B I O L O G Y

Comparative Ecology of Colonizing Species of Vascular Plants

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During the summer of 1967 two trips were made to Surtsey and one trip to the nunatak areas Braedrasker and Kárasker in Vatnajökull.

On the 20th of June when the author investigated particularly the northern part of Surtsey no trace at all could be seen of about 15 small specimens of Cakile edentula (Bigel) Hook. and a single specimen of Elymus arenarius L. which had been found growing in the sand on the south bank of the coast a month earlier (Thorarinsson, pers. comm.). They must therefore either have been washed away by the sea or covered by the loose sand which the wind blows to and fro on the coast now and then. The same day, however, 6 specimens of Cakile edentula, 5 of them tiny seedlings only, and the 6th rather small, were observed near the high tide mark on the north-east coast of Surtsey in a straight easterly direction from the little lake and about midways between this lake and the nearest shore. These plants were growing where a layer of sand had nearly covered heaps of ashore drifted seaweeds, mainly Ascophyllum nodosum. No plants had been observed in this area before. Besides that two additional small specimens of Cakile were found near the north-west corner of the little lake.

On June 26th it was observed that one of these Cakile specimens had flowered (Thorarinsson, pers. comm.), the first plant specimen ever to flower on Surtsey.

During the summer of 1967 some mosses also started to grow on Surtsey. At first mosses were observed on sand near the north-west corner of the lagoon on the north coast. On September 9th two separate clusters of mosses were observed in this locality, one of them being about 70 cm in diameter. These mosses could have been dispersed to the island by man. On this same day the author observed some moss clusters near the central part of the island (see map) where, at

least, no macroscopic plants have been observed growing before and this locality is situated more than 500 m from the shore at an altitude of about 60 m. The mosses were growing in four separated clusters on a thin sand or tephra layer covering the edge of a lava field where the lava is still lukewarm. These mosses have been identified by the bryologist B. Jóhannsson, Department of Botany, Museum of Natural History, Reykjavik, and the names are published here with his kind permission. The species are Funaria hygrometrica Hedw. and Bryum argenteum Hedw. Both these species are common on Heimaey and elsewhere in Iceland (Jóhannsson pers. comm.) and are very often dispersed by man. The locality where they grow on Surtsey is situated just along a footpath commonly used by scientists working on the island and, as mentioned before, more than 500 m from the shore. It is therefore most likely that these two additional species have been dispersed by man, although various measures have been taken to prevent human disturbance and dispersal of biota to the island.

On the same day a tiny plant was observed growing in a mixture of sand and tephra on the south-east coast of Surtsey by the amateur algologist S. Hallsson. This locality is very much alike most of the localities on the north-northeast coast area where all the cormophytes known to grow in Surtsey had been found until this very day, i.e. situated at the high tide mark on the relatively flat coast, but at a distance of about 1 km farther south. This plant was investigated by the author the next day and identified as Honkenya peploides (L.) Ehrh. and it has without doubt been dispersed by the sea from Heimaey as the other Honkenya specimens found in Surtsey.

During the days September 9 to 11 a thorough study of all the specimens of vascular plants found on Surtsey was carried out. It then became evident that a small grass specimen, which was at first thought to belong to Elymus arenarius L. could hardly be correctly identified. It was considered, because of the shape of the base of the blade, the ligula and the sheath, to be more alike Festuca rubra L. Later microscopical investigation of a transverse section of a blade in a laboratory confirmed this identification. Festuca rubra L. is a very common species in the Vestman islands (Fridriksson and Johnsen 1967) and for instance found on Súlnasker, about 10 km east-north-

east of Surtsey. As easterly winds are common here, Festuca rubra might have been dispersed by sea this short distance to Surtsey At least the transport of seeds by sea could have taken so short a time that the seeds might have survived such an immersion in salt water. The fact that Festuca rubra was found on Surtsey, growing near the high tide mark on the coast, supports the suggestion of dispersal by sea. This species could though also have been dispersed by birds this short distance as numerous birds have been observed on Surtsey (Gudmundsson, 1966 and 1967) and very often seen on the coast of the island. The total number of specimens observed growing on the island at this time was 46 cf. fig. 1, but some of them were very small and other almost covered by sand. These specimens belonged to five species:

Honkenya peploides (L.) Ehrh. 26 specimens were observed. None of the specimens had flowered and no buds were observed.

