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CONTRIBUTIONS TO THE FLORA AND PLANT GEOGRAPHY OF WEST GREENLAND

II.

THE *CAREX CAPITATA*-, THE *LUZULA MULTIFLORA*-, AND THE *TORULARIA HUMILIS*-COMPLEXES

BY

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WITH 15 FIGURES IN THE TEXT AND 5 PLATES

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INTRODUCTION

During the work at determining the plants collected in 1946 on the Botanical Expedition to West Greenland I have met with various systematic and at the same time plant geographical problems. Three fairly important complexes of species involving such problems will be mentioned in detail in the present paper. Within all the three complexes of species there is a species with a narrow area limited to the most continental part of West Greenland. The floristic contrast that can be ascertained between this area and the area of coastal mountains on the Davisstrædet thus is further increased. In one case the continental species with the narrow area is new to science: it has been termed *Luzula groenlandica*. In all the three cases the continental West Greenland species occurs highly isolated. Finally several other instances of isolated occurrences in the Søndre Strømfjord area are mentioned. The importance of these isolations to the theory of a large continental Glacial-Age refugium in the Søndre Strømfjord area is discussed.

THE *CAREX CAPITATA* COMPLEX

Differences in regard to the size, form, and colour of the perigynium and its being provided with small spines were used by SMITH (1940) to distinguish *Carex arctogena* SMITH from *Carex capitata* L. s. str. According to SMITH these species have the following distribution:

Carex capitata s. str.: Iceland—Fennoscandia—the Alps—Caucasus—Northern Russia—Northern Asia—Alaska—Yukon—the Pine Lake district in Canada—Washington—New Hampshire—North-West Newfoundland—West Greenland.

Carex arctogena: Fennoscandia—Greenland—Eastern North America—South America (Patagonia and Tierra del Fuego).

In Scandinavia SMITH has illustrated the distribution by dot maps: *Carex capitata* is connected with the zone of conifers and the subalpine zone; it extremely rarely ascends a little above the birch limit. *Carex arctogena* is alpine. A map of the world range of *Carex capitata* complex is found in RAYMOND (1950, p. 27).

Because of the war SMITH was unable to examine the comprehensive material from Greenland found in the Botanical Museum of Copenhagen. I have now studied this material and supplemented it with material of my own collected in 1946 and with four collections from the Nûgssuaq peninsula kindly submitted to me by Mr. KNUD JACOBSEN, M. Sc., in all 57 collections. Further I have examined the material from Iceland found in Copenhagen, in all 45 collections.

RAYMOND (1949) has examined a comprehensive material from North America. He does not think it possible to attribute the rank of species to SMITH's *C. arctogena*, but reduces it to f. *arctogena* (Smith) Raymond. I shall not in this place make any decisive statement on the systematic rank of the two types, but want to state that when there are morphological as well as geographical and ecological differences between the two types, they would at least deserve to be termed subspecies. In what follows they will for practical reasons be treated as species in accordance with SMITH.

Carex arctogena Smith.

As might be expected from the distribution in Scandinavia, it is the northern and alpine species, *Carex arctogena*, which is the universally distributed species in Greenland. This already clearly appears from Smith's list of localities. The distribution in Greenland appears from the large map in fig. 1. The distribution of basalt has also been indicated in this map, as accurately as possible considering the small scale. Both in West and East Greenland the species seems to be absent on basalt; it occurs exclusively in the areas of the Archean rock.

In West Greenland this is most marked. The four localities on Nûgssuaq, which are due to Knud Jakobsen, are all in the western gneiss area. M. P. Porsild (1920) writes about the occurrence on Disko: "Only seen a few times in the gneiss-domain on the south coast." However, he adduces a station from the continent Pâtût (Hartz), and this is situated in the basaltic area of Nûgssuaq. The rocky foundation here, however, consists partly of basalt, partly—in the mountains—of sediments. It is remarkable that this station of the species was not mentioned by A. E. Porsild (1926), who has thoroughly studied the flora at Pâtût. Nor does Hartz himself (1894, pp. 49–51) mention any "*Carex capitata*" in the report on his travels, although the species does not belong to those occurring everywhere and hence naturally would be mentioned. As, finally, there is no material from the place in the Botanical Museum in Copenhagen, it is no doubt justifiable to disregard Pâtût as a station of *Carex arctogena*.

In East Greenland *Carex arctogena* has been found by P. F. Scholander (see Devold & Scholander 1933) immediately south of the basaltic area and by Th. Sørensen (1933, p. 110) a good distance to the north on a south-facing slope in a "caldera". This station is rather isolated, but the isolation may very well be supposed to be due to edaphic conditions. Further the Nordvestfjord in Scoresby Sund is very little known. If in time the species will be found in the interior gneiss area in Scoresby Sund, this will make the isolation of the northernmost locality less pronounced.

In Iceland, where the mountains consist of basalt and other late eruptive rocks, *C. arctogena* has not been found with certainty. Two finds perhaps may be interpreted as hybrids between *C. capitata* and *C. arctogena* (Northern Iceland, Bildsárskard, 8/1891, St. Stefanson; brownish, rather short perigynia; very short weak spines on a few of them.—Southern Iceland, Prestibakki, 8/1901, Helgi Jónsson; rather pale, short perigynia with a few small spines). No doubt *C. arctogena* ought to be searched for in the Icelandic highlands, particularly in the areas richest in precipitation, where the soils may be supposed to be leached.

Carex arctogena is not the only species behaving like this. In Greenland *Loiseleuria procumbens*, *Diapensia lapponica*, *Potentilla tridentata*, and *Carex rufina* (BÖCHER 1938, maps figs. 70, 88, 92, and 125) have nearly the same distribution and avoid the basalt. These are species which are generally recognized as acidophilous, and hence their relations to the basalt are rather easy to understand. It should, however, be noted that the two dwarf shrubs and *Carex rufina* occur in Iceland, and *Loiseleuria* is even frequent there. It must be the damper climate in Iceland and the consequent leaching which assert themselves. The question then arises whether *Carex arctogena* may simply be termed acidophilous. Hardly so; for SMITH writes that in Scandinavia it is "calciphilous but not exclusive to lime." Thus, if anything, it tends towards the basic side.

Observations in summer 1946 of the stations of *Carex arctogena* in West Greenland seem to indicate that the species is somewhat acidophilous, but not exclusive to acidic soils. As regards the humidity of the soil it seems that the species is little fastidious. At Kangâmiut it was found on a heath-covered steep slope together with *Salix herbacea*, *Loiseleuria procumbens*, *Phyllodoce coerulea*, and *Juncus trifidus*, and near Pâ (in lat. 66° north) it was collected on an open spot rich in lichens on *Empetrum-Betula nana* heath. At the head of the Søndre Strømfjord I found it on the beach of an oligotrophic lake and on a mountain plateau, 600 m above sea level, in damp moss on the bank of an oligotrophic wet bog. At the margin of the inland ice it grew in a rather damp grass vegetation of *Poa pratensis*, *Calamagrostis neglecta*, *C. lapponica* var. *groenlandica*, and *Carex incurva*, a vegetation which, to judge from similar ones in this region, grows on neutral soil. In the Angmagssalik area KRUUSE (1912, p. 144) found *C. arctogena* on a grassy slope with *Agrostis borealis*, *Festuca rubra*, *Juncus trifidus*, *Potentilla tridentata*, and *Chamaenerium angustifolium*, and others, a flora indicative of slightly acid soil, but also of rather a dry soil.

Perhaps the different ecological behaviour of the species in Greenland and Scandinavia is due to its having other edaphic requirements in the north than at its southern limit. Indeed, numerous examples are known of species making widely different demands on the soil in various parts of their area (see BÖCHER, CHRISTENSEN & SKYTTE CHRISTIANSEN, 1946). Among arctic plants this applies to *Arnica alpina*, which in Scandinavia is considered as calciphilous, but in Greenland, if anything, is acidophilous (SØRENSEN 1933, p. 168, BÖCHER 1938, p. 189). Here, it is true, there is a possibility that we have to do with two different races; but there are hardly any grounds for this supposition in the case of *Carex arctogena*, which varies very little morphologically.

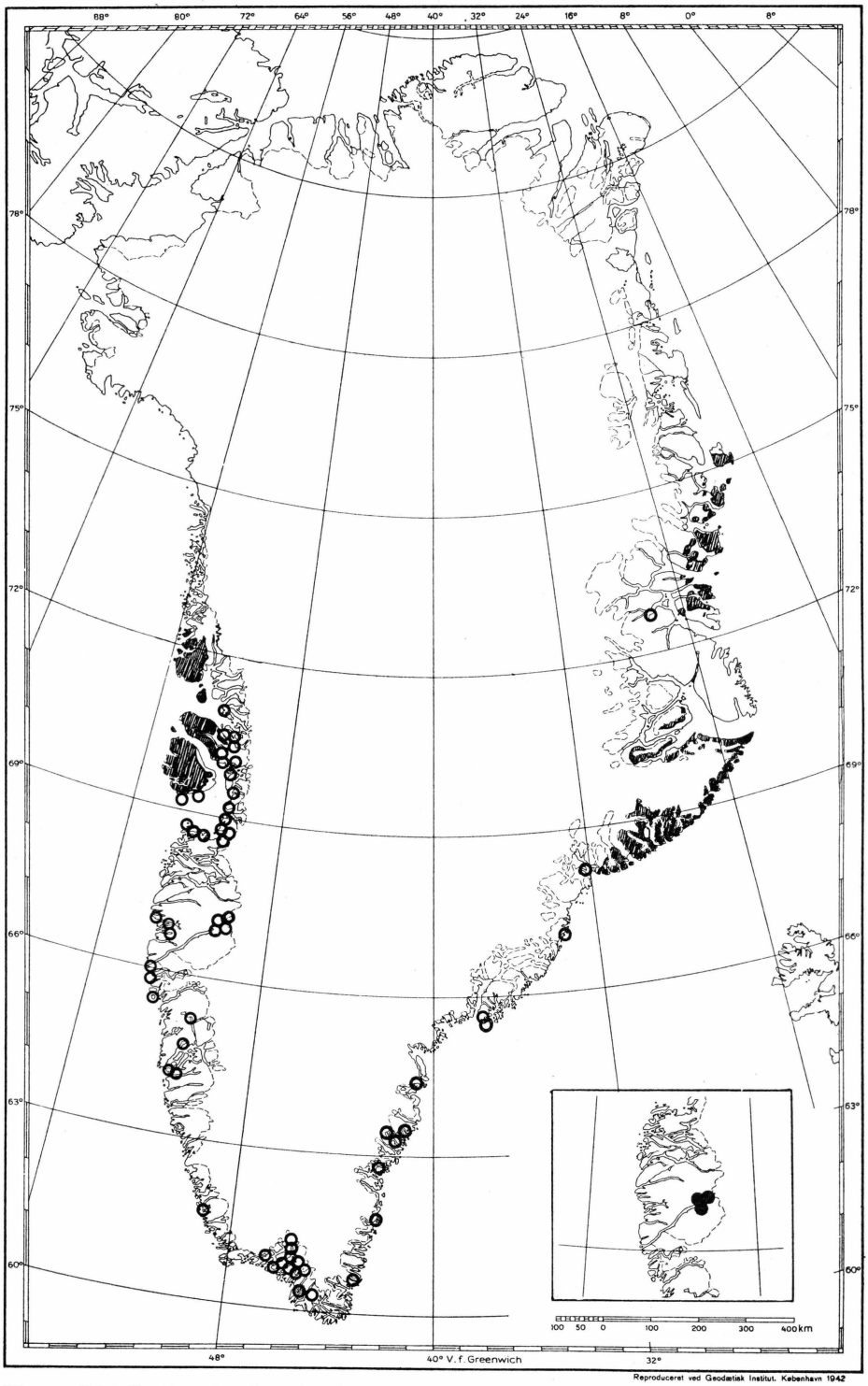

Fig. 1. Distribution in Greenland of *Carex arctogena* Smith (large map) and *Carex capitata* (small map below on the right). Dark hatching on the large map indicates the occurrence of basalt.

