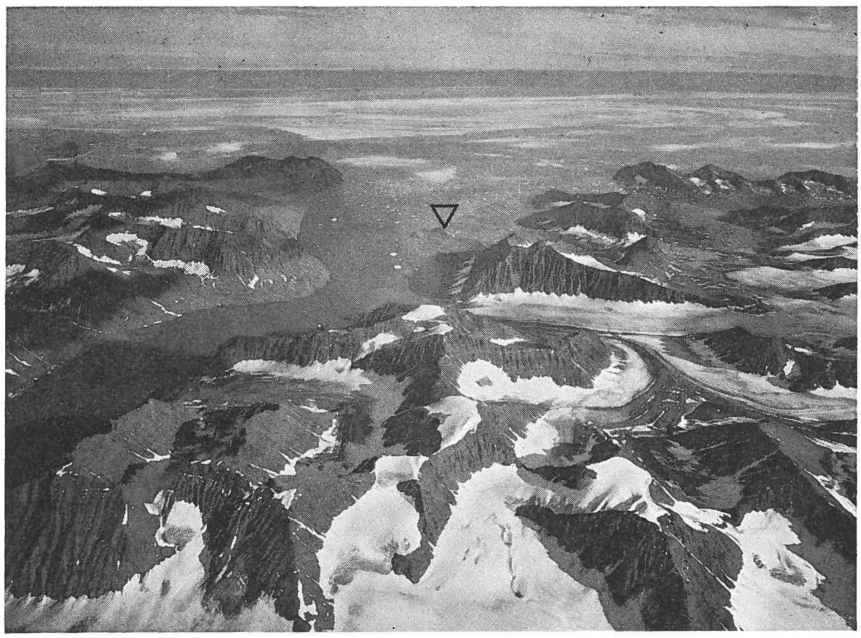

Fig. 10. Aerial photograph of Knighton Fjord. The arrow shows the position of the hot springs (Plate 1, locality R). Reproduced with the permission (A 515/72) of the Geodetic Institute, Copenhagen.

Fig. 11. The hot springs at Knighton Fjord (Plate 1, locality R; Fig. 10). (T. I. Hauge Andersson, 22.8.1972).

Table 3. *Some temperature observations at the Knighton Fjord hot springs (Fig. 8, no. 12). (Data made available by* T. I. HAUGE ANDERSSON).

Water temperature	
at the outlet:	52° C
in the lowest pool close to the river:	42° C
Soil temperature (measured *c.* 5 cm below the moss carpet and along a line at right-angles to the stream from a point 1 m below the outlet)	
10 cm from the edge of the stream:	32° C
50 cm from the edge of the stream:	24° C
100 cm from the edge of the stream:	17° C
200 cm from the edge of the stream:	16° C
Air temperature (measured from a point 1 m below the outlet)	
30 cm above the edge of the stream:	10° C
200 cm above the edge of the stream:	8° C

2 m and 0.3 m respectively above one of the springs. Additional temperature measurements are given in Table 3.

The methane content of the gas samples (CH_4 = 0.4 %) was considerably lower than that of the Rømer Fjord springs; again there were no traces of volcanic gases. Like that of the Rømer Fjord springs, the water is very pure and slightly alkaline (pH = 9.9).

The vegetation around the springs and outlets was luxuriant and deminated by *Alchemilla glomerulans*, *Geum rivale*, *Sedum rosea*, *Epilobium palustre*, *Salix glauca*, *Euphrasia frigida* and *Festuca vivipara* (Table 4), in striking contrast to the surrounding fell-field. The habitats of *Ophioglossum azoricum* have been described above (p. 14–15). The warmest zone, close to the outlets, was dominated by mosses and liverworts (Table 5). These included *Archidium alternifolium* (HEDW.) MITT. and *Fossombronia wondraczekii* (CORDA) DUM., both new to the bryophyte-flora of Greenland.

There was a luxuriant growth of blue-green algae in all the hot springs. In places it formed a thick carpet or drooped like curtains from the stones. Samples were brought back but they have not yet been identified.