Cakile edentula (Bigel) Hook. 14 specimens were observed, most of them vigorous and healthy looking. Far the biggest specimen was about 70 cm long and 40 cm broad. All 14 specimens had flowered and were with fruits, 5 of them were also still with a few flowers.

Elymus arenarius L. 4 specimens were observed. None of them had flowered.

Mertensia maritima (L.) S.F. Gray. A single small specimen with only one leaf of a normal size was observed. No sign of buds could be seen.

Festuca rubra L. A single small specimen was observed. No sign of flowering could be seen.

Most of these specimens are growing in loose sand at the high tide mark on the relatively flat coast and the sea will without doubt wash many of them away during the winter. Two or three of the Cakile specimens, the westernmost growing Honkenya and the Mertensia, however, have a slight chance of escaping being washed away. But as the winter storms are heavy and the sand is very loose they are in great danger of being covered by sand-drifts or simply blown away.

Dispersal

Of the five species of vascular plants which have been observed growing on the island Surtsey up to the present day, four are halophilous species and have without doubt been dispersed to the island from the Vestman Islands. The seeds of both Cakile and Honkenya are of a large size and well adapted to floating (Löve, D. 1963) and they are known to be able to stand immersion in salt water. Seeds of Mertensia and Elymus are also relatively large and able to float. The fifth species, Festuca rubra, might also have been dispersed by sea this short distance from the Vestman Islands to Surtsey, but it is also quite possible that this species has been dispersed by birds. Other species of coastal plants might as well be dispersed to Surtsey in the near future by the sea and they will probably be able to grow in the uniform sand habitat of the coast. Seeds and parts of other plant species will probably also continue to drift ashore on Surtsey, but it is rather unlikely that the seeds will germinate or that the plants will be able to grow in this coastal habitat. More non-coastal species common in the Vestman Islands might occasionally be dispersed to Surtsey from the nearest islands, or even the Icelandic mainland which is only about 32 km away from Surtsey, by birds, and some of such species may succeed in surviving. Dispersal of species with light seeds by wind should also be possible over these short distances mentioned before. Mosses seem to have been dispersed to Surtsey already by man and even some species of vascular plants might be dispersed in the same way in spite of every attempt made to prevent such dispersal.

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In August 1967 an expedition was made to the nunataks Braedrasker and Kárasker in Vatnajökull's big southern outlet Breidamerkurjökull. Braedrasker was investigated earlier in 1963, 1965 and 1966. In 1965 seven plots of the size of 1 m^2 each were marked in the oldest part of the nunatak for making it possible to study the plant succession on the nunatak (Einarsson 1967 and 1968) and vegetation analyses carried out in these plots in 1965, 1966 and 1967. The results of the analyses are found in table 1. The Hult-Sernander scale was used

for cover estimation. Still in 1967 the cover in all plots was far less than 1/16 of the surface. Some changes have been observed to have taken place in these plots during the years 1965 - 1967. Some of the first observed specimens in the plots have not survived and others have invaded. In plots nos. 3 and 6 specimens found in 1965 were dead in 1966, and in plots nos. 2 and 7 specimens found in 1966 had disappeared in 1967. In both 1966 and 1967, however, new colonizing species were found in many of the plots, for instance nos. 1, 2 and 3, and the number of specimens of some of the species has also increased in some of the plots. In each of plots nos. 2 and 5 for instance, one specimen of Poa alpina L. was found growing in 1965, and in 1966 several small specimens of the same species were observed growing around the old ones and in 1967 most of them were still about. In plot no. 7 one specimen of Cerastium alpinum L. was found growing in 1965; in 1966 several seedlings of the same species were observed around the old specimens and in 1967 the old one was dead but three of its descendants had survived and were healthy looking.

The total number of species of vascular plants found in Braedrasker is 23, cf. table 1, but some of the species have only been observed once and not found again. The most common vascular plant in 1967 was Saxifraga caespitosa L. closely followed by Poa alpina. Then come Poa flexuosa Sm., Cerastium cerastoides (L.) Britton and Cerastium alpinum. The mosses on Braedrasker are becoming more prominent than before, but the most common species are still Philonotis tomentella Mol. and Rhacomitrium canescens (Hedw.) Brid.