One circumstance is fairly important in this connexion. The distribution of the species is typically low arctic (cf. BÖCHER 1938, pp. 224 and 268) with a slightly continental tendency, as it is somewhat rare in South-East Greenland, common in the interior of South Greenland, and rather common in the Søndre Strømfjord and Sydostbugten. Its continental tendency is in good agreement with its "bicentric" distribution in Scandinavia, its two areas here corresponding to the climatically most continental parts of the mountains. It only reaches the sea north of Lofoten. Numerous examples are known of continental species which near their oceanic limits become more or less exclusive to lime, and our case is presumably a similar one.

This problem of altered edaphic demands within the area of the same species is actually highly complicated. It can only be solved by a combination of culture experiments (to reveal edaphic races) and detailed investigations of the soil. In our special case it will be of great interest to learn whether it is simply the *p*H of the basalt soils or quite different properties of these soils which are decisive.

In this connexion there is reason to mention the distribution of *Carex microglochin* in Greenland. Its area (BÖCHER 1938, fig. 122) highly reminds of that of *C. arctogena*, but it is rarer. *Carex microglochin* avoids the basalt of Greenland, but is frequent in Iceland and calciphilous in Scandinavia and Newfoundland. In this case it may be established that the species avoids the basalt in Greenland, but at the same time it may occur elsewhere on typically basic soil. At the head of the Søndre Strømfjord it was observed in two places only, both at river mouths on bluish, greasy clay. One of these places was analyzed, a soil sample showing *p*H 7.6, a potassium value of 19 and an extremely high phosphoric acid value of 44 (see BÖCHER 1949b). This species obviously requires very special conditions of the soil. Besides, it is also low arctic with a continental tendency.

Carex capitata L. s. str.

In contrast to *Carex arctogena*, *C. capitata* s. str. has an extremely limited distribution in Greenland. It has only been recorded from the interior of the country about the Søndre Strømfjord:

July 1927, O. Hagerup, "Søndre Strømfjord" (without further statement of the place, but according to information later received from Dr. O. Hagerup it was found at the head of the fjord, probably in Loc. 5 (see map in BÖCHER 1949a).

August 1946, T. W. Böcher, at the bottom of the valley, 10 km east of the head of the fjord, ab. 50 m above sea level. Loc. 3.

August 1946, T. W. Böcher, Vandfaldskløften in the inner southern creek of the fjord, a lakeshore ab. 300 m above sea level. Loc. 9.

The three localities are seen in the small map in fig. 1, at the bottom, on the right. From one of the localities there is a vegetation analysis. The species was growing on a luxuriant tussocky *Rhododendron lapponicum* heath in small hollows together with *Calamagrostis neglecta*, *Kobresia simpliciuscula*, *Carex capillaris*, *C. incurva*, *Juncus arcticus*, and *Tofieldia pusilla*. *p*H was measured at 6.8—6.9. *Carex capitata* was extraordinarily tall here, and the big pale fruits were early ripe and fell off already in the first half of August. In my notes I have further mentioned the same type with pale, early ripe fruits from a *Carex incurva* sociation east of Keglen in Sandflugtsdalen (Loc. 2) nearly 10 km farther east than the locality just mentioned.

The area in question is highly continental and the lowlands almost subarctic. The soil is often basic and very rich in nutrients. Hence it must be a very suitable place for *Carex capitata* s. str., which according to SMITH is a meadow plant exclusive to lime and with a subalpine-boreal distribution.

An inquiry into its total distribution reveals strange facts. In Alaska it avoids the southern, oceanic areas along the Pacific (HULTÉN 1942, map 226). In Scandinavia (SMITH, fig. 3) it is missing in the south-western parts of Norway, but is frequent in the central areas from 61° northwards. It still reaches the west coast at 67°. Thus this species, too, shows a slightly continental tendency. Its abundance in Iceland perhaps should be interpreted as a result of the soil. The soil rich in lime makes it possible for a species otherwise continentally stamped to occur in an area with an oceanic climate. For that matter, it varies somewhat in Iceland: It may have dark brown scales and perigynia, but the form and size of the perigynia agree with the typical *Carex capitata* s. str. (e. g. Skutustaðir, 7/1935, Ing. Davidsson). HULTÉN has made the same observation in his material from Kotzebue.

It may seem strange that *C. capitata* is absent in the interior of South Greenland, the most subarctic parts of Greenland. These regions, however, no doubt, because of the much heavier precipitation, have more acid soils and hardly proper meadows rich in lime. The distribution therefore may ecologically be intelligible enough, but such an isolation of an area is connected with a problem of the history of immigration which cannot be ignored.

The nearest stations east of the head of the Søndre Strømfjord are in Iceland, 1200 km off. The nearest sure occurrences in the south are in Newfoundland, ab. 1700 km. off. Towards the west it is not easy to state the distance, as it has not been decided whether the station on the south coast of Baffin Land (POLUNIN 1940, p. 109) is of *C. arctogena* or *C. capitata*. SMITH, however, records *C. arctogena* from the northern Labrador; hence it seems most probable that the plant from

Baffin Land belongs to *C. arctogena.* At any rate the distance to the south coast of Baffin Land is 1000 km, and hence it cannot be denied that the West Greenland area is extremely isolated. If, as everything tends to show, the nearest station of the species in America is Newfoundland, we have here to do with a southern species, which has a similar gap as e. g. *Sisyrinchium montanum* and *Selaginella rupestris* (BÖCHER 1948), and thus the theory of the survival of the southern species during the last Glacial Age will be further accentuated; cf. p. 36—37.

THE *LUZULA MULTIFLORA* COMPLEX

Luzula multiflora has long been worrying Greenland botanists. Most Danish authors operate with two species, *Luzula frigida* (Buch.) Samuels. and *Luzula multiflora* (Retz.) Lej. The hitherto common view is based on Professor G. SAMUELSSON's determinations made in 1918. According to SAMUELSSON there are three types in Greenland, which he terms *L. multiflora*, *L. frigida*, and *L. frigida* var. *contracta* Samuels. The latter is the most frequent type. Whereas *L. frigida* Samuels. has been described in LINDMAN, "Svensk Fanerogamflora" (1918) there is no description of the variety *contracta* available. Obviously SAMUELSSON intended describing it later on in a paper. On some of the labels he has written *L. frigida* var. *contracta* Samuels. in schedula.

Quite recently the question has arisen whether *Luzula sudetica* (Willd.) D. C. does not occur in Greenland, too, or covers the specimens formerly referred to *L. frigida* (see POLUNIN 1943). Further the rank as a species of *L. frigida* has been exposed to some criticism from several quarters, thus from SAMUELSSON himself, who in HULTÉN's "Flora of the Aleutian Islands" (1943) reduces it again to varietal rank.

During the expedition in 1946 a large material of *Luzula* was collected, mainly dried material, but also seed samples and living plants; for at our arrival at the continental parts of West Greenland it struck me that the *L. multiflora* s. l. here behaved in quite a different way, both habit and ecology being considerably changed as compared with those of the specimens in the coastal regions in South-West Greenland. Hence I came to suspect that we had to do with a new species.

Fortunately the seed samples from the continental regions were supplemented with samples from other regions collected by KAJ LARSEN and KNUD JAKOBSEN. All seed samples were sown with a view to comparative culture experiments and chromosome countings. The chromosome countings (BÖCHER & LARSEN 1950) highly supported the assumption that the material from the continental regions belonged to a separate species.

A revision of the whole complex in Greenland was a natural consequence. The material in the Botanical Museum of Copenhagen was

very rich, but it was in many respects valuably supplemented by the collections in Stockholm and Oslo, which were kindly submitted to me. Finally KNUD JAKOBSEN most kindly placed his collections at my disposal.

Discussion of Systematic Characters.

(A) Chromosome number and morphology. According to NORDENSKIÖLD (1949) and BÖCHER & LARSEN (1950) we have the following well separated cytological types in the *Luzula multiflora* complex:

(1) 2n 12. Medium-sized, short rod-shaped chromosomes: *Luzula pallescens*, see fig. 2a and NORDENSKIÖLD *loc. cit.* fig. 4.

(2) 2n 24. Medium-sized, short rod-shaped chromosomes, two of them with distinct trabants. The chromosomes not of equal length, some of them being about two thirds shorter than the others: *Luzula groenlandica*, see fig. 2b—c and further particulars below.

(3) 2n 36. Rather small, rod-shaped chromosomes, two of them with very small trabants can be seen in some plates: *Luzula multiflora*, *L. multiflora* ssp. *frigida*, and *L. multiflora* ssp. *frigida* var. *contracta*[1], see fig. 2d—e and figs. 1—2 in NORDENSKIÖLD *loc. cit.*

(4) 2n 48. Nearly spherical, small chromosomes: *Luzula sudetica*, see fig. 5 in NORDENSKIÖLD *loc. cit.*

Cytologically there are four different types, and there is much to be said in favour of the view that there are four corresponding species. If morphological conditions were as plain as the cytological ones, the problem would be an easy one. The question arises whether the 24-chromosomed type can be separated morphologically from the others, and whether within the group with 36 chromosomes we have one or more species.

(B) Size of the seeds. This character is considered the best for a distinction between the species and enters as a character in the keys in the Scandinavian floras. In the case of Greenland M. P. PORSILD (1935) has measured the sizes of the seeds of *L. multiflora* and *L. multiflora* ssp. *frigida* in Godthaabs Fjord, and here was able to demonstrate a clear difference: 1.5 mm long seeds in *L. multiflora* and 1.1 mm long seeds in *L. multiflora* ssp. *frigida*. However, there are several collections, among them some determined by SAMUELSSON as *Luzula frigida* and which have seeds of a length of about 1.5 mm. It is presumably a fact that the character large seeds mostly occurs together with the other

[1] These systematic names will be used by the present writer. On the reasons for the view of *L. frigida* as a subspecies see p. 16.

multiflora characters; but that in certain rare cases it may occur together with the *frigida* characters.

In the case of *L. sudetica* things look somewhat complicated. According to SAMUELSSON (1922, p. 244) the seeds in Swiss material measure 1.1–1.4 mm, while LINDMAN's flora states their length as 0.75 mm and LID's Norw. flora as barely 1 mm. In a material collected by C. H. OSTENFELD in Upper Engadine in Switzerland and determined

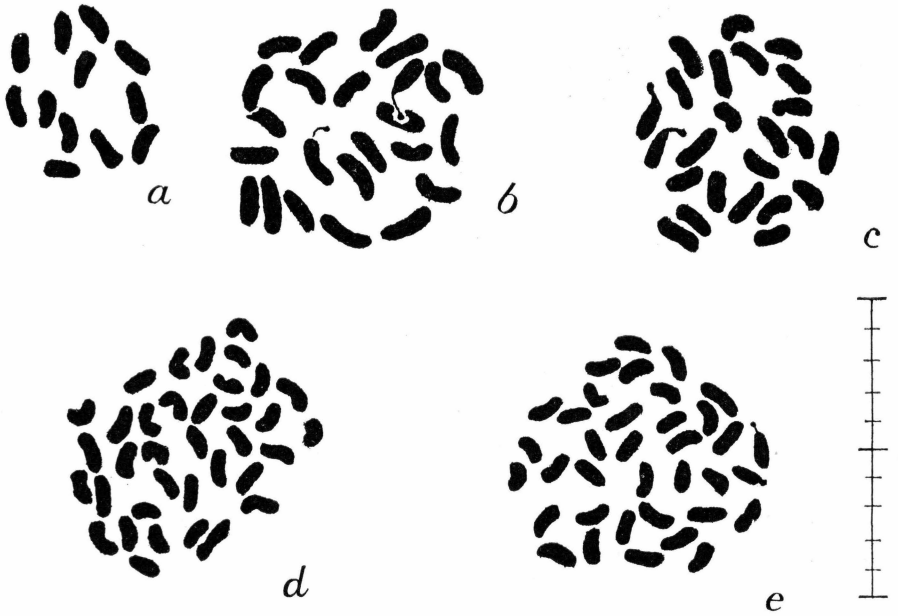

Fig. 2. Metaphase plates from root tips of (a) *Luzula parviflora* from the Botanical Gardens in Montreal. (b) *Luzula groenlandica* var. *fuscoater* from Ungava. (c) *Luzula groenlandica* from Søndre Strømfjord in West Greenland. (d) *Luzula multiflora* ssp. *frigida* from Tigsaluk south of Sermiliarsuk in West Greenland. (e) *Luzula multiflora* from the bog Lyngby Mose. Denmark. Scale 10 μ long.

by SAMUELSSON as belonging to *L. sudetica* the average size of the seeds is 1.1 mm (range: 0.9—1.2). As a further complication it should be added that FERNALD (1945), who finds himself unable to distinguish *L. frigida* from *L. sudetica*, states the size of the seeds of "*L. sudetica* var. *frigida*" to be 1.0—1.6 mm. These discrepancies are connected partly with the fact that the various authors define their *L. sudetica* differently, partly with the fact that this species like the others varies, and many things tend to show that the Scandinavian material of *L. sudetica* on the whole has smaller seeds than the material from Switzerland.