One very interesting zoological observation was made. The snail, *Lymnaea vahlii* MØLLER, lived in the hot springs, especially around the algae. A zone of mainly empty shells was found near the outlets of the springs where the water was warmest. It is presumed that the snails live close to the outlet during the winter and migrate further away during the summer.

The discovery of this snail in East Greenland is most remarkable as it is otherwise known in Greenland only from a few localities in the

Table 4. *Frequency analysis of species occurring by the hot springs at Knighton Fjord (Fig. 8, no. 12). Presence or absence recorded within 10 circles of 0.1 m²* (RAUNKIÆR, *1909*). *A full species lists is given in Table 5.* (*Material collected by* T. I. HAUGE ANDERSSON, *22.8.1972*).

Species	1	2	3	4	5	6	7	8	9	10	F %
Alchemilla glomerulans	×	×	×	×	×	×	×	–	×	×	90
Festuca vivipara ssp. *hirsuta*	×	×	×	–	–	×	×	×	×	×	80
Euphrasia frigida	×	×	–	–	×	×	–	×	×	×	70
Sedum rosea	×	–	×	×	×	–	–	×	×	–	60
Vaccinium uliginosum	×	–	×	–	×	×	×	–	–	–	50
Epilobium palustre	–	–	–	–	×	×	–	–	×	×	40
Geum rivale	×	×	–	×	–	–	–	–	×	–	40
Salix glauca	–	×	–	–	–	×	×	×	–	–	40
Taraxacum croceum	–	–	–	×	–	–	–	×	–	×	30
Veronica alpina	–	×	–	–	–	×	×	–	–	–	30
Carex sp.	–	–	×	–	–	–	–	×	–	–	20
Empetrum hermaphroditum	×	–	–	–	–	–	–	×	–	–	20
Equisetum arvense	–	–	–	–	–	–	×	×	–	–	20
Pinguicula vulgaris	–	–	–	–	–	×	×	–	–	–	20
Platanthera hyperborea	–	–	×	–	–	–	–	–	–	×	20
Polygonum viviparum	×	–	–	×	–	–	–	–	–	–	20
Scirpus quinqueflorus	–	–	–	–	–	×	–	–	–	×	20
Sibbaldia procumbens	×	–	–	–	–	–	–	–	–	×	20
Alchemilla filicaulis	–	–	×	–	–	–	–	–	–	–	10
Antennaria canescens	–	–	–	–	–	–	–	×	–	–	10
Carex bigelowii	–	–	–	–	–	–	×	–	–	–	10
Epilobium anagallidifolium	–	–	–	×	–	–	–	–	–	–	10
Potentilla crantzii	–	–	–	×	–	–	–	–	–	–	10
Pyrola minor	×	–	–	–	–	–	–	–	–	–	10
Tofieldia pusilla	–	–	–	–	–	×	–	–	–	–	10
Eriophorum scheuchzeri	–	–	–	–	–	–	×	–	–	–	10
Aulacomnium palustre	–	×	×	×	–	×	×	–	×	×	70
Marchantia alpestris	–	×	–	×	–	×	×	–	×	–	50
Calliergon stramineum	–	–	–	–	×	–	–	–	–	–	10
Mnium medium	–	–	–	–	×	–	–	–	–	–	10

south and south-west (POSSELT, 1898: 257). Its distribution now shows a striking similarity with that of *Epilobium palustre* and *Scirpus quinqueflorus* discussed above (pp. 17–18; p. 28).

Although Table 1 includes all the vascular plants noted at the Rømer Fjord and Knighton Fjord springs, we have listed separately in Table 5 all those recorded to date from the immediate vicinity of the Blosseville Kyst springs, including bryophytes.