Just after 1940 the Björnsson brothers at the farm Kvísker, the nearest farm west of Breidamerkurjökull observed that a small area in the middle of Breidamerkurjökull, situated about 13 km from the margin of the glacier, had become free of ice. According to their opinion the ice most likely retreated from this area in the late thirties, i.e. about 30 years ago (Björnsson, S. 1958), and in 1957 and 1958 they made expeditions to the area which they named Kárasker and found 33 species of vascular plants growing scattered in the area (Björnsson, H. 1958). Kárasker which is built up of basalt and rhyolite (Einarsson, Th., pers. comm.) and almost completely covered

by basalt-rhyolite morains, is a mountain slope, sloping 5° to 20° to the east-north-east. In early September 1965 it was about 500 m broad and 1 200 m long, the altitude being from 580 to 760 m.

Hálfdán Björnsson from Kvísker (1958) describes the vegetation of Kárasker as being pretty luxuriant in some sheltered depressions and rivulet beds and dominated by grasses and other vascular plants. In the more exposed gravel flats between the depressions Björnsson, however, reports the vegetation to be very sparse and scattered but mostly dominated by the same species. This means that in Kárasker there was already then, about 20 years after it became free of ice, a distinct difference between the vegetation in the sheltered depressions with a favorable snow cover and soil moisture and the vegetation of the more exposed and dry gravel flats between the depressions. In the six years old Braedrasker no such difference can as yet be observed, on the contrary, the plants seem to be growing there completely accidentally scattered over the oldest part of the nunatak. Thirty three species of vascular plants were then found in Kárasker, cf. table 2. The most common ones were Cerastium cerastoides and Poa alpina. Three species of mosses not identified are reported, but the mosses were found in few places only and were much less prominent than the vascular plants. No lichens or fungi were observed. In a small rivulet, however, some filamentous algae were observed.

During the 1961 expedition five additional species of vascular plants and five species of mosses were found cf. table 2. No lichens or fungi were observed. The vegetation was still dominated by grasses, but mosses seemed to be a little more prominent than before. Far the most common species were Poa alpina and Cerastium cerastoides, but Arabis alpina L., Deschampsia alpina (L.) R. et S., Oxyria digyna (L.) Hill, Poa flexuosa and Trisetum spicatum (L.) Richt. were also common.

In 1963 three additional species of vascular plants were observed in Kárasker, cf. table 2. The mosses were obviously more prominent than in 1961. One fungus, Russula alpina (Blytt) Möll. et Schaeff., was observed. On flat rocks in the central part of the nunatak some thalli of a crustaceous lichen were found together with

Rhacomitrium canescens, the biggest of them being 5 to 8 mm in diameter, but without any apothecia and as a whole so immature that it was not possible to identify them although they all seemed to belong to the same species. The vegetation of the most sheltered depressions was getting still more luxuriant and in most places dominated by Poa alpina, which is the most common plant species of the nunatak. Other common species of vascular plants were Cerastium cerastoides, Arabis alpina, Deschampsia alpina and Poa flexuosa. On the more exposed gravel flats the vegetation was much more sparse and scattered, but also dominated by Poa alpina, especially in the central and the southern part of the nunatak, other common species being Poa flexuosa, Saxifraga caespitosa, Saxifraga oppositifolia L., Trisetum spicatum and Rhacomitrium canescens. On a few gravel flats in the northern part even Arabia alpina was dominating. Most of the plant specimens in Kárasker were observed to be very healthy looking and seemed to be doing well.

In 1965 still two additional species of vascular plants were observed in Kárasker, cf. table 2, and some species of mosses. Vegetation analyses were carried out in eight plots which were clearly marked for future studies of the plant succession. As a whole the vegetation of the sheltered depressions had not changed much, although mosses are still becoming more prominent. The same species of vascular plants are dominating, i.e. Poa alpina and other grasses, but Cerastium cerastoides and Arabis alpina were not as common as before, at least not relatively. On the gravel flats the vegetation was somewhat more prominent, the dominating species being Poa alpina, Deschampsia alpina, Poa flexuosa, Poa glauca, Vahl., Oxyria digyna, Saxifraga caespitosa, Trisetum spicatum and Phleum commutatum Gaud.