In the measurements of lengths mentioned also the caruncle of the seed is included. It seems, however, that the measurement of the caruncle, only, is at least as important as a systematic character as the total

length of the seed. It is quite clear that *L. multiflora*, ssp. *frigida*, and its var. *contracta* have long caruncles of their seeds and the same holds good of *L. pallescens*, which for that matter has very short seeds. On the other hand *L. sudetica* and the species called *L. groenlandica* have quite short caruncles. They are mostly 0.1 mm, while they are ab. 0.3 and up to 0.5 mm in ssp. *frigida* and *L. multiflora*. SAMUELSSON (1922) states that the caruncle in *L. sudetica* in a dry state is about one tenth of the length of the whole seed, whereas in *L. multiflora* it is about one fourth of the length of the whole seed.

During the work at determining the plants I measured many seeds from Greenland material. The result was three groups (the parentheses indicating the numbers of seeds measured):

Typical individuals of

L. multiflora	size of seed	1.4—*1.50*—1.6 (26)
L. multiflora ssp. *frigida*	– – –	1.1—*1.27*—1.5 (33)
L. multifl. ssp. *frigida* var. *contracta*	– – –	1.1—*1.28*—1.4 (43)
L. groenlandica	– – –	0.9—*1.04*—1.2 (80)

The mean values give three separate types. The variation, however, is so great that the extreme values overlap. Any clear-cut distinction is out of the question on the basis of the sizes of the seeds. Still, particularly if many seeds are available for the determination, it will mostly be possible to refer a plant to a definite species. If the majority of the seeds are about 1 mm in length or about 1.2—1.3 mm or 1.5 mm this will be of great importance for the determination. But as mentioned above there are morphologically good specimens of "*L. frigida*" with seeds about 1.5 mm in length, and within e. g. *L. groenlandica* some collections may have seeds of a length of 0.9—1.05 mm, some of 1.0–1.1 and a few of 1.1—1.2 mm. If we include *Luzula pallescens*, which is not found in Greenland, there are four sizes of seeds. These are seen in Plate 3 and may be summarized as follows:

Small seeds, mostly 0.8—1.1 mm long

* caruncle long..... *Luzula pallescens* (1)

** caruncle short ..... *Luzula sudetica* and *groenlandica* (2)

Larger seeds, mostly 1.2—1.6 mm long with long caruncles

* seeds 1.1—1.4 mm long ... *Luzula multiflora* ssp. *frigida* incl. var. *contracta* (3)

** seeds 1.4—1.6 mm long..... *Luzula multiflora* (4)

Type (1) see Plate 3 fig. 9, type (2) see Plate 3 figs. 1, 2, 3, and 6, type (3) Plate 3 figs. 4—5, type (4) Plate 3 figs. 7—8.

(C) Length and colour of the perianth. According to SAMUELSSON (1922) the two rows of perianth leaves are of nearly equal length, 2.5–3 mm long in *L. multiflora*, whereas the inner leaves of the perianth are shorter than the outer ones in *L. sudetica*, the outer ones here being only 2.0—2.5 mm. The colour is dark brown in *L. sudetica* and ssp. *frigida* and light brown in *L. multiflora*. I have measured some lengths of perianths in Greenland material and it seems to me that on the whole both the absolute length of the perianth and the relative lengths of the two rows of leaves give serviceable systematic characters. The unfortunate thing is that the ranges of variation to the two sizes of the perianths are not well-defined. Presumably favourable conditions will be able to increase the length of the perianth a little and poor conditions to reduce it somewhat. But by a close study of many flowers on one individual or in a collection it is possible to go far as regards the determination by means of the properties of the perianth only. Of particularly great importance is the size of the perianth at the distinction between *L. groenlandica* and *L. multiflora* ssp. *frigida* var. *contracta*; cf. Plate 2 fig. 2.

On the basis of the properties of the perianth (and the fruit) the following groups may be set up:

Short perianth, ab. 2 mm. Leaves of the perianth mucronate
Luzula pallescens (1)

Medium-sized perianth, ab. 2–2.5 mm. Inner leaves of the perianth often shorter than the outer ones, pointed, not mucronate
Luzula sudetica and *groenlandica* (2)

Long perianth, ab. 2.5–3.2 mm. Whorls of nearly equal length.

* Perianth of the same length as the fruit, dark brown.....
Luzula multiflora ssp. *frigida* and its var. *contracta* (3)

** Perianth mostly longer than the fruit and light brown
Luzula multiflora (4)

The characters distinguishing the latter two groups are not worth much. As to the colour it may be stated that SAMUELSSON on several labels of *L. multiflora* from Greenland has written "dark form of *L. multiflora*". There are also otherwise typical specimens of ssp. *frigida* in which the perianth projects over the ripe fruit. The perianth hardly gives any possibility of a sharp distinction between *L. sudetica* and *L. groenlandica*. However, it should be noted that the typical *L. groenlandica* has a broad membranous margin of the perianth leaves. The dense inflorescence thus gets a spotted appearance, while the whole inflorescence of *L. sudetica* is dark. Further the style is preserved very long in *L. sudetica*, whereas it falls off early in *L. groenlandica*.

(D) Inflorescence and habit. The inflorescence has many very similar heads on shorter or longer stalks in typical *Luzula multiflora*, typical *L. multiflora* ssp. *frigida*, and *L. sudetica* (Plate 2 fig. 1 left), although the stalks in the latter may be rather short. In *L. multiflora* ssp. *frigida* var. *contracta* we have often a single dense head or one large head and some smaller short-stalked heads. The same applies to *L. groenlandica*, see Plate 1 and 2, fig. 1.

The habit in *L. sudetica* is very slender. It has thin upright straws, which often are single and never grow in large tussocks. All the others have a dense tussocky growth, and in old individuals numerous straws rise from the same tussock, see Plates 1.

Thus it is possible on the basis of several morphological characters to distinguish *Luzula groenlandica* with 24 chromosomes from *L. sudetica* with 48 chromosomes and *L. multiflora* ssp. *frigida* var. *contracta* with 36 chromosomes. On the other hand it is difficult to make a sharp distinction between *Luzula multiflora* and ssp. *frigida*. The distribution of these two, however, is clearly different (see below). We have a case in which the morphological distinction cannot be made sharp enough, and in which, besides, there is a cytological correspondence, but in which there are distinct geographical-ecological differences. This seems to justify the interpretation of the *frigida*-type as a subspecies. Hence I have here used the combination *L. multiflora* ssp. *frigida* (Buch) Krecz. This also involves that we may retain var. *contracta* (Samuels.) as a variety attached to ssp. *frigida*. As to this variety it may be added that culture experiments with typical ssp. *frigida* and *L. frigida* var. *contracta* showed that the two types keep apart in cultures and that the dense crowding of the flowers in the variety is not due to modification. On the other hand studies in herbaria show that there are transitional stages between typical *frigida* and the variety, and indeed the distribution in Greenland shows a high degree of correspondence (see below). Hence it is presumably justifiable not to consider the *contracta* type as a subspecies, but as a variety of ssp. *frigida*.

As mentioned above, the typical *Luzula groenlandica* has a pale membranous margin of the perianth leaves so that the heads look spotted. However, there are forms in which the perianth leaves are uniformly brown, and here the heads look dark brown as in *L. sudetica* and ssp. *frigida*. Such forms are found both in Greenland and in North America. From Ungava in Labrador the dark form has been studied cytologically and cultivated. Like the typical plant it had 24 chromosomes and the character with the dark perianth leaves was retained in culture. It seemed natural to separate out the dark form as a variety of *L. groenlandica*. It was named *fuscoatra*.

At the examination of the herbaria there were some few plants which could not with certainty be classed with any of the above-mentioned systematic units. As these plants even were remarkably similar, they might be supposed to belong to an independent variety or subspecies. The material is too scarce to base anything on it at present. Cytological investigations are especially needed. In future these deviating plants should be kept in mind, for they remind in some respects of *L. sudetica*, which grows both in Iceland and in North America. The plants are 12–30 cm in height with one stem, only, which at the top carries a single dark head the perianth leaves of which are ab. 2.5—2.7 mm in length. The seeds are rather short and thick (1.0—1.2 mm), but the caruncle is often rather long. The involucral leaf is short and mostly projects obliquely in relation to the direction of the stem. SAMUELSSON has determined some of the plants in question as belonging to *L. frigida* var. *contracta*, and I feel most inclined to agree with him in spite of the size of the seeds and the slender, single, upright stalk, which may remind of *L. sudetica*. There are five collections belonging to the deviating type: Godthaab (P. H. Sørensen 1891), Narssaq north of Julianehaab (L. K. Rosenvinge 1888), Igaliko (A. Berlin 1883), Umanak in Claradalen (J. Devold 1932), and Labrador, Torngat region, head of main arm of Ekortiarsuk Bay (Woodworth 1926). In the following key the deviating type has not been considered.

Key to the species and Latin diagnoses.

The species, subspecies, and varieties of the *Luzula multiflora* complex discussed above may be surveyed in the following key:

1. Perianth leaves relatively long (2.5—3.5 mm), dry seeds as a rule more than 1.1 mm and always with a long caruncle. 2 n 36.
   2. Perianth longer than the fruit, heads brown, rarely blackish brown, seeds big, 1.4—1.7 mm, leaves rather broad:
      Luzula mulitflora (Retz.) Lej.
   2′. Perianth mostly the same length as the fruit, heads blackish brown, seeds 1.1—1.4 mm (very rarely 1.0 or 1.5 mm). Leaves somewhat narrower.
      3. Several stalked heads of nearly the same size:
         Luzula multiflora ssp. *frigida* (Buch.) Krecz.
      3′. One big sessile head, sometimes also one or very few smaller, short-stalked heads:
         Luzula multiflora ssp. *frigida* (Buch.) var. *contracta* Samuels.

1′. Perianth leaves relatively short (2—2.5 mm), dry seeds as a rule under 1.1 mm. 2n 12, 24, or 48.

2. Perianth leaves mucronate. Seeds small with long caruncle. Often many small, oblong, pale brown heads. 2n 12:
Luzula pallescens Sw.

2′. Perianth leaves pointed, not mucronate. Seeds with short caruncle. Straw and leaves often very rich in anthocyanin. 2n 24 or 48.

3. Several (1—5) heads of nearly the same size, these often being clustered. Straw mostly single, thin, upright. Lower involucral leaf reaching high above the uppermost heads and continuing nearly in the direction of the stem. The style keeps long on the capsule. 2n 48:
Luzula sudetica (Will.) D. C.

3′. One big sessile head and also fairly often a few small short-stalked heads. Straw several together, often in rather large tussocks. Lower involucral leaf short, often broad and not rarely projecting obliquely in relation to the direction of the stem. The style falls off early. 2n 24.

4. Perianth leaves with a broad pale margin so that the heads become greyish-white—brown spotted:
Luzula groenlandica.

4′. Perianth leaves without a pale margin; dark brown heads:
Luzula groenlandica var. *fuscoatra.*

Diagnoses[1].

Luzula groenlandica sp. n.

Caules 10—25, interdum ad 30 cm alti, in caespites densos congregati, cum foliis saepe purpurascentes. Bractea infima saepe lata, patula. Flores in capitulum majus sessile unicum, nec raro insuper minora plura breviter pedunculata dense congregati, parvi, tepalis 2—2,5 mm longis, castaneis, pallide marginatis. Semina 0,9—1,1 raro ad 1,2 mm longa, caruncula ca. 0,1 mm longa praedita. Chromosomata in cellulis somaticis 24, breviter bacilliformia.