Table 5. *List of vascular plants and bryophytes recorded from the immediate vicinity of hot springs on the Blosseville Kyst.*

Vascular plants

Agrostis borealis K
Alchemilla filicaulis K
– *glomerulans* K, R_1, R_2
Antennaria canescens K, R_1, R_2
Arabis alpina R_1
Arctostaphylos alpina K
Betula nana R_1
Botrychium lunaria K, R_2
Campanula gieseckiana K, R_1
Cardamine pratensis K
Carex bigelowii K
– *capillaris* K
Cassiope tetragona K
Cerastium arcticum R_1
– *cerastoides* R_1
Cystopteris fragilis ssp. *fragilis* K, P, R_1
Empetrum hermaphroditum K, R_2
Epilobium anagallidifolium K
– *lactiflorum* K
– *palustre* K, R_1, R_2
Equisetum arvense K, R_1
Eriophorum scheuchzeri K, R_1
Euphrasia frigida K, R_1, R_2
Festuca vivipara ssp. *hirsuta* K
Gentiana nivalis K
Geum rivale K
Harrimanella hypnoides K
Hieracium alpinum K
Huperzia selago K
Juncus ranarius K
Limosella aquatica K
Ophioglossum azoricum K
Oxyria digyna K, R_1
Phyllodoce coerulea K
Pinguicula vulgaris K, R_1, R_2
Platanthera hyperborea K, R_1
Polygonum viviparum K, R_1, R_2
Potentilla crantzii K, R_1
Pyrola minor K
Sagina procumbens K
– *saginoides* P, R_1, R_2
Salix glauca K
– *herbacea* K, R_1, R_2
Scirpus quinqueflorus K
Sedum rosea K, R_2
Selaginella selaginoides K
Sibbaldia procumbens K, R_1
Subularia aquatica R_2
Taraxacum croceum K
Thalictrum alpinum R_1, R_2
Tofieldia pusilla K
Triglochin palustre K
Trisetum spicatum P
Vaccinium uliginosum K, R_1
Veronica alpina K, R_1

Bryophytes

The names of the mosses are those used by WIK *et al.* (1959–1969); those of the liverworts are those used by ARNELL (1956). Material of all the species is in the Botanical Museum, University of Copenhagen (**C**).

Mosses

Anisothecium sp. R_2
Archidium alternifolium K
Aulacomnium palustre K, R_1, R_2
– *turgidum* R_1
Bryum sp. K
Calliergon stramineum K, R_2
Campylium stellatum K
Campylopus subulatus var. *schimperi* K
Dicranum scoparium K

Liverworts

Anthelia cf. *juratzkana* K
Cephalozia ambigua K
Cephaloziella sp. K
Fossombronia wondraczekii K
Gymnocolea inflata K
Marchantia alpestris K, R_1
Orthocaulis kunzeanus K
Plagiochila asplenioides var. *subarctica* K
Plectocolea subelliptica K

(continued)

Table 5 (cont.).

Mosses	Liverworts
Drepanocladus revolvens K	*Preisia quadrata* K
– *uncinatus* K	*Riccardia pinguis* K
Fissidens osmundoides R_2	*Scapania curta* K
Hylocomium splendens K	– *irrigua* var. *rufescens* K
Hypnum pratense K	– *paludicola* K
Mnium medium K, R_1	*Tritomaria quinquedentata* K
Oncophorus virens K	
Philonotis fontana R_1, R_2	
– *tomentella* K	
Pohlia sp. K	
Pohlia sp. R_2	
Polytrichum alpinum K	
– *longisetum* K	
Racomitrium canescens K	
Sphagnum nemoreum K	
– *teres* K	
– *warnstorfii* K	
Tomenthypnum nitens K	

Abbreviations

K Knighton Fjord: M. SPENDER, 1932 (BÖCHER, 1933a: 12, 16; 1933b: 5, 6); T. I. HAUGE ANDERSSON, 1967, 1972.

P Johan Petersen Bugt: H. WAGER, 1932 (BÖCHER, 1933b: 7, as Kap Beaupré but see the present paper Table 2, no. 10).

R_1 Rømer Fjord, northern springs: I. H. M. SMART, 1969.

R_2 Rømer Fjord, southern springs: I. H. M. SMART, 1969.

