THE WILDFOWL TRUST'S SECOND EXPEDITION TO CENTRAL ICELAND, 1953

By Peter Scott, Hugh Boyd and W. J. L. Sladen

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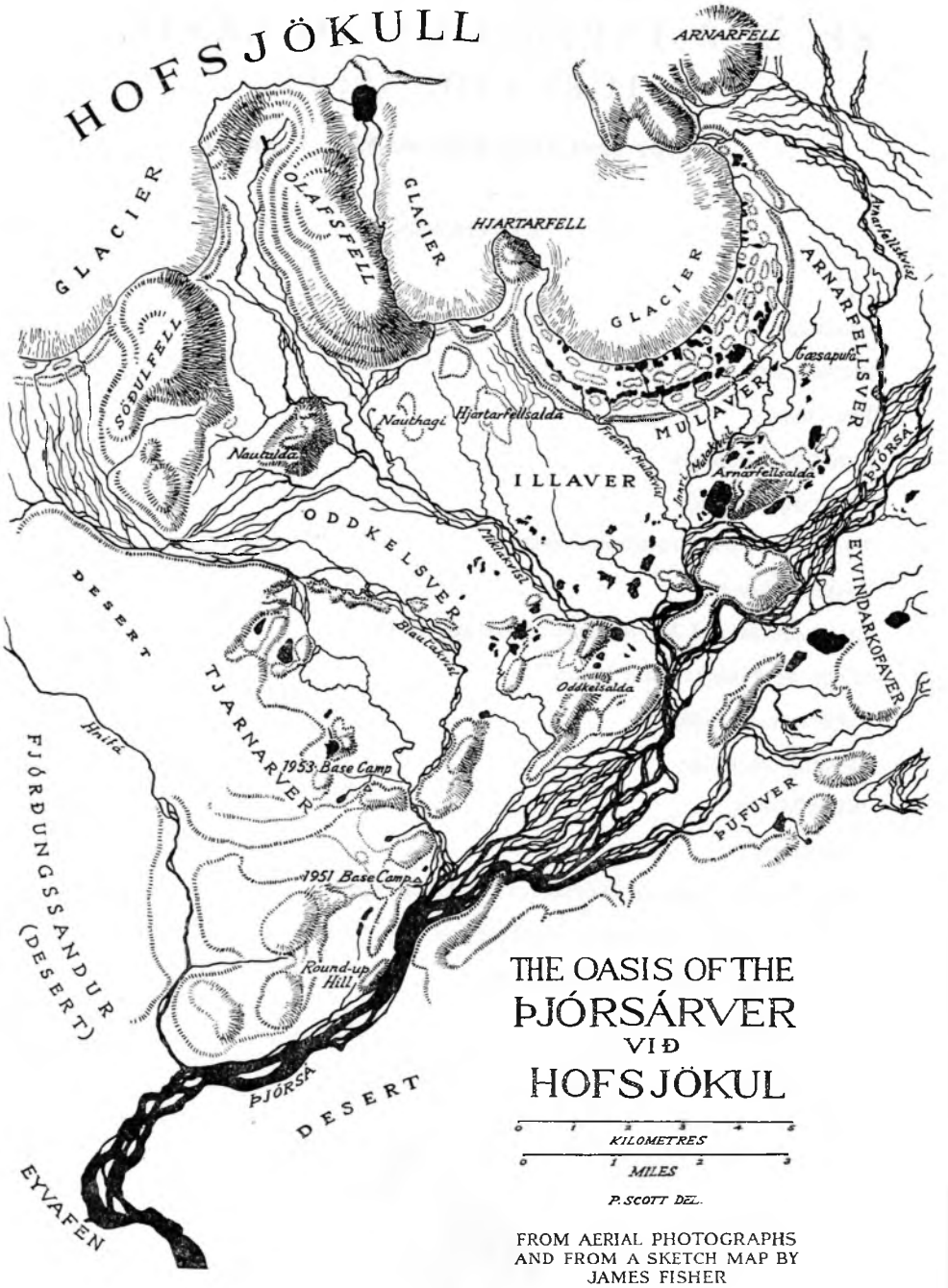
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FROM AERIAL PHOTOGRAPHS AND FROM A SKETCH MAP BY JAMES FISHER