Hab. ad intimum sinum Søndre Strømfjord Groenlandiae occidentalis. Typus in tab. 1. depictus, in Museo Botanico Hauniensi depositus.

Luzula groenlandica var. *fuscoatra* var. n.

A typo differt tepalis marginibus pallidis destitutis.

Hab. in Groenlandia occidentalis et in Labrador.

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[1] I am indebted to Mr. TYGE CHRISTENSEN, M. Sc., for the latinizing of the diagnoses.

Distribution and Ecology.

The distribution in Greenland of the *Luzula multiflora* complex is interesting. The various species or subspecies belong to three very different types of distribution. In figs. 3—6 all the finds originating from the collections in the museums in Copenhagen, Oslo, and Stockholm are indicated by dots.

Luzula multiflora (fig. 3). A subarctic species connected with South-West Greenland, but also found in the interior of Godthaabsfjord.

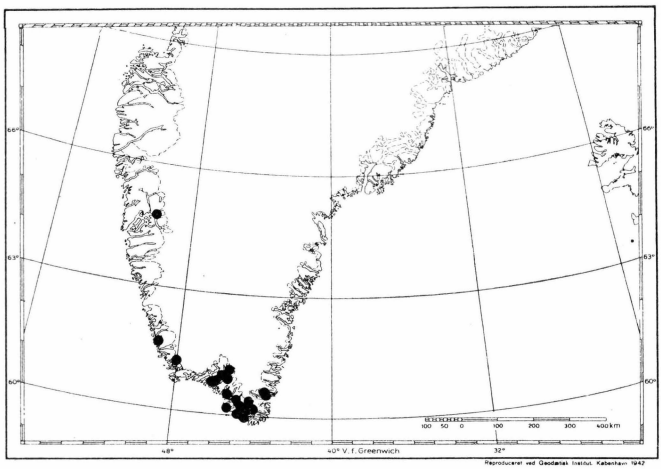


Fig. 3. Greenland range of *Luzula multiflora*.

Northern limit in West Greenland: 64°50′ (Ujaragssuit, M. P. Porsild 1931), northern limit in East Greenland: 60°30′—60°31′ (Narssaq, Møretun, and Grønlia in the area of the Lindenowsfjord, Devold & Scholander 1932, Herb. Oslo). The ecology of the species in Greenland has not been elucidated in detail. In South Greenland it grows in scrubs, and on luxuriant heaths and grassy or herbaceous slopes, i. e. on acid soil rich in humus.

Luzula multiflora ssp. *frigida* and its var. *contracta*, as appears from figs. 4—5, have nearly the same distribution. Both can be characterized as typical low arctic species. The existing finds show a slight difference in the distribution in East Greenland, where only typical *frigida* has been ascertained in the Scoresbysund area. Northern limit in West Greenland: *L. multiflora* ssp. *frigida*: 71°33′ (Qeqertalik, Nûgâtsiaq, M. P. & R. T. Porsild 1929); var. *contracta*: 72°31′ (Laksefjord, Orpik, M. P. Porsild 1911). Northern limit in East Greenland: ssp. *frigida*: 70°30′ (Hurry Inlet, P. Dusén 1899 (Herb. Stockholm)), var. *contracta*: 65°56′ (Tunok, C. Kruuse 1902).

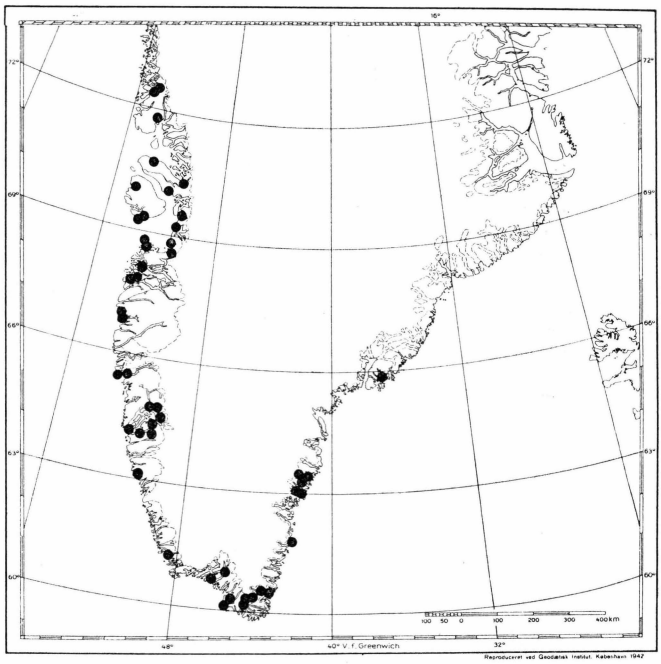


Fig. 4. Greenland range of *Luzula multiflora* ssp. *frigida* var. *contracta*.

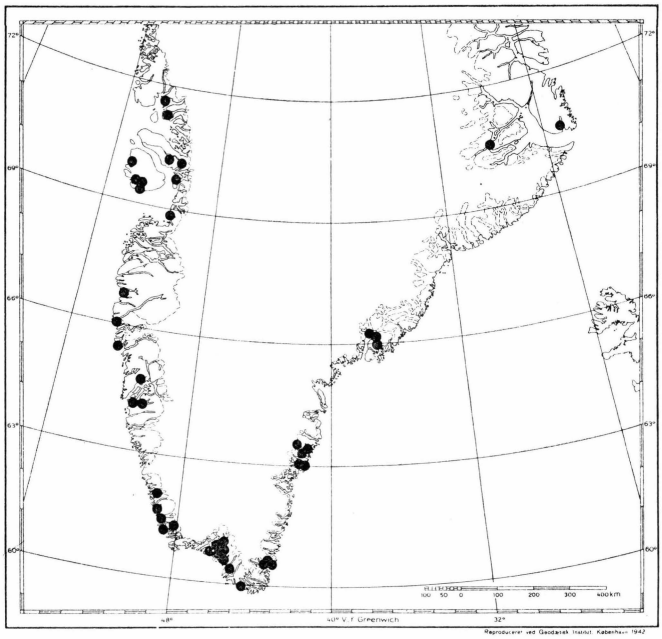


Fig. 5. Greenland range of *Luzula multiflora* ssp. *frigida*.

Luzula multiflora ssp. *frigida* is widely distributed in the Scandinavian mountains and is also found in its typical form in North America (e. g. North-West Newfoundland, Quirpon Harbor, Wiegand, Gilbert & Hotchkiss 1925 (Herb. Oslo)). I have seen var. *contracta* from Dovre in Scandinavia and from Pistolet Bay in North-West Newfoundland (Fernald, Wiegand & Long 1925). Neither of them has been recorded from Iceland, which is peculiar. Further it is remarkable that the two forms of woodrush have not been found at all in the continental inland

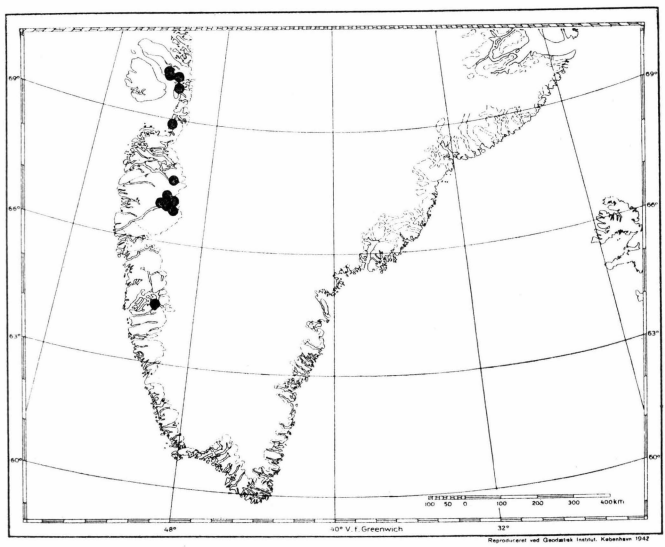


Fig. 6. Greenland range of *Luzula groenlandica*.

around the two large Strømfjords in West Greenland. Both Icelandic soils and the soils of continental West Greenland are on the whole rich in nutrients and even the humus soils are but slightly acid. As both ssp. *frigida* and its var. *contracta* in Greenland seem to be attached to rather oligotrophic communities one may incline to the opinion that edaphic conditions are decisive of the absence in Iceland and the most continental part of West Greenland. Apart from some occurrences together with *Carex microglochin* NORDHAGEN's analyses (1943) also suggest that ssp. *frigida* in Norway is attached to acidophilous communities (e. g. *Carex rigida-Lachenalii* sociations, *Deschampsia flexuosa*- and *Vaccinium myrtillus*-sociations in subalpine birch woods).

Luzula groenlandica (fig. 6). It seems appropriate to give an account of the finds on record:

West Greenland: Northern limit: 70°—70°05′, Nûgssuaq peninsula; Sarqaq and the Sarqaqdalen, J. Vahl 1835, Knud Jakobsen 1947 (var. *fuscoatra*), — Qeqertaq ilua, Knud Jakobsen 1948. — Disko Bugt: Ritenbenk,

J. Vahl 1935, Christianshaab, Thygesen 1875, J. Lagerkranz 1934 (var. *fuscoatra*, Herb. Stockholm). — Nordre Strømfjord: near the edge of the inland ice, A. Kornerup 1879. — Head of the Søndre Strømfjord: Amerlertoq, J. A. D. Jensen 1884, "Søndre Strømfjord" O. Hagerup 1925, (probably Loc. 5, cf. BÖCHER 1949 a) — Own collections (1946) Loc. 4: Ringsødal with its surroundings (2 stations), Loc. 1: margin of inland ice, Loc. 2: Keglen with surroundings (5 stations), Loc. 3: Hassels Fjeld with surroundings (air base) (4 stations), Loc. 5: Strømfjordshavn with surroundings (2 stations); collected in 16 places in all. — Godthaabsfjord: Itivnek (64°20′, southern limit), Warming & Holm 1884, Noe Nygaard 1914. The latter specimen is a big robust plant of a slightly deviating type, if anything, var. *fuscoatra*.

North America: Ungava in Labrador (seeds from here obtained through the botanical garden of Montreal were sown and the plants later cultivated in Copenhagen. They belong to var. *fuscoatra*). The following collections include forms which no doubt are related to *L. groenlandica:* Anatolak in Labrador (C. S. Sewall 1928 "*L. campestris* var. *alpina* Gaud"), Torngat region, Head of Nachwak Bay (Woodworth 1926) — Cape Merry peninsula, Fort Churchill, Frits Johansen 1929 (Herb. Oslo) — Fullerton in Hudson Bay, Macoun 1910, called "*L. campestris* var. *sudetica*", but by SAMUELSSON termed *L. brunnescens* Samuelss. in sched. 1918. A 30—40 cm high plant which has small seeds and a pale margin of the perianth leaves, but the habit and lower involucral leaf reminds of *L. sudetica*.

On the whole *Luzula groenlandica* has a continental-low arctic distribution and obviously belongs to the American floral element in Greenland. Its occurrence in America ought to be investigated in more detail; the *Luzula multiflora* complex here should be investigated more closely. Before chromosome countings are made of a greater number of forms, it is impossible to attain to an adequate systematic classification.

The ecology of *Luzula groenlandica* is widely different from that of *L. multiflora-frigida*. In the Søndre Strømfjord area it particularly occurred in the valleys and not above 350 m above sea level. It has been recorded 16 times in my diaries. Of these 11 are situated on beaches of lakes and 5 at the bottoms of valleys without lakes. The species was in no cases found on the beach of acid lakes. In two cases it was found near neutral, rather oligotrophic lakes and in nine cases near alkaline or salt lakes. 6 *p*H analyses from places where the species occurred range between 6.1 and 8.0. *Luzula groenlandica* prefers open neutral or some what basic, fine-grained soil, which must not be too dry. The biggest individuals were seen on recently dried-up soil near the air base or on half-open soil in the salt-lake basins. Here the species seemed particularly to prefer places where the bottom during the summer dries up to some degree. *Luzula groenlandica* has been recorded from the following communities.