The bryophytes collected by M. SPENDER at the Knighton Fjord springs were determined by HARMSEN (1933). The material has recently been revised by K. HOLMEN and B. LANGE (*Sphagnum*) as follows:

Cinclidium subrotundum	Not detected.
Dicranum sendtneri LIMPR.	HARMSEN's determination was probably based on material of *D. elongatum* but no material of *Dicranum* was detected in the revision.
Drepanocladus lycopodioides	Redetermined as *D. uncinatus* var. *subjulaceus*.
Oncophorus virens	Originally overlooked.
Sphagnum quinquefarium	Earlier considered by LANGE (1952) to be indeterminate but redetermined by her as *S. nemoreum* (LANGE, 1973). Additional material of this species was collected in 1972 by T. I. HAUGE ANDERSSON.
Sphagnum warnstorfii	Originally overlooked.

Other springs

The Rømer Fjord (Fig. 8, no. 14) and Knighton Fjord (12) springs are only some of those known in East Greenland although they are the only ones that have been botanically investigated. WAGER & DEER (1939: 24) state that there are about six sets of springs along the coast between Kangerdlugssuaq and Scoresby Sund. In Fig. 9 we have shown five but that at Rømer Fjord, of which WAGER & DEER were unaware, represents two sites. No doubt there are others as yet undiscovered.

The water temperatures of the hot springs on the south side of Rømer Fjord and Knighton Fjord (58° and 54°C respectively) are some of the highest recorded in Greenland. They are exceeded only by those at Kap Tobin (Ûnarteq) (16), south-east of Scoresbysund, which range in temperature from 58°–62°C, and those on the south side of Storefjord (20), slightly further north, where a temperature of 60°C has been recorded.

South Greenland

The hot springs at Ûnartoq island (8) (Fig. 12) were the first to be discovered in Greenland and they are the most carefully investigated. The temperature of the water reaches 40°C and the pH fluctuates between 5.3 and 9.2, perhaps owing to artificial pollution, such as the introduction of soap by visitors. The gas, principally nitrogen, differs from that of all other hot springs in Greenland in having an appreciable amount of helium (He = 2.25 %) (PERSOZ, LARSEN & SINGER, 1972).

These springs are of considerable botanical interest as it was here that K. HOLMEN, a member of the 1963 expedition of the Greenland Botanical Survey, discovered three mosses new to Greenland: *Mnium hornum*, *Rhodobryum roseum* and *Rhytidiadelphus triquetrus* (HELK, 1965). He has very kindly allowed us to publish the following information based on his unpublished notes.

Mnium hornum formed large cushions along the outflow stream of the hot springs. *Sphagnum teres* and the following vascular plants were sometimes present in these cushions: *Equisetum arvense*, *Viola palustris*, *Polygonum viviparum*, *Sagina procumbens*, *Scirpus quinqueflorus*, *Carex rariflora*, *Nardus stricta* and *Agrostis stolonifera*. *Mnium hornum* has not yet been found anywhere else in Greenland.

Rhodobryum roseum and *Rhytidiadelphus triquetrus* grew in a rather dry *Festuca rubra* community (Table 6) close to the hot springs where the soil was still warm. It is remarkable that *Botrychium simplex* was also present in this habitat. This is a very rare fern in Greenland being known only from four other localities (ØLLGAARD, 1971), while both *Rhodobryum roseum* and *Rhytidiadelphus triquetrus* are known from only a few, all in South Greenland.