In 1967 three new species of vascular plants were found in Kárasker. The total number of vascular plants found in this 30 year old nunatak is therefore 46 and 38 of them have been observed during two or more separate trips to the nunatak. In 1967 identifiable lichens were found in Kárasker for the first time, i.e. Peltigera apthosa (L.) Willd. and Stereocaulon sp. In the eight plots there had been some changes since 1965, new species had colonized many of the plots and others passed away, and in half of the plots the

vegetation cover had increased. Especially the cover has increased in plots nos. 7 and 8, cf table 2, which are both found in a favourably sheltered depression in the oldest part of the nunatak. In plots nos. 3 and 5, which are found on gravel flats, the vegetation was also covering a higher percentage of the surface than in 1965, and in plot no. 5 mosses were found for the first time in 1967.

At the present time it is difficult to make any comparison between the plant succession and vegetation of the nunataks and the colonization of Surtsey by higher plants. So far no vascular plants have succeeded to survive during the winter on Surtsey, as they have been covered by sand or washed away by the sea, and therefore no permanent vegetation has as yet been established there. As already mentioned some of the plant specimens observed growing on Surtsey have a fair chance to survive this winter, at least the mosses in the central part of the island.

The vegetation of the two nunatak areas has, however, been compared with the vegetation of the third nunatak area in Breidamerkurjökull. The name of this area is Esjufjöll, and it is much bigger than the other two. Esjufjöll are composed of four mountain ridges, the biggest ranging about 500 m above the surrounding ice. This area has a flora of 96 species of vascular plants and has without doubt been free of ice during the whole postglacial period, and as its vegetation is untouched by man and sheep, it is probably very close to a climax vegetation. The Kvísker brothers, mentioned earlier, have investigated this area and the present author studied it in 1961. As the area, however, is very big, it needs a much more intensive investigation. But so far it can be stated that the grass species, which dominate the vegetation of Kárasker and Braedrasker, are without doubt pioneer species which do not play any important role in the vegetation of Esjufjöll.

Most of the species of vascular plants found in Braedrasker and Kárasker are considered to have been dispersed to these nunataks by wind and they have probably been blown along the surface of the ice to the nunataks from the nearest mountains, a distance of 5 - 7 km. Some of the species, however, might have been dispersed by birds;

Vaccinium uliginosum L., which was found growing in Kârasker for the first time in 1967, has thus without doubt been dispersed to the nunatak by birds.

References

Björnsson, H. 1958: Gróður og dýralíf í Káraskeri. Jökull 8. 19-20.

Björnsson, S. 1958: Könnunarferð í Kárasker. Jökull 8. 15-17.

Einarsson, E. 1967: Comparative Ecology of Colonizing Species of Vascular Plants. Surtsey Research Progress Report III, 13-16.

" 1967: The Colonization of Surtsey the New Volcanic Island by Vascular Plants. Aquila. In press.

" 1968: Vegetationen på nogle nunatakker i Vatnajökull. Naturens Verden. In press.

Fridriksson, S. and Johnsen, Björn, 1967: On the vegetation of the Outer Westman Isles, 1966. Surtsey Research Progress Report III, 20-36.

Gudmundsson, F. 1966: Birds observed on Surtsey. Surtsey Research Progress Report II, 23-28.

" 1967: Bird Observations on Surtsey in 1966. Surtsey Research Progress Report III, 37-41.

Löve, D. 1963: Dispersal and Survival of Plants. North Atlantic Biota and their History, 189-205. Oxford.

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TABLE I

All species of vascular plants and the most prominent moss species found in Braedrasker. The numbers 63, 65, 66 and 67 in the column marked Year mean that the species were found for the first time in 1963, 1965, 1966 and 1967 respectively. The results from the vegetation analysis carried out in 1965, 1966 and 1967 in seven plots marked 1 to 7 are found in columns 1 to 7 respectively. For cover estimation the Hult-Sernander scale was used.