SUMMARY

Accurate measurements of the population of the Pink-footed Goose *Anser brachyrhynchus* by the marking and sampling method required ringing of these geese on a much larger scale than had previously been achieved. The success of the Trust's 1951 expedition to the Pinkfoot breeding-colony in Þjórsárver, near the Hofsjökull icecap, suggested that techniques of capture then discovered might be very successful if developed and used throughout the period of about four weeks when the adult geese are flightless through moult and the young have not yet grown their wings. A party of eight, including three Icelanders, spent 29 days in this oasis of vegetation in the central highlands. 4144 adult geese and 4861 goslings were caught. 260 of the adults carried rings put on in previous years and marking methods are described in some detail. The size of the breeding colony in mid-July 1953 is estimated from local recapture data at 8200 adults and 10,200 goslings.

Recaptures provide evidence that comparatively few one-year-old geese were captured, and that two-year-olds were present in numbers and distributed throughout the colony, rather than assembled in non-breeding flocks, but it is considered unlikely that two-year-olds breed successfully.

The numbers of predators present in the area in 1953 was smaller than in 1951. Attempts to measure gosling losses are described. None of the methods used is very precise, but it appears that in both 1953 and 1951 the losses between hatching and entry into the measurable British population in mid-October amounted to about three-fifths of the goslings hatched. The casualties occur mainly in the first two or three weeks of life and immediately on arrival in Britain (in late September and the first week of October). Losses of this magnitude are consistent with the estimated replacement rate necessary to maintain the species at its present level of numbers.

The length of the flightless period is thought to be rather shorter than was previously believed—about 25 days. A number of abnormal geese which were caught are described.

Examination of some birds for evidence of fungal respiratory disease was negative.

Three new species of birds were added to the list of 32 seen in the area in 1951, and 44 new species of plants to the list of 108 then found. A collection of plants was preserved for the British Museum (Natural History).

INTRODUCTION

During the summer of 1951 a Trust expedition consisting of five people had visited the Central Highlands of Iceland and found there, in the oasis of Þjórsárver við Hofsjökul[1], the largest known breeding colony of Pink-footed Geese. As described in the Fifth Annual Report (pp. 79–115), the party marked 1151 of the geese during the period of about a month in July when the goslings are old enough to ring but cannot yet fly and the adults have moulted their flight feathers and are themselves flightless. The most efficient method of capturing the geese for marking—by rounding them up at the top of a hill and herding them into a net—was only discovered during the last few days of the 1951 expedition, when on one occasion 267 geese were captured in a single drive.

As the Trust's population study of the Pinkfoot progressed it was realised that accurate population measurement demanded marking on a much larger scale than had hitherto been attained. It was thought that if the method used during the last week of the 1951 expedition could be employed during the whole of the three to four weeks of the flightless period, and even, perhaps, improved upon, a really useful number of geese could be marked, and the inaccuracies arising from samples which are too small could be greatly reduced.

Accordingly special nylon stake-nets were made and an expedition of eight was planned for the summer of 1953—two seasons after the previous one. Once more it was supported mainly by grant from the Royal Society. Further grants were made by the Zoological Society of London, the Bristol, Clifton and West of England Zoological Society, the British Museum of Natural History and the Wildfowl Trust. The party of five from England consisted of the authors, Arthur Mansfield and Christopher Sellick. In Reykjavík, Kjartan Kjartansson, a student on vacation, joined the expedition as interpreter. We set off in two vehicles, a bus and a truck, on 7 July, travelling first along roads to Hvitavatn and the Kerlingarfjöll Hut (Ásgarð) and then across country. The vehicles were driven by the well-known Icelandic travellers Guðmundur Jónasson and his brother Jón Jónasson. After frequent delays during the crossing of a pass with snowdrifts, an extensive lava flow, marshes and soft sand, across all of which no road of any kind existed, the site for the Base Camp, which had been selected in 1951, was finally reached two days later on 9 July. The same afternoon the cavalcade of ten riding ponies arrived by a different route, having followed the Þjórsá ; they were in the charge of Valentinus Jónsson (a member of the 1951 expedition) and Árni Magnusson. The new camp site was about a mile from Bolstaður, the Base in 1951, and had the advantage of a series of cold springs and a small stream which arose from them.