(1) *Calamagrostis neglecta* soc. on the beach of alkaline or salt lakes together with *Primula stricta*, *Carex alpina*, *Draba hirta*, *D. lanceolata*,

Juncus arcticus, *Melandrium triflorum*, *Braya linearis*, *Torularia humilis*, *Lomatogonium rotatum*, *Gentiana tenella*, and *Euphrasia frigida*.

(2) *Carex incurva* soc. on shore of salt take together with *Juncus arcticus*, *Primula stricta*, *Leptobryum pyriforme*, and *Distichium capillaceum*.

(3) *Calamagrostis lapponica* var. *groenlandica* soc. rich in *Aulacomium turgidum* with *Carex alpina*, *Lomatogonium*, and *Ranunculus affinis* in a depression (without any lake), which dries up in summer.

(4) Scattered individuals seen on open spots in *Betula nana–Ledum decumbens* heath rich in lichens on beach of salt lake (see fig. 17 in BÖCHER 1949b).

Distribution and ecology are in good agreement. The continental distribution may very well be due to edaphic requirements: the species seems to require a mineral soil which is fairly rich in nutrients, circumneutral, and not too dry.

This ecological account only applies to the typical *L. groenlandica*. As to var. *fuscoatra* little information is available. Seeds of plants collected in the Sarqaq valley in Nûgssuaq by KNUD JAKOBSEN were sown in Copenhagen and developed into var. *fuscoatra*. According to kind information from KNUD JAKOBSEN the plants in question were growing partly in the river valley in an *Equisetum variegatum* sociation, partly in willow vegetation along a brook. From its associates (e. g. *Carex microglochin*, *Pinguicula vulgaris*, *Rododendron lapponicum*, *Dryas*) it may be concluded that the soil was neutral-slightly basic and not dry. To all appearance, there is thus, as regards the habitat, good agreement between the variety and the main type. Too little is known about the distribution of the variety at present, but it is remarkable that it has been found north and south of the most continental area, viz. on Nûgssuaq and Disko Bugt in the north (on the coast or near it), and in the interior of Godthaabsfjord, where the degree of continentality is much less pronounced than in the interior about the Strømfjords.

Luzula sudetica also has a special ecology. According to NORDENSKJÖLD (1949 p. 81) *L. sudetica* grows on moister soil than ssp. *frigida*. As far as can be judged from NORDHAGEN's analyses (1943) the soil on which *L. sudetica* is found is never extremely acid, but nor basic, either. Most of his *p*H values from places with *L. sudetica* range between 5 and 6.

THE *TORULARIA HUMILIS* COMPLEX

The name of *Torularia humilis* (C. A. M.) Schulz has been preferred for the plant which was previously referred to the genus of *Braya* (*B. humilis* (C. A. M.) Robins.) and which was first of all by C. A. MEYER (LEDEB. Ic. fl. ross. II 1830) referred to the genus of *Sisymbrium*. The characters distinguishing *Torularia* are not, it is true, very numerous, and one of them, "semina uniseriata", which was to characterize *Torularia*, does not apply to the Greenland material, which has biseriate seeds. The difficulties which have appeared at the distinction between *T. humilis* and *Braya linearis* in North-West Greenland (SØRENSEN 1933, GELTING 1934) also suggest that the generic difference is not very pronounced. The two species in the Søndre Strømfjord area, however, are very different and in culture in Copenhagen (fig. 7) just as clearly different both in respect of habit and the duration of the flowering. *Braya linearis* ceases flowering at an early stage and has unbranched flowering stalks which at the top carry the mostly head-shaped compact, rather short siliques. *Torularia humilis* is greatly branched from the base and has a long continuing flowering, an elongated inflorescence, and long siliques (see Plates 4—5). BÖCHER & LARSEN (1950) found 2 n 42 in *Braya linearis* and 2 n 56 in *Torularia humilis* both from the Søndre Strømfjord in West Greenland.

In ABBE's work on *Braya* in North-East America there is a detailed study of *Torularia humilis* and the variation of this plant. Already before I read ABBE's work I had by means of differences in the length of the styles been able to divide the material from East and West Greenland, respectively, into two groups. As ABBE mentions the same difference, this was felt as a strong support of my results, for it must be admitted that the East and West Greenland populations at a more superficial examination do not seem very different.

ABBE has studied 130 sheets of specimens from America and Greenland and finds himself able to distinguish 6 different types, which he calls geographical races. However, he calls attention to the fact that the morphological properties characteristic of these types are "over-

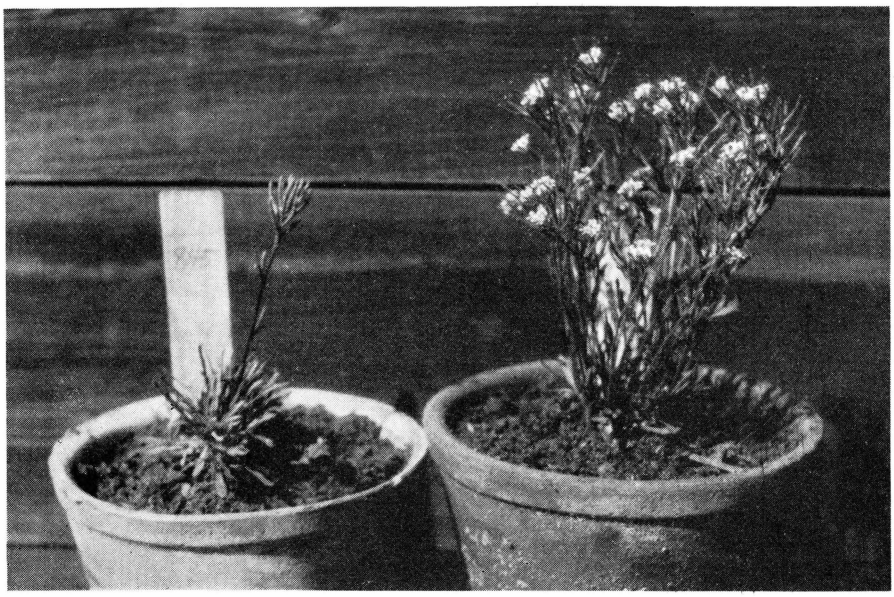


Fig. 7. On the left, *Braya linearis*, on the right, *Torularia humilis*, in culture in the Botanical Garden of Copenhagen (phot. May 1948). Both have developed after sowing of seeds from Søndre Strømfjord. On *Torularia humilis* the head-shaped stigmas are seen as small bright dots.

lapping to such an extent that it would be unjustificable to propose them as varieties." This may be a correct view of most of the races, but it hardly applies to the Greenland ones. According to ABBE's key of the differences between the races the East Greenland one is distinct from all the others by its short style. His key shows the following differences between the two Greenland types.

East Greenland type: Styles of mature fruits short (0.2—0.7, aver. 0.3—0.4 mm long); stigma in fruit not capitate; siliques glabrescent to moderately pubescent, from 0.9—1.2 (aver. 1.0) mm wide. Petals (dry) 3—4.2 mm long.

West Greenland type: Styles of mature fruits long (0.3—1.2, aver. 0.7–1.0, mm); stigmas markedly to moderately capitate; siliques glabrescent, 0.8—1.0 (aver. 0.9) mm thick. Petals (dry) 2.6—3.6 mm long.

Very recently the Danish botanist of the Peary Land Expedition, KJELD HOLMEN, M. Sc., has found *Torularia humilis* at a single station in North Greenland (see below p. 28). His material agrees completely with that found in North-East Greenland and thus we may distinguish between a West Greenland and a North and North-East Greenland type of the species.

As will be shown below, several differences may be added to these. Most important for a quick determination is the style length, where

the mean values are clearly different, for which reason, by examining a certain number of siliques, it will be possible to place a specimen in one of the two groups. I have had an opportunity to see material from North America, also from the west (Alberta, above Lake Louise $^{28}/_{8}$ 1924, C. H. Ostenfeld), and in all cases found long styles. The Central Asiatic material in the Botanical Museum of Copenhagen, on the other hand, has short styles. The original specimen pictured on p. 218 in SCHULZ (1924) has also short styles, whereas the specimen drawn in BUSCH (1931 p. 591) has long styles. It originates from the Kurajskojan steppe. In SCHULZ's diagnosis the style is stated to be 0.5—0.75 mm, rarely up to 1.5 mm. Thus there seems to be much evidence that in Asia there are both long- and short-styled plants and perhaps forms with intermediary lengths of style. SCHULZ has seen material of *Torularia humilis* from the whole of its area of distribution except North and North-East Greenland. This may be the reason why he has not particularly noted the deviating appearance of the North and North-East Greenland plants.

GELTING (1934 p. 60) has compared the East Greenland population with MEYER's original description and finds that the East Greenland plants deviate by the colour of the flower, the length of the silique, by the fact that there are bracts in the lowermost part of the inflorescence and by the duration of life. None of the differences, however, are so radical that they invite separation of the East Greenland plant as a particular species. The figure in BUSCH also shows bracts in the lowermost part of the inflorescence. Altogether the time is not ripe for a monographical treatment of *Torularia humilis*. We must first have more studies of the chromosome number of plants from both Asia and America. But it must be justificable to discuss now whether the differences found between the two Greenland populations are great enough for a systematic distinction between them.

(1) Morphological differences. The difference in the length of style is illustrated by fig. 8, which shows two typical styles, not extreme contrasts. The figure also shows the difference as regards the breadth of the silique, the stigma, the pubescence, and the transition between ovary and style, which is abrupt in the East Greenland population. The last-mentioned characters are of importance at the determination of plants from North-East Greenland, which besides siliques with short styles have a number of siliques with fairly long styles. Such plants are not frequent; they occur in SEIDENFADEN's material from the head of Loch Fyne ($^{3}/_{8}$ 1929) and in TULINIUS's collections from Ymers Ø.

SØRENSEN (1941 fig. 11) pictures an individual of *T. humilis* from Ella Ø, where two basal siliques have fairly long, but broad styles,

whereas all the terminal siliques have very short styles. The individual in question is acauline, which is connected with the fact that inflorescence or infructescence at any stage of development may survive the winter and continue its development in the succeeding growth season. Of course it is not possible to know whether this fact is due to a genetic factor, but no West Greenland plants display any sign of acaulinity or of the inflorescence being developed through two seasons.

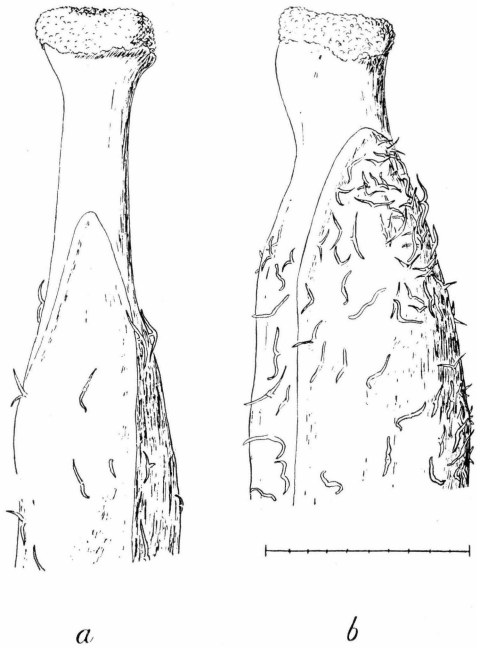


Fig. 8. Upper part of ovary in (a) *Torularia humilis* from Søndre Strømfjord ($^3/_8$ 1946, T. W. Böcher) and (b) *Torularia humilis* ssp. *arctica* from Ymer Island, Dusén Fjord ($^{10}/_9$ 1933, E. Tulinius). Scale 1 mm. long.

The colour of the corolla is described by GELTING as bluish-violet, during the postfloration paler, and by SØRENSEN (1933) as pale lilac. MEYER's original plant had white corollas and SCHULZ denotes them as "alba, dein pallide-violacea", thus in his diagnosis uniting plants with pale lilac and plants with white corollas. The West Greenland plants had white, rarely pale lilac corollas. The same according to A. E. PORSILD (1943) applies to plants from Canada.

There is no remarkable difference in size between specimens of the two populations. Fully developed plants from North-East Greenland reach heights between 4 and 22 cm, from West Greenland heights between 5 and 24 cm. A number of the plants from the head of the

Søndre Strømfjord, however, are extraordinarily vigorous with a range of 45 to 55 flowering stalks from the same rosette, cf. Plate 5.