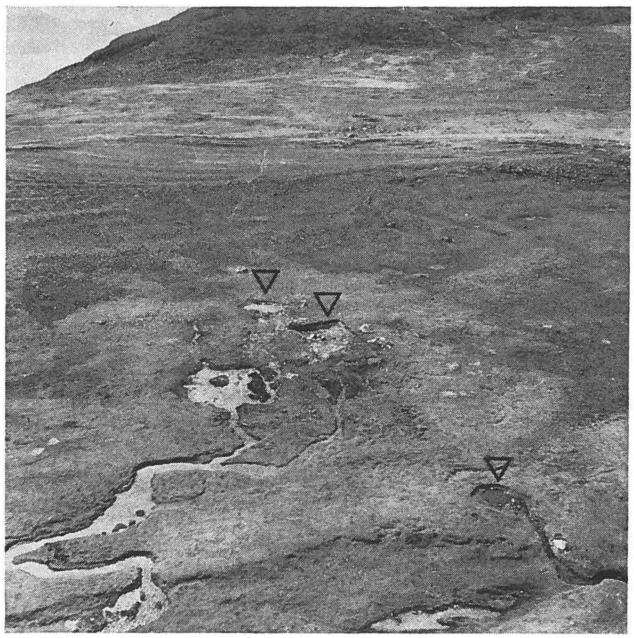

Fig. 12. The Ûnartoq springs in South Greenland (Fig. 8, no. 8) looking south-east. The three springs are arrowed. (Reproduced with permission of the Geological Survey of Greenland).

Table 6. *Species lists for 10 random 15 cm square quadrats in a Festuca rubra community by the hot springs of Ûnartoq island (Fig. 8, no. 8). (Data made available by* K. Holmen, *21.7.1963)*

Species	1	2	3	4	5	6	7	8	9	10	F %
Festuca rubra	×	×	×	×	×	×	×	×	×	×	100
Polygonum viviparum	–	×	–	–	×	–	×	×	×	–	50
Potentilla tridentata	–	–	–	–	×	×	–	–	×	×	40
Thalictrum alpinum	–	×	–	×	–	–	×	×	–	–	40
Cardamine pratensis	–	–	–	–	–	–	×	–	×	–	20
Carex panicea	–	×	×	–	–	–	–	–	–	–	20
Equisetum arvense	–	–	–	–	–	×	–	×	–	–	20
Ranunculus acris	–	–	×	–	–	–	×	–	–	–	20
Luzula confusa	–	–	×	–	–	–	–	–	–	–	10
Poa pratensis	–	–	–	–	–	–	–	–	×	–	10
Rhinanthus sp.	–	–	–	–	–	–	×	–	–	–	10
Selaginella selaginoides	–	–	–	×	–	–	–	–	–	–	10
Rhytidiadelphus squarrosus	×	–	×	×	×	×	×	×	×	×	90
— *triquetrus*	×	×	×	×	–	×	×	×	×	–	80
Rhodobryum roseum	–	–	×	–	×	×	×	×	×	×	70
Hylocomium splendens	×	–	–	×	×	×	×	–	–	–	50
Drepanocladus uncinatus	×	–	–	–	–	–	–	–	–	–	10
Pleurozium schreberi	–	–	–	–	–	–	–	–	–	×	10
Polytrichum alpinum	×	–	–	–	–	–	–	–	–	–	10

West Greenland

With a few exceptions the hot springs in West Greenland are all on Disko island. They are relatively cool, the highest temperature recorded being 18.8°C from a spring at the head of Mellemfjord (2), but they appear to be more subject to temperature fluctuations (M. P. PORSILD, 1902: 117) than those elsewhere in Greenland. Physical and chemical data of the springs at Østerlien (5) near Godhavn have been published by LETTEVALL (1962).

No proper vegetational analyses are available from the hot springs in West Greenland for comparison with those from the other areas but most authors (especially M. P. PORSILD, 1902, 1914, 1920, and more recently BÖCHER, 1963) emphasize the striking effect that the springs have on the surrounding vegetation. Several distinctly southern species, which in West Greenland have their northern limits on Disko island, are almost always associated with the hot springs (M. P. PORSILD, 1920). They include *Epilobium hornemannii*, *E. palustre*, *Listera cordata*, *Leucorchis albida*, *Platanthera hyperborea* and *Corallorhiza trifida*.