[1] Pronunciation of Icelandic names :

Þ, þ = th as in thin.	j = y
Ð, ð = th as in then.	ll = tl as in Bootle.
Á, á = ou as in thou.	ó = as in blow.
f = v	ö = er as in her.

Thus :—Þjórsá = Thyorsou (The affix á = river).
Hofsjökull = Hŏfsyerkootl (-jökull = glacier).
Þjórsárver við Hofsjökul = Thyorsourvair vith Hŏfsyerkool (-ver = meadows and the whole phrase therefore means " The meadows of the River Þjórsá at the Hofsjökull icecap." In this phrase the word Hofsjökull is in the dative and has only one concluding l so that the t sound is absent.)

Between 10 July and 6 August flightless geese were rounded up in 36 drives which resulted in 8745 being newly ringed while a further 260 were caught which had been ringed in previous years, giving a total of 9005.

During the four weeks the technique of round-up was carefully studied and developed so that many of the later catches were of considerable size. After one round-up 3167 geese were assembled on the top of a low hill, and in a different area 3115 were walked into the nets. Very great pains were taken to avoid any injuries or losses which might have resulted from the drives ; the goslings were fed while waiting to be marked, and every effort was made to reduce to the minimum the splitting-up of families. The number of known deaths attributable directly or indirectly to the activities of the ringing-party was 13 goslings and one adult—0·16% of the geese handled.

By 21 July it was apparent that the 7000 rings originally taken in by the expedition were likely soon to run short. It was therefore arranged by radio that a further 3000 (the last remaining in Iceland of the appropriate size) should be flown in by light aeroplane, which duly landed on one of the two landing-strips laid out by the expedition. These had been marked so as to be visible from the air by riding the ponies in single file round the perimeter of the selected strips of desert some three miles from the Base camp.

The throats of 254 of the geese were swabbed by Sladen for evidence of a fungus infection. The results are discussed in a separate paper by Sladen and Austwick (pp. 133–138). Sladen also made an extensive collection of botanical specimens, now in the British Museum (Natural History). Lists of the species of flowering plants and mosses will be found at pp. 93–97.

By 6 August most of the geese were able to fly again and the party returned to Reykjavík in a single truck on 7 August, while the ponies made their way down by way of the Þjórsá route.

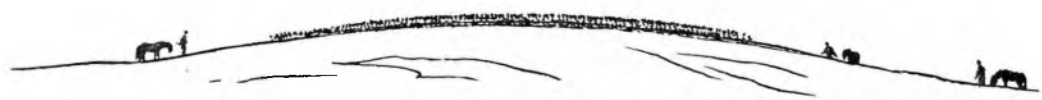
The present paper may be regarded in part as an addendum to Scott, Fisher and Guðmundsson (1952)—5th Annual Report, pp. 79–115. As, on this second occasion, all eggs had hatched some time before the expedition arrived in the oasis, no new observations on nesting geese were made, but in other fields it was possible to make useful comparisons between the two seasons and, in addition, some new discoveries were recorded.

During the expedition Scott and Sladen recorded the methods of capture and marking on ciné-film. The material obtained has been combined with shots of rocket-netting to produce a 16 mm. film illustrating ' A Population Study of the Pink-footed Goose.'

THE OASIS

The Þjórsárver við Hofsjökul—the area in which the geese breed—is about 13 miles long by 7 miles wide at 2000 feet above sea level. It is a patch of rich vegetation surrounded on three sides by lava desert and bordered on the fourth by the terminal moraine of the Hofsjökull ice-cap. The bulk of the vegetation consists of four species of dwarf willow, and extensive areas of sedge and cotton grass, but more than 150 other species of plants are represented. There are many tributaries leading from the ice-cap into the Þjórsá, often running in ' braided channels ' across broad levels of black shingle. There are also several shallow lakes and large numbers of pools in the more marshy parts of the oasis.