(2) Duration and life form. Most botanists consider *T. humilis* a perennial. SØRENSEN (1941), however, writes that its life duration is rather limited. Some West Greenland individuals seem to indicate a certain tendency towards being biennial, and in culture in Copenhagen plants of West Greenland origin become biennial after flowering in the second season. A. E. PORSILD considers the species to be perennial, but adds that the root is weak and that the plant usually dies after the second flowering. The individuals from West Greenland often in proportion to their size have rather a small root, while e. g. the East Greenland plant pictured by SØRENSEN has rather a vigorous root, and GELTING with reference to his plants emphasizes that these have a 30 cm long vigorous tap-root.

(3) Ecology. According to kind information received from KJELD HOLMEN the plants found by him in 1949 in northernmost Greenland were growing on dry, sunny basalt rock ledges at the lake Midsommersøen (lat. 82°15′ N., long 35°20′ W.) in the most continental part of North Greenland. The ground was free of snow on May, 27th. Together with *Torularia humilis* a number of high-arctic species occurred, viz. *Potentilla pulchella*, *Puccinellia angustata*, *Melandrium triflorum*, *Poa abbreviata*, and *Taraxacum phymatocarpum*.

The North-East Greenland plant according to GELTING grows on dry, warm soil, particularly soil rich in lime and exclusively on ground free of snow, often on *Elyna* heath. SØRENSEN, however, has seen *T. humilis* covered with snow in winter and has found it up to 5—600 m above sea level. Like GELTING he only mentions dry stations, even loose sand. To all appearance the plant occurring in North and North-East Greenland is a xerophyte.

The West Greenland plant has a different ecology. M. P. PORSILD in 1914 found it at Itivdlinguaq (main loc. 10) on raised marine clay, I. A. D. JENSEN in 1884 on a clayey plain near the river falling into the northern arm of the Strømfjord. My observations may be summarized as follows:

(a) On open sand and clay in bottom of valley (Loc. 3); the soil not particularly dry.

(b) On clay near the shore (Loc. 9). Water oozing out. Accompanying plants: *Carex microglochin*, *Juncus arcticus*, *J. castaneus*, and *Saxifraga aizoides*. 24 cm high individuals, see Plate 5.

(c) Thin clayey soil overlaying wet rocks on a south-facing slope (Loc. 3). Here partly in *Festuca rubra-Tortella fragilis* soc. with *Gentiana detonsa* and *Sisyrinchium montanum*, partly in moss (*Schistidium apocarpum*, *Barbula recurvirostris*, *Riccia sorocarpa*, and others) together with *Juncus bufonius*, *Sedum villosum*, and *Primula stricta*. The *Torularia* plants 5—13 cm high.

(d) Loess soil on the transition between dry steppe and alkaline lake-shore vegetation (Loc. 3). The vegetation gives evidence of salinity (*Puccinellia deschampsioides*, *Lomatogonium rotatum*, *Plantago maritima*, *Pottia Heimii*); *p*H 7.7, Lt 6.4; 17.2 per cent. sodium-potassium saturation, see soil analysis in BÖCHER 1949 b Table 9 (no. 5).

(e) On the shore of salt lakes where main localities 3, 4, and 5 meet. Particularly where the soil gradually dries up; here in *Puccinellia deschampsioides—Plantago maritima* soc. with *Primula stricta* and *Carex capillaris*. *p*H 8.4, Lt 4.3, see BÖCHER 1949 b Table 8 (no. 5).

The West Greenland plant thus prefers a soil rich in lime, saline, not too dry, and has been found only in the valleys, which have a nearly subarctic climate.

On Anticosti Island *Torularia humilis* according to MARIE-VICTORIN (1938 p. 540) grows in the estuary of the Jupiter river on limestone gravel. From Asia it has been stated to grow on gravel and sand along rivers, often on somewhat saline soil or on loess soil. This occurrence, indeed, highly reminds of that in West Greenland.

Thus it appears that the North and North-East Greenland *T. humilis* morphologically and ecologically differs from the West Greenland form. As compared with the latter it is more arctic and more xerophytic. This must justify the reference of the North and North-East Greenland plant to a subspecies of its own; this is named *arctica* and given the following diagnosis:

Torularia humilis (C. A. M.) Schulz ssp. *arctica* ssp. n.

Perennis. Radix palaris, valida, ad 30 cm longa. Caules in planta fructigera 4—22 cm alti, siliquas ferentes 1—2 cm longas, ca. 1 mm latas, in stylos abrupte transeuntes plerumque 0.3—0.4 modo mm longos, stigmatibus non vel paulum capitatis coronatos. Sepala 2.0—3.5 mm, petala 3—4.5 mm longa, pallide violacea.

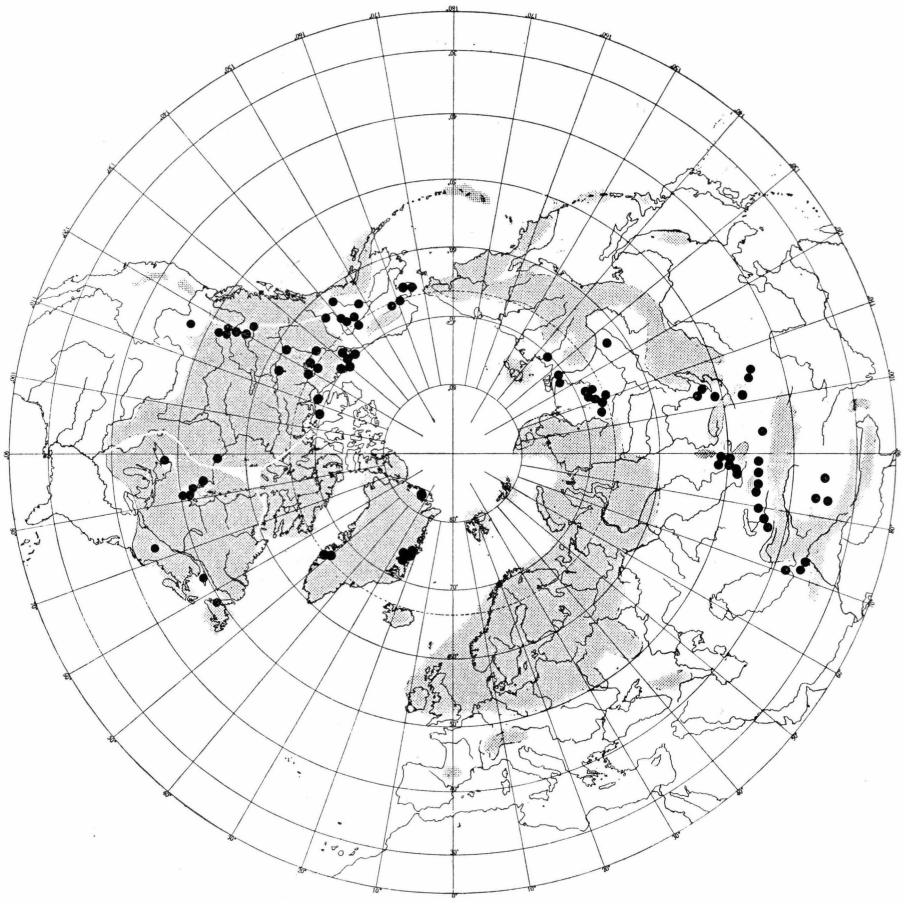
Hab. in Groenlandia boreo-orientali interiore, latitudine 72°54′—82°15′.

Typi in tab. 4 depicti, in Museo Botanico Hauniensi depositi.

A comparison of ssp. *arctica* with Central Asiatic material (Pamir, about 3,800 m above sea level, July 1898, Ove Paulsen; in arenosis prope Tunzam) shows that the subspecies is coarser and bigger with broader siliques and more and bigger flowers, which are always violet. The siliques of the Asiatic plants are 0.75—0.9 in breadth, the sepals are ab. 2 mm long and the petals 3—3.3 mm long in a dry state. They are 13—16 cm high and white-flowered. BUSCH's description and picture show that Asiatic plants may also have somewhat bigger flowers than those examined by me. He states the breadth of the silique to be 0.75 mm and, like SCHULZ, the length of the style to be 0.5—0.75, rarely up to 1.5 mm. Particularly the tenderer growth of the Asiatic plants is remark-

able. It would, indeed, be very interesting—and it is hardly quite improbable—if they belonged to a more original type with a low chromosome number.

Torularia humilis ssp. *arctica* grows very isolated in North and



Total range of *Torularia humilis* in relation to the maximum Pleistocene glaciation (grey areas).

North-East Greenland. It represents the northernmost occurrence on earth of *Torularia*. According to SCHULZ (1924) 12 species of this genus are known. 10 of these occur in Central Asia, 1 in South-West Asia and on the Mediterranean, and 1 in South-East Russia near Simbirsk. Only one species, *T. humilis*, reaches America-Greenland. Accordingly the centre of origin of the genus seems to be in Central Asia (particularly the plateaux); from there, then, there is radiation to the Mediterranean area and America.

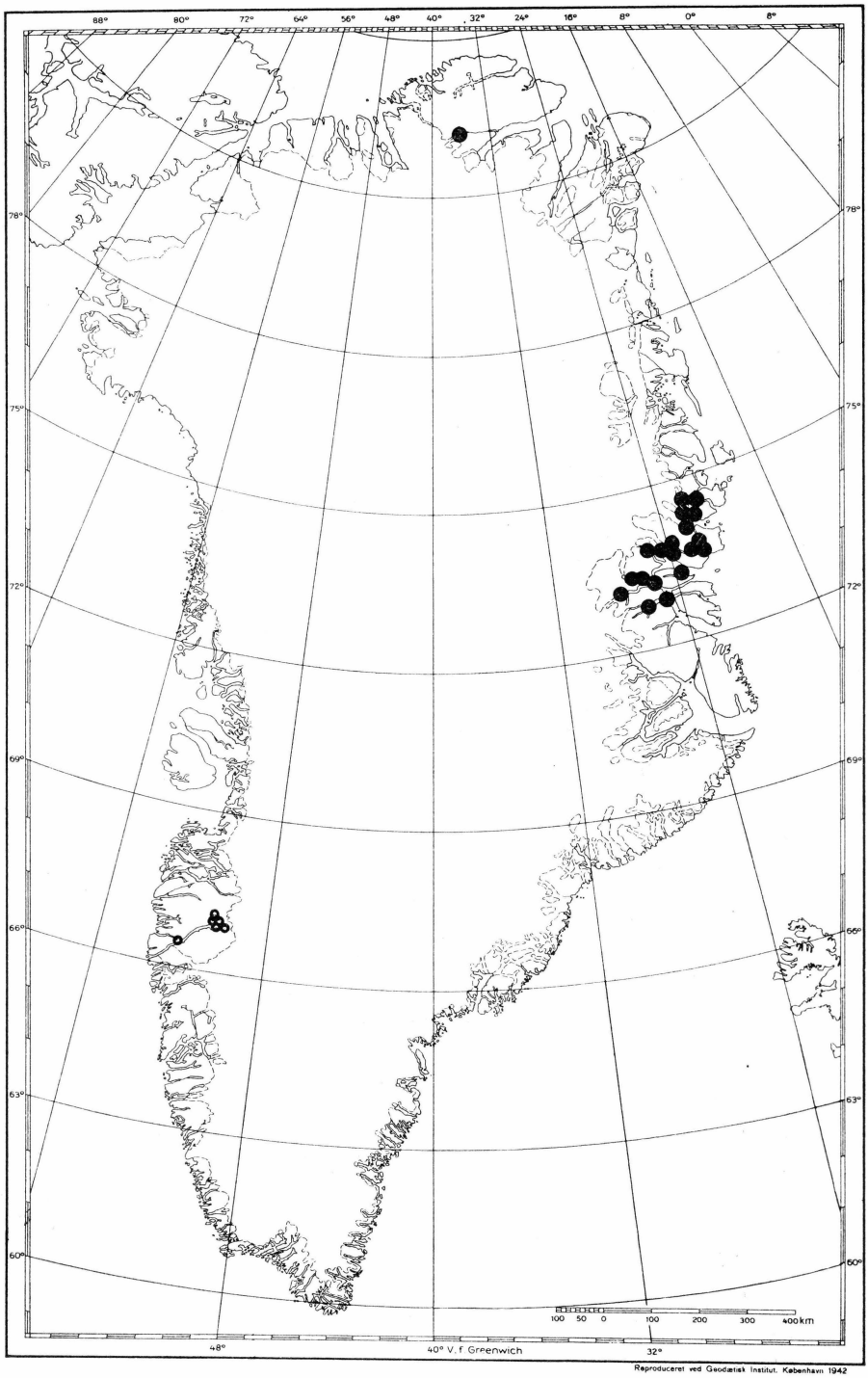


Fig. 10. Large solid dots: *Torularia humilis* ssp. *arctica*. small rings: *Torularia humilis* (typical form).