The phytogeographical significance of the Blosseville Kyst hot springs

In the Arctic, a hot spring has a profound effect on the local flora and vegetation and, as we have shown, this is particularly striking in an area as barren as the Blosseville Kyst. The spring itself never freezes and it will maintain a zone of perennially unfrozen soil around it. Consequently, plant growth and germination begin early as soon as the days lengthen sufficiently and growth will continue correspondingly longer than in the surrounding areas. The temperature of the spring will largely determine the area which it influences. How near to the outlet the vegetation is able to grow will be determined also by the pH and chemical composition of the water and the gas. As mentioned above, the Rømer Fjord and Knighton Fjord springs are particularly pure. Where the soil is heated but not irrigated, it may dry out and support only an open vegetation. This is true of the open clay areas by the Knighton Fjord springs which have only scattered individuals of *Ophioglossum azoricum*, *Sagina procumbens* and *Limosella aquatica*. The latter two species behave as annuals and the aerial parts of *Ophioglossum* probably die down before the end of the summer. On the other hand, desiccation is likely to be minimised in areas affected by steam.

It is to be expected that warm springs along the Blosseville Kyst will enable species to occur which are normally found further south. Whether they have reached the springs from the south, or by birds flying across the Denmark Strait from Iceland, or whether they are occupying refugia from a more favorable period it is impossible to say.

Where the spring localities represent a species' northern limit on the east coast there is no necessity to invoke colonisation from Iceland but this does seem a likely explanation of the presence of *Ophioglossum* and *Geum rivale*, both of which occur in Greenland only around the Knighton Fjord springs. If such an origin is conceded, then it must also be considered for *Subularia aquatica*, *Epilobium palustre* and *Sagina procumbens* since the nearest populations of these species are not in Greenland but in Iceland. The aquatic plant *Limosella aquatica* is another candidate for dispersal from Iceland, particularly in view of its occurrence on a bird-