During the 1953 expedition the good weather raised the level of the milky water in all the glacier rivers with the result that the Þjórsá could not be forded, as it had been in 1951. The party was therefore confined to the north-west side of the big river.



CATCHING METHODS

It might be thought that the publication of a detailed description of the method by which such large numbers of geese can be captured held the elements of danger that it might be used for their destruction or in some other way detrimental to their welfare. This aspect has been most carefully considered and we believe that the danger is not very great for the following reasons.

Icelandic farmers, some of whom (our guides) are now intimately acquainted with the technique, are, in our view, extremely unlikely to use it for the capture of geese for food because they do not face starvation as their forefathers did in ancient days. Canned food is easier and cheaper to get and more tasty than dried goose-meat.

Secondly, the Icelandic Government, at the suggestion of the Trust, is in the process of declaring sanctuaries in all the Pinkfoot breeding colonies in Iceland. Although it might be possible for unauthorised persons to visit the Þjórsárver við Hofsjokul late in the season, a large expedition with ponies and the necessary equipment could not be prepared without Government permit, and drives on the scale here described could not be undertaken except by a large expedition.

We believe therefore that, although marking on this scale should not be necessary again for several years, it is desirable for any future expedition to be able to obtain the best results with the least disturbance to the geese, rather than have to learn the technique all over again by experience—which in this case took two seasons to acquire.

In 1951 the method of rounding-up the flightless geese into a gaggle on top of a hill and then driving them into a corral or pen of netting was only discovered during the last week of the expedition. That year the expedition consisted of five people, though for one major drive it was reduced to four by the fact that James Fisher had sprained his ankle.

In 1953 the number was increased to eight. Ten might perhaps have been better, indeed of people who know the technique there could hardly be too many. On the second expedition only two members of the party, Scott and Valentinus Jónsson, had had the 1951 experience, and the remainder had to learn the details of the method from the early catches.

The technique was the product of two observations in 1951 : first that, when flightless, Pinkfeet tend to run up-hill, and secondly that when they get to the top they pause, looking all round, as though loth to leave the summit. In 1951 and in the early catches in 1953 the tactics were to place ' backstops ' behind a suitable hill bordering a feeding marsh, and then drive the geese towards the hill, closing in behind them when they reached the top. The distribution of the geese in the oasis is irregular but there are certain areas in which the feed is evidently good and here geese are usually to be found. It may be only a few hundred yards to the nearest hill-top. Such drives could muster several hundred birds, but were directly dependent on the topography. Certain hills lent themselves much better than others to the unseen approach of the backstops.

But as the bigger drives were thought out and attempted a new method developed. This involved selecting any hill or mound—however small—in the middle of a large feeding area, spacing the team all round it, and as nearly as possible equidistant from it, and moving in simultaneously (to a prearranged timetable) towards the centre, in slow time. This was satisfactory as it gave the birds plenty of time to move forward, and indeed it was an essential part of the technique that they should not be hustled. Superimposed upon this simple plan were the main physical features of the oasis—the glacier tongues with their jumbled moraines and the Þjórsá. Neither the moraines nor the river formed any barrier to the geese, indeed they were an ideal source of escape, but the mounds of soft grey shingle were virtually impassable to men and horses and the Þjórsá was equally uncrossable. Between these two boundaries the tributary streams running from the glaciers to the Þjórsá were, most of them, only crossable even on horseback at certain selected fords. Thus the big round-ups were also to some extent circumscribed by the topography.

Nevertheless these big round-ups of 1000–3000 geese were obviously by far the most rewarding and did not seem to be any more disruptive to the goose-flocks than the smaller ones. With the knowledge and experience we now possess, it would probably have been possible to mark the same number of geese in, say, four big drives and perhaps four or five smaller drives of outlying arms of the oasis (instead of 36). Such a programme could have been carried out in 14 days between 18 and 31 July. Had a crossing of the Þjórsá been possible a further four days would have been needed extending the period to 18 days, say from 16 July to 2 August. The time taken in between drives is dictated by the necessity for resting the ponies (and incidentally the men). Icelandic ponies can maintain their strength on the available grazing in the oasis, if given every third day off for rest and feeding.