Species	Year	1			2			3			4			5			6			7		
		65	66	67	65	66	67	65	66	67	65	66	67	65	66	67	65	66	67	65	66	67
Arabis alpina	65							1														
Cardaminopsis petraea	66																					
Cerastium alpinum	65																			1	1	1
Cerastium cerastoides	65																					
Draba norvegica	67																					
Epilobium lactiflorum	65																1					
Festuca vivipara	67																					
Luzula spicata	65																					
Minuartia rubella	65																					
Oxyria digyna	65					1																
Phleum commutatum	66																					
Poa alpina	65	1	1	1	1	1	1							1	1	1					1	
Poa flexuosa	65										1	1	1									
Poa glauca	65																					
Sagina intermedia	65																1	1	1			1
Sagina procumbens	65																1	1	1	1	1	
Saxifraga caespitosa	65		1	1		1	1													1		
Saxifraga oppositifolia	66		1	1																		
Saxifraga rivularis	67																					
Silene maritima	66																					
Sedum annuum	65																1					
Trisetum spicatum	63																					
Veronica fruticans	66																	1				
Ceratodon purpureus	63					1	1															
Philonotis tomentella	65	1	1	1	1	1	1		1	1					1	1			1			
Pogonatum urnigerum	66					1																
Pohlia wahlenbergii	63								1	1								1	1		1	1
Polytricum juniperinum	66		1	1																	1	1
Rhacomitrium canescens	63					1			1	1	1	1	1		1	1					1	1

TABLE II

All species of vascular plants, fungi, lichens and the most common moss species found in Kárasker

The numbers 58, 61, 63, 65 and 67 in the column marked Year mean that the species were found for the first time in 1958, 1961, 1963, 1965 and 1967 respectively. The results from the vegetation analysis carried out in 1965 and 1967 in eight plots marked 1 - 8 are found in columns 1 - 8 respectively. The numbers found in the second line from above mean the estimated percentage of the vegetation cover in each plot. For cover estimation the Hult-Sernander scale was used. In some of the plots the mosses were not identified to the species.

Species	Years	1		2		3		4		5		6		7		8	
		35		25		15	20	20		1	5	30		25	40	60	70
		65	67	65	67	65	67	65	67	65	67	65	67	65	67	65	67
Arabis alpina	58			1	1	1						1	1	1	1	1	1
Armeria maritima	58																
Cardaminopsis petraea	58																
Cerastium alpinum	58			1													
Cerastium arcticum	61																
Cerastium cerastoides	58	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Deschampsia alpina	58	1	1													4	4
Draba norvegica	58																
Epilobium anagallidifolium	58														1		
Epilobium lactiflorum	58			1								1	1			1	1
Erigon boreale	67																
Festuca rubra var.mutica	58																
Festuca vivipara	58																
Galium normanicii	58																
Gnaphalium supinum	61																
Luzula spicata	58																
Minuartia rubella	61																
Oxyria digyna	58	2	2			1		1	1			1	1			1	1
Phleum commutatum	58			2	2			1	1								
Poa alpina	58	1	1	1	1		1	1	1	1	1	1	1	1	2	1	1
Poa flexuosa	58	1	1	2	2			1	2		1						
Poa glauca	58	1	1														
Ranunculus glacialis	58																
Rhodicia rosea	58																
Sagina intermedia	58																
Sagina procumbens	63																
Sagina saginoides	65																
Salix herbacea	61																
Salix callicarpaea	63					2	3										

Species	Years	1		2		3		4		5		6		7		8	
		35		25		15	20	20		1	5	30		25	40	60	7
		65	67	65	67	65	67	65	67	65	67	65	67	65	67	65	6
Saxifraga caespitosa	58						1									1	
Saxifraga cernua	58																
Saxifraga nivalis	58																
Saxifraga oppositifolia	58																
Saxifraga rivularis	58																
Sedum annuum	65																
Sedum villosum	58																
Sibbaldia procumbens	67																
Silene acaulis	61																
Silene maritima	63																
Taraxacum sp.	58																
Thymus drucei	58																
Trisetum spicatum	58	1	1			1	1	1	1			1	1	1	1	1	
Vaccinium uliginosum	67																
Veronica alpina	58																
Veronica fruticans	58																
Viscaria alpina	61																
Brachythecium rivulare	65																
Bryum affine	61																
Ceratodon purpureus	65															1	
Hygrohypnum sp.	65											1	1				
Philonotis tomentella	61	2	2									1	1	1	2		
Pohlia annotina	61																
Pohlia proligera	61																
Pohlia wahlenbergii	61							1	1			1	1			4	
Polytrichum alpinum	61													2	2		
Polytrichum juniperinum	61																
Rhacomitrium canescens	61	1	1					1	1							1	
Mosses (not identified)				2	2	1	2				1						
Russula alpina	63													1	1		
Peltigera apthosa	67														1		
Stereocaulon sp.	67																