The total distribution of *Torularia humilis* and its distribution in Greenland appear from figs. 9—10. On the map of the total distribution the chief limits of glaciation are indicated by means of maps in FERNALD (1929), TOLMATCHEW (1932), and HULTÉN (1937). The Asiatic occurrences, which, as it were, wedge in between previously ice-covered terrain, are extremely remarkable. In the south the plant is found on the plateaux, but not on the ridges of the mountain ranges. In the north it grows in the lowlands. In America it is in Alaska connected with non-glaciated areas, farther east, on the other hand, it is found on terrain which at certain period was ice-covered. It is customary to distinguish between three ice-sheets in America, the Cordilleran in the west, the Keewatin in the middle of the continent, and the Labradorian in the east. It is known that these ice-sheets reached their maximum distributions in various periods and that the area of maximum accumulation of ice shifted from west to east during the Ice Age (WRIGHT 1937 p. 187). Whereas the occurrences in the Rocky Mountains may be explained by assuming the occurrences of ice-free nunatak areas here, the more northerly occurrences near Great Slave Lake and Great Bear Lake may be explained through a supposition that the species here spread from refugia in the north when the Keewatin ice-sheet was retreating towards the east. Also the occurrences near Southern Hudson Bay and James Bay are situated almost where the Keewatin and the Labradorian ice-sheets each from its direction, but at different times, reached an outer limit. The species may have followed the retreating Keewatin ice-sheet and penetrated into the space between the latter and the Labradorian ice-sheet. The other East American stations, perhaps with a single exception, are situated in places which are considered to have been ice-free. It is obviously a species which prefers conditions on the margins of large ice-sheets, and it seems that it has to a small degree, only, been able to capture terrain after the Ice Age on the extensive areas in Northern Asia and Central Canada which were formerly glaciated. If we keep this fact in mind, the small Greenland areas look very interesting. There seems to be no room for doubt that these narrow areas of occurrence are historically conditioned. GELTING (1941) has already discussed the Greenland occurrences. He supposes that the inland ice was formerly divided by an ice-free zone from the south-west to the north-east and that the species then migrated across the country through the ice-free corridor. Of course there is a possibility that this is true. But the remarkable difference between the East American-West Greenlandic population and the North and East Greenlandic one is not very indicative of it. The fact that short-styled forms are found both in Asia and North-East Greenland would seem to indicate that the North and North-East Greenland population had immigrated from

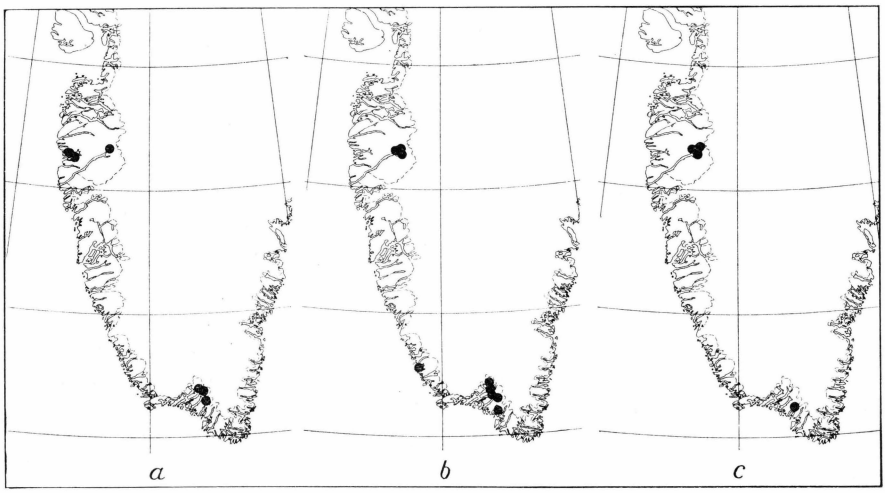


Fig. 11. Greenland ranges of *Roegneria* (*Agropyrum*) *violacea* (a), *Scirpus pauciflorus* (b), and an undetermined *Antennaria* species, closely related to *A. compacta* (c).

Siberia as GELTING supposes in the case of *Draba sibirica* or *Potentilla stipularis*. The long-styled West Greenland population, on the other hand, originally probably came from America. However this may be, it is a fact that the three small Greenland areas support the theory of continental refugia during the Glacial Age in Greenland.

The West Greenland area is situated more than sixteen degrees of latitude north of the nearest station in Newfoundland. Similar great distances are mentioned on p. 10 in connexion with the occurrence in the Søndre Strømfjord of *Carex capitata*. The area of *Luzula groenlandica* in continental West Greenland, too, lies isolated. The isolation, it is true, is not so pronounced if we include its var. *fuscoater*, considering that this form and some closely related ones are found in Labrador. However, nobody has succeeded in finding forms in American material which agree with the typical *Luzula groenlandica*. Hence it is not excluded that the latter is an endemic Greenland race occurring in the same small area in which typical *Torularia humilis* and *Carex capitata* have their Greenland occurrences.

Besides the above-mentioned species it is worth mentioning *Arctostaphylos uva ursi*, which in Greenland has been found only in the Søndre Strømfjord area. But there are also some species with two or three areas isolated from each other in Greenland one of which coincides that of the species already mentioned near the Søndre Strømfjord. These species deserve a more detailed mention:

(1) Species found only near the Søndre Strømfjord and in the continental area of the Godthaab region: *Sisyrinchium montanum* (see

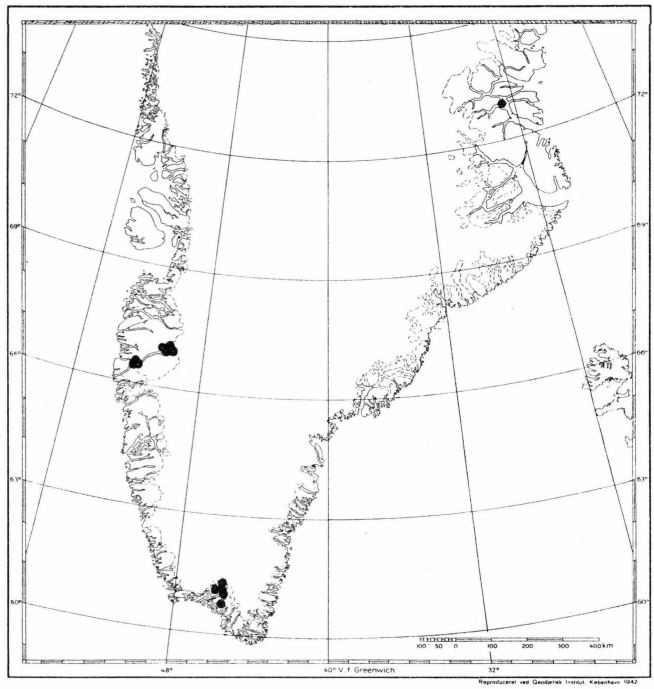


Fig. 12. Greenland range of *Gentiana detonsa*.

Fig. 13. Greenland range of *Juncus bufonius*.

Böcher 1948), *Ranunculus cymbalaria* (see M. P. Porsild 1935, Böcher 1949 a).

(2) Species with the same distribution as the preceding group, but further found in the interior of South Greenland: *Orchis rotundifolia*, *Juncus alpinus* var. *alpestris*.

(3) Species found only near the Søndre Strømfjord and in South Greenland (chiefly in the interior): *Roegneria violacea* (fig. 11 a and

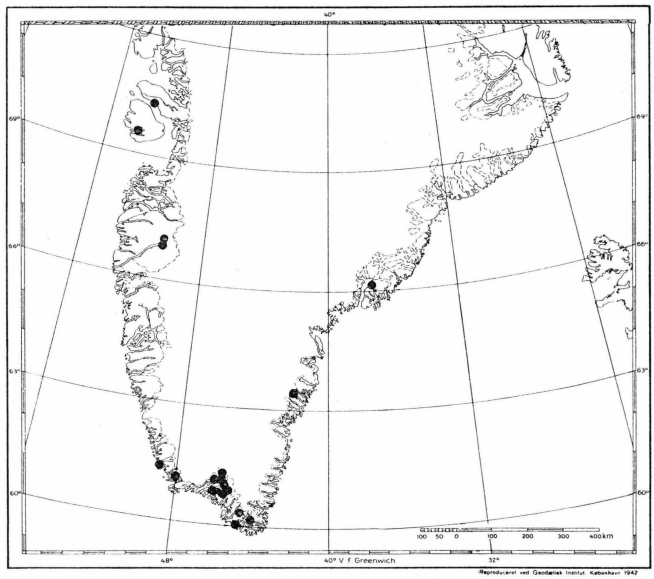


Fig. 14. Greenland range of *Gentiana aurea*.

Melderis 1950), *Scirpus pauciflorus* (fig. 11 b), *Antennaria* sp. ad *compacta* (fig. 11 c), *Potamogeton gramineus*, *Roripa islandica*.

(4) Species distributed as the preceding ones, but further with a single station in North East Greenland: *Gentiana detonsa*, *Juncus bufonius* (see figs. 12—13).

(5) There are several species with many small areas, no doubt each of them isolated and one of them situated near the Søndre Strømfjord. As examples of this category *Gentiana aurea* and *Primula stricta* (figs. 14—15) may be mentioned.

(6) Finally there is one species which falls under Gelting's bicentric category, and which grows at the head of the Søndre Strømfjord and in North Greenland: *Gentiana tenella*; see map in Gelting 1941 p. 84.

Thus there are at least 18 species with an isolated area near the Søndre Strømfjord. Among these there are several the small Greenland

areas of which are situated very far from the nearest areas outside Greenland. This applies to the *Sisyrinchium* species and *Ranunculus cymbalaria*. The latter has its northern limit in Labrador in lat. 54° north. The stations of *Orchis rotundifolia* and *Arctostaphylos uva ursi* nearest to Greenland are situated in the interior of Hudson Bay and on Anticosti-Newfoundland. *Primula stricta* is found isolated at Akureyri

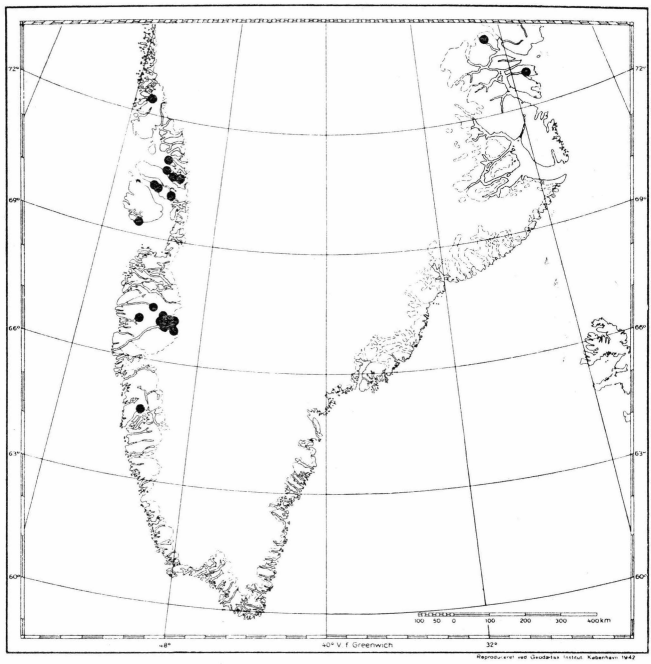


Fig. 15. Greenland range of *Primula stricta*.

in Iceland (map fig. 143 in GRØNTVED 1942) and in northern Labrador. *Gentiana detonsa* is common in North and South-West Iceland (GRØNTVED, *loc. cit.*), but in America occurs only as westerly as on the arctic coast of Mackenzie district. *Gentiana tenella*, which is common in Iceland, is found at a single station in Northern Quebec (RAYMOND 1950 p. 326) but otherwise in America not before Colorado and Alaska, and *G. aurea*, which likewise is common in Iceland, is in America found only in Unalaska and Sitka. The *Antennaria* species which is closely related to *A. compacta* seems also to occur in a few places in the northernmost Labrador and southern Baffin. *Juncus bufonius*, if anything, is cosmopolitan and accompanies man. Its behaviour in Greenland, however, is very strange. At the head of the Søndre Strømfjord it grew near salt lakes and near the *Sisyrinchium* station (cf. p. 28), and in North-East Greenland it has been found in the Storefjord on Liverpool Land

(July 1933, A. Noe-Nygaard) far from any human dwelling. It is common in Iceland, but has not been mentioned at all as occurring in the Canadian Eastern Arctic by POLUNIN 1940.