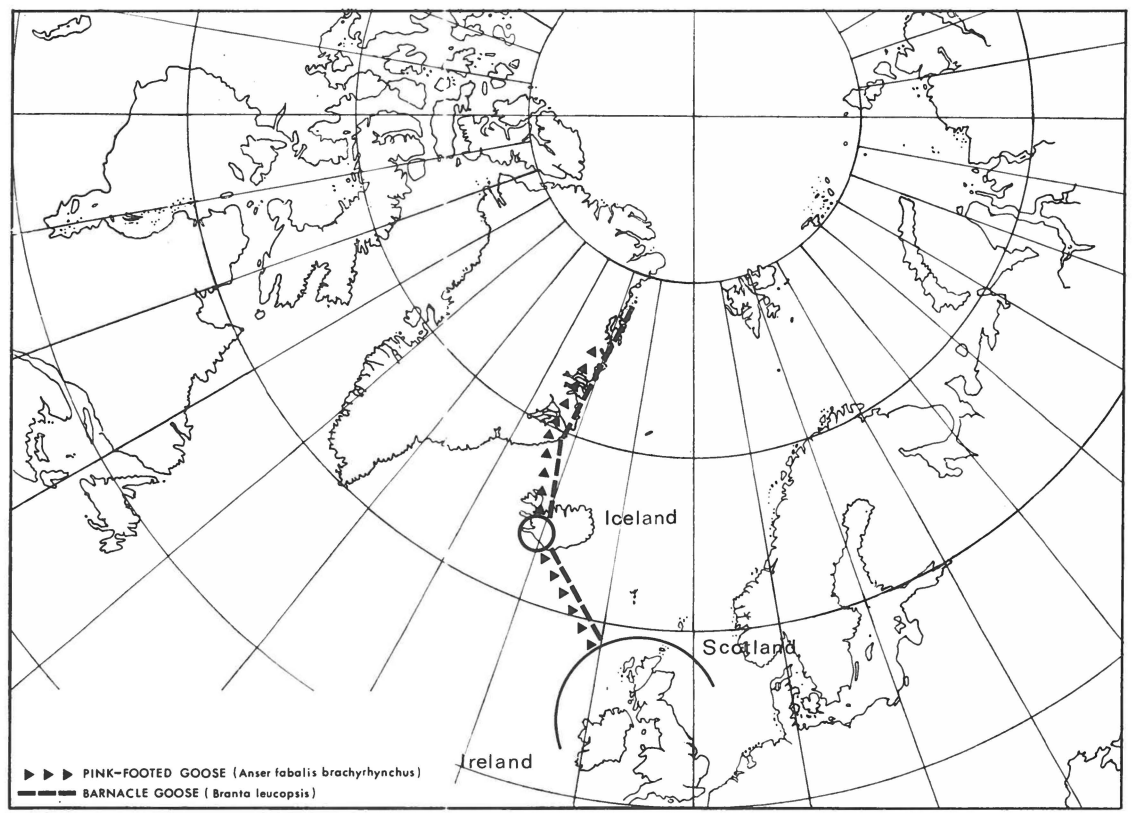

Fig. 13. Map showing the migration routes between the British Isles, Iceland and East Greenland of the pink-footed and the barnacle goose. Both species breed in East Greenland and there is a very large breeding population of the pink-footed goose in Iceland.

island in Scoresby Sund, yet it can be argued that, as is the case with *Triglochin palustre*, the spring habitat is the only one available to it between its localities in more favourable areas further south and in Scoresby Sund in the north.

There is a striking similarity between the hot-spring flora of the Blosseville Kyst and Iceland. We have already stated that *Ophioglossum azoricum* and *Fossombronia wondraczekii* were considered by OSTENFELD (1899) to occur in Iceland only around hot springs. He also lists *Limosella aquatica* as being very rare away from such habitats. To the same category belongs *Archidium alternifolium* of which HESSELBO (1918) states "typical of warm clay flats, and in S. and W. Iceland it is met with around every hot spring". Finally, *Epilobium palustre*, *Sagina procumbens* and *Juncus ranarius* are listed by OSTENFELD as being common around hot springs.

The possibility of long-distance dispersal by birds, especially geese, was discussed by IVERSEN (1952–53) in a paper on the origin of the flora of West Greenland. There are two species of geese which migrate in considerable numbers between Iceland and East and Northeast Greenland (Fig. 13). These are the pink-footed goose (*Anser fabalis brachyrhynchus* BAILLON) and the barnacle goose (*Branta leucopsis* BECHST.) of which the Greenland populations have been estimated at 20,000 (CHRISTENSEN, 1967) and 13,000–14,000 (ATKINSON-WILLES, 1963) respectively. It is not known precisely at what point the geese arrive in East Greenland but the shortest route (300 km = 6 hours flying) would take them from Northwest Iceland to the central part of the Blosseville Kyst.[1]) If they took this route they would no doubt be attracted to the lush vegetation around the hot springs before resuming their flight northwards. IVERSEN states that "It is inconceivable that these immense numbers of geese would not occasionally carry seeds with them to Greenland, even if the time of their arrival (May) is not the best season for transport of seeds". CHRISTENSEN, however, has shown that about 15,000 of the East Greenland pink-feet are non-breeding birds which migrate to Greenland to moult and arrive between mid-June and mid-July, about a month later than the breeding birds and at a more favourable time for seed germination.

A number of recent plant-finds from Scoresby Sund are also suggestive of dispersal from Iceland, although there is of course no reason to suppose that such dispersal was recent. The discovery of *Limosella* has

[1]) Since this was written we have been informed by Mr. A. Ross that Rømer Fjord and Knighton Fjord lie on the migration route from Iceland of both species of geese and that they then fly not up the Blosseville Kyst but across the icecap to Gåsefjord in Southwest Scoresby Sund.

already been referred to. In 1958 LÆGAARD (1960) discovered *Potamogeton praelongus* and *P. perfoliatus*, both new to the Greenland flora, in a tarn by Rypefjord (71°02′ N.lat.). Finally, in 1971, one of us (G.H.) discovered *Sparganium hyperboreum* in a tarn with nesting barnacle geese on the north side of Flyverfjord (71°37′ N.lat.) and *Utricularia minor* in a small pool by a tarn with nesting pink-feet on the east side of Schuchert Dal (71°26′ N.lat.). The former species was not previously definitely known north of Angmagssalik and the latter is new to East Greenland; both are common in Iceland.

In conclusion, we should like to suggest that the circumstantial evidence of plant dispersal from Iceland, while not conclusive, is nevertheless very strong.

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PLANT INDEX

Alphabetical list of the species mentioned in the text, figures and tables (excluding Table 1). The more important references are in bold type.

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