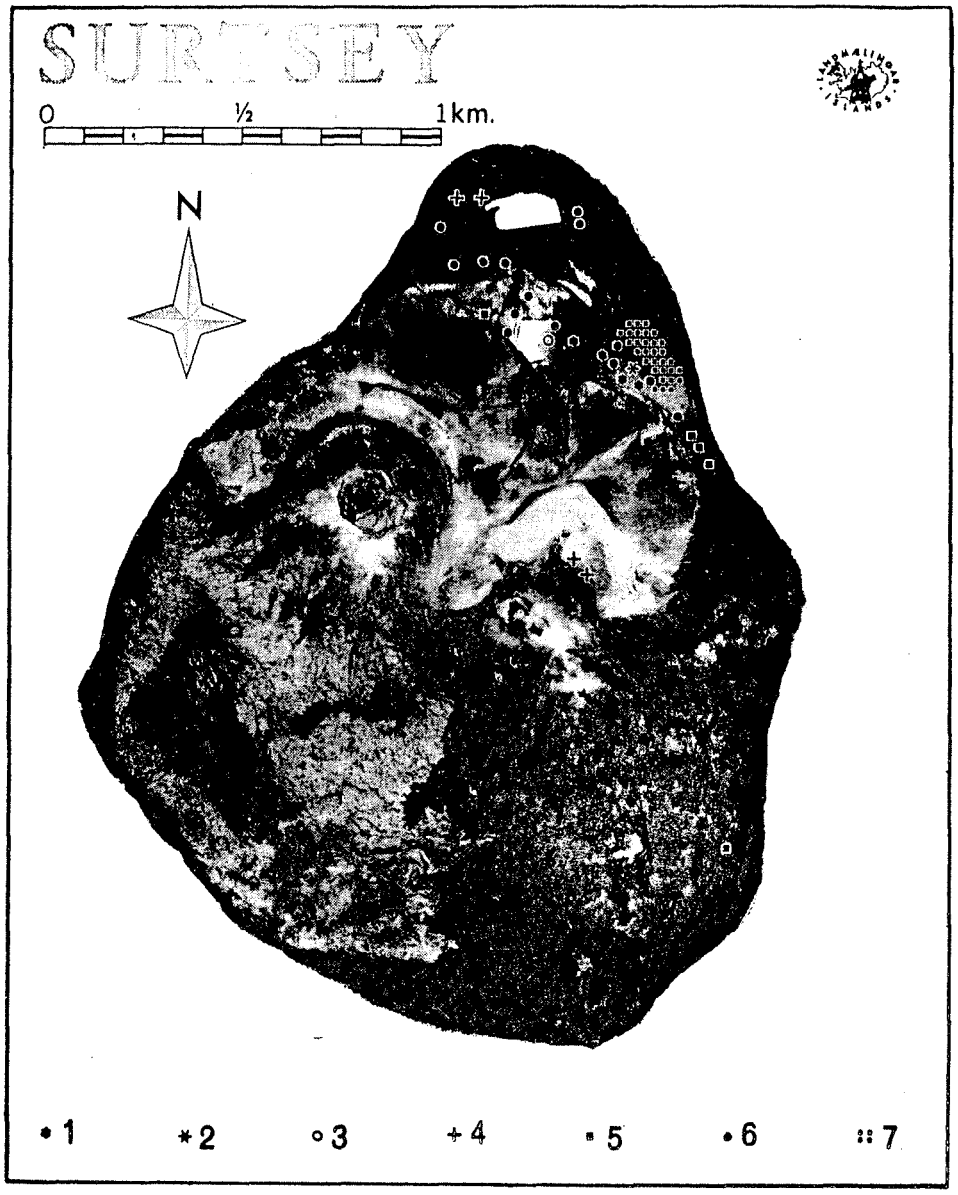

Figure 1. Air photograph of Surtsey 13 July 1967. Landmælingar Íslands (Icelandic Survey Department). All the plant localities mentioned in the paper as they were on 11 September 1967 are marked on the photograph. Each of the bigger marks shows the locality of one specimen. 1: Elymus arenarius, 2: Festuca rubra, 3: Mertensia maritima, 4: Mosses, 5: Honkenya peploides, 6: Cakile edentula, 7: 21 specimens of Honkenya peploides scattered over a small area.