It is difficult for me to imagine that a merging of so many small isolated areas as the one which may be ascertained in the Søndre Strømfjord can be explained except through the theory of perglacial survival. It is true that the area in question is comparatively well investigated and that the conditions of climate and soil here without doubt are rather unique, but presumably this can at most weaken the theory. It is true that future investigations in Greenland may lead to more findings of many of the species mentioned, but they will hardly be able to show that the species in question have a distribution which can be explained completely from ecological conditions (climate, soil). The idea that the Søndre Strømfjord area during the last Glacial Period housed a large continental refugium to plants and animals perhaps is supported also by my observations of terraces and loess deposits in the interior (1949b). Different observations thus give further support to the theory previously (1938) advanced that even southern species might exist during the last Glacial Period in Greenland.

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PLATES

Plate 1.

Luzula groenlandica, on the left from the shore of a salt lake north-west of Strømfjordshavn, Søndre Strømfjord Loc. 5, Aug. 3rd, 1946 (T. W. Böcher no. 858), on the right from the air base in the Søndre Strømfjord, Loc. 3, July 27th, 1946 (T. W. Böcher no. 860).

Scale 10 cm. — M. Køie phot.

Plate 2.

Fig. 1. On the left *Luzula sudetica* from Switzerland, in the centre *L. groenlandica* from the Søndre Strømfjord and on the right *L. multiflora* ssp. *frigida* var. *contracta* from West Greenland. Note the great morphological similarity between the latter two species, which, however, can easily be distinguished by the sizes of the flowers. — M. Køie phot.

Fig. 2. Two rows of flowers showing the difference in size between flowers of *Luzula groenlandica* (above) and *L. multiflora* ssp. *frigida* var. *contracta*. ab. × 8. — M. Køie phot.

Fig. 1.

Fig. 2.

Plate 3.

Different seed samples from species of the *Luzula multiflora* complex. (1) *L. groenlandica* from the Søndre Strømfjord in West Greenland. (2) *L. groenlandica* var. *fuscoater* from Ungava in Labrador. (3) *L. sudetica* from Riesengebirge. (6) *L. sudetica* from the Alps. (4) *L. multiflora* ssp. *frigida* var. *contracta* from Holsteinsborg, West Greenland. (5) *L. multiflora* ssp. *frigida* from Rødeø in Scoresby Sund, East Greenland. (7—8) *L. multiflora* from South Greenland, Tasermiut and Qaqortoq. (9) *L. pallescens* from Montreal. × ab. 9. — M. Køie phot.

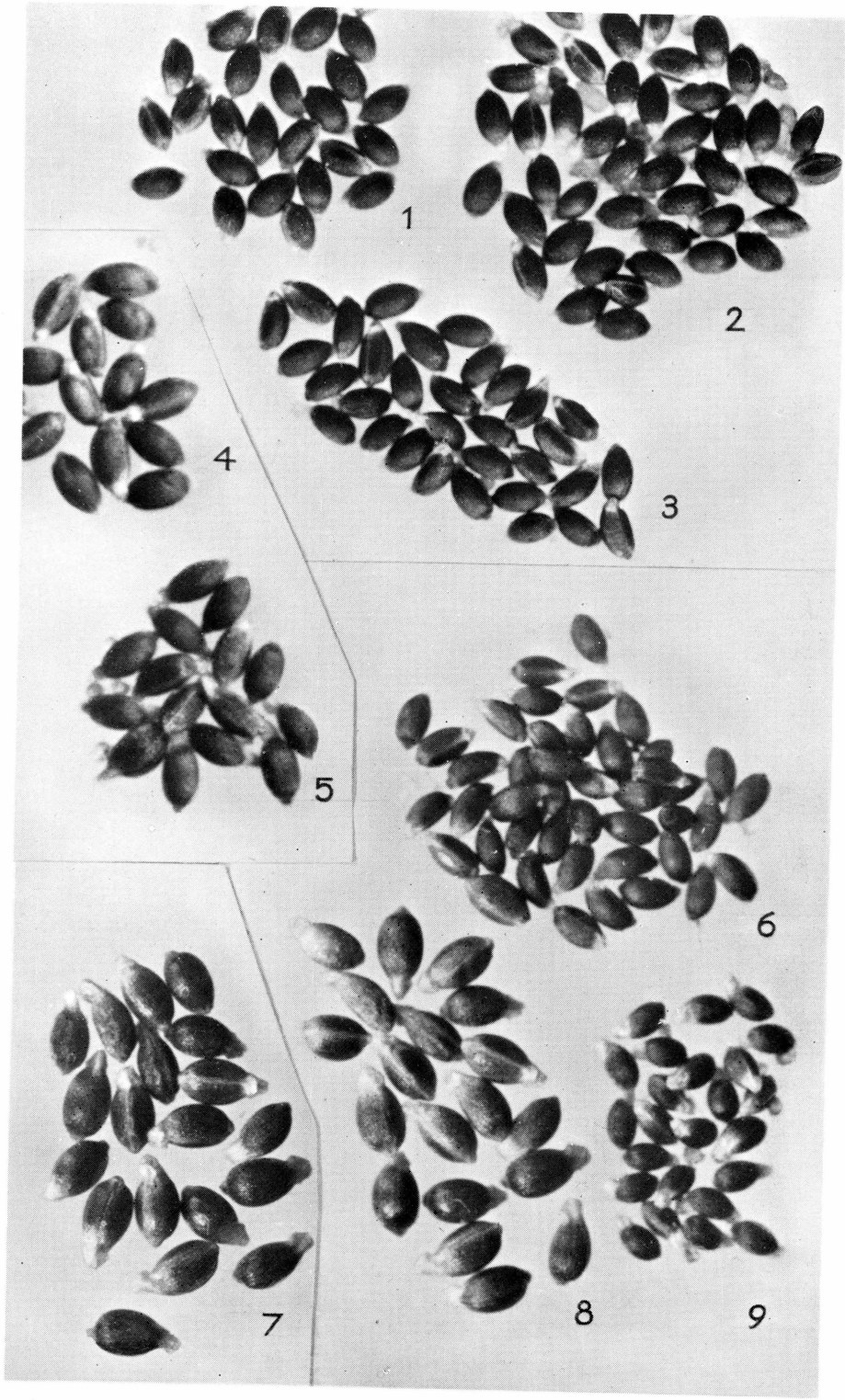
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Plate 4.

Torularia humilis ssp. *arctica.*

Above on the left: Jordanhill (74°07′) North-East Greenland, $^{27}/_{7}$ 1930, G. Seidenfaden. Two small flowering plants.

Above on the right: Ymers Ø, Duséns Fjord, north of the anchor place. $^{10}/_{8}$ 1933, E. Tulinius. Very vigorous plant with quite mature siliques.

Below on the left: Granatelv, Clavering Ø, $^{19}/_{7}$ 1933, Th. Sørensen. A vigorous plant in full bloom.

Below on the right: The west side of the head of Loch Fyne, barren, $^{3}/_{8}$ 1929, G. Seidenfaden. Two tender plants with mature siliques, which are broad, but with rather a long style. Note the basal position of the siliques.

Scale 10 cm. — M. Køie phot.

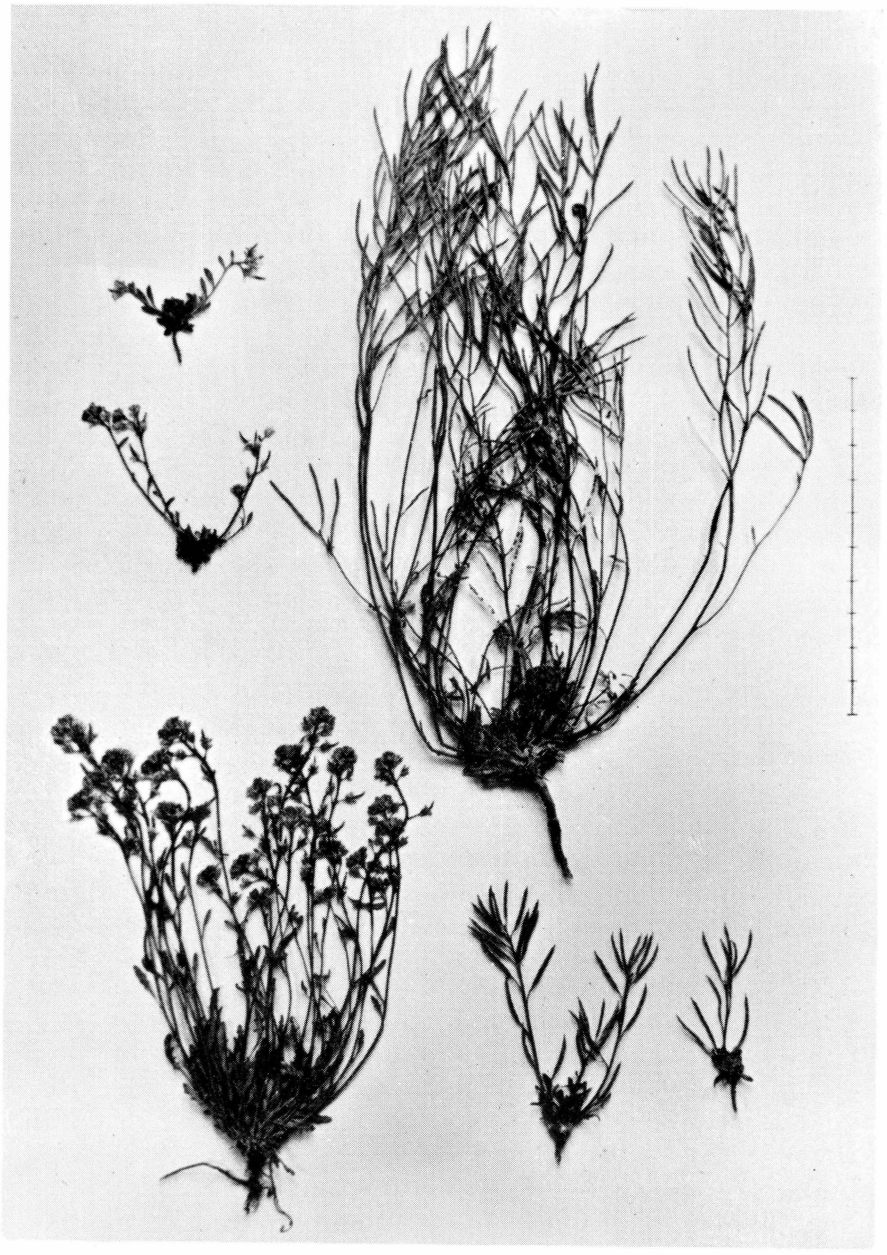

Plate 5.

Torularia humilis.

Above: In clay on a slope at Vandfaldskløften, Søndre Strømfjord, Loc. 9, $^{21}/_{8}$ 1946, T. W. Böcher. Very vigorous individual, which has also flowered the preceding season.

Below on the left: Thin soil overlaying wet rocks on south-facing slope, Hassels Fjeld, Loc. 3, $^{6}/_{8}$ 1946, T. W. Böcher.

Below on the right: Three small individuals from the same station as the preceding one, but collected $^{27}/_{8}$ 1946, T. W. Böcher.

Scale 10 cm. — M. Køie phot.

Plate 5.