From the time that a gaggle of geese is gathered together on a hill-top, it acquires (provided that there are more than 50 birds) a type of cohesion based on the security which the birds feel once they are part of a flock. This is familiar in most species of herd animals and in many respects the rounding-up of geese resembles the rounding-up of sheep. Thus when surrounded by four or five of the team a flock of even 3000 geese could be held in a state of equilibrium. In this state the goslings and sometimes the adults would feed, preen, sit down and even sleep. The general lack of panic, even of any signs of fear, was most remarkable at such times. The fact that birds perfectly capable of flight often remained with the gaggle until after they had been herded into the corral illustrates the curious sense of security apparently derived from being with the mass of other geese.

In 1951 until the last catch the nets had been staked out *before* the drive began (in some cases several days before) but on 1 August 1951 the geese were rounded-up first and the nets put out afterwards, while the birds were held by the rest of the party. This method was exclusively used in 1953.

The earlier arrangement required a considerable amount of netting with long ' wings ' leading to a horseshoe-shaped pen. But the new method needed only the pen and a short guiding wing.

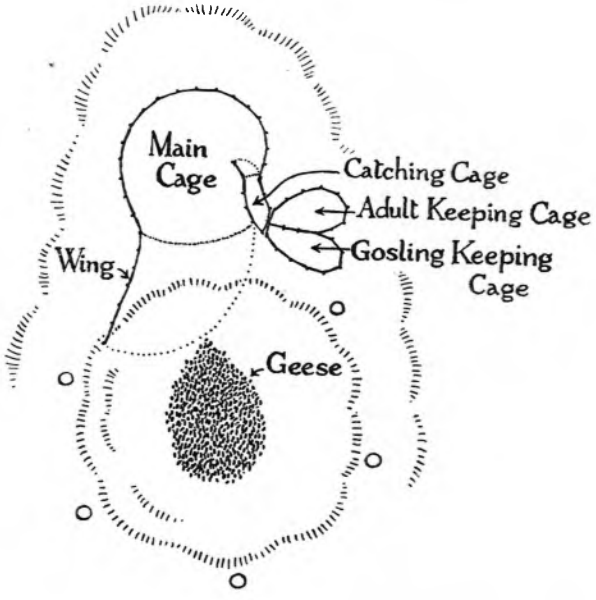
In 1953 three nets totalling 120 yards in length, three feet high and of half-inch mesh (knot to knot) were made of 210-6-ply nylon. This was to be supported every six feet by a four-foot greenhart stake. Unfortunately it was found at an early stage that the six-ply nylon was not really strong enough. The geese made frequent holes and were able to escape until the netting was doubled, which reduced the operative length of netting to 60 yards. Furthermore it was found that the stakes should be not more than three feet apart. Since some of the stakes broke, and others had been used for various important improvisations round the camp, we were glad of the cache of rather shorter but still serviceable stakes which had been left in the Kofi (stone and turf shepherd's hut) near the base camp at Bolstaður in 1951. Three nets of 40 yards each would have been adequate had they been made at least of 210-9-ply, and perhaps ideally of 210-12-ply, and we should have taken with us at least 150 greenhart stakes, though aluminium angle or tube would have been even better. The chafing of the thin netting on the stakes during a catch wore a great many holes.

In 1951 the nets had been laid out first, then the stakes had been driven in and the nets attached to them. It was discovered in 1953, however, that the nets could remain permanently attached to the stakes, and that this actually reduced the chances of tangling.

Having rounded-up the geese the pattern of the later stages of the catch was as follows : while the birds were held on the hill-top by five of the party, three others would unload the nets from the pack pony ; having selected a suitable place some 40–50 yards away (as free as possible from stones on which the geese tend to damage their toe-nails) they would proceed to set up the pen, two of them paying out the net from the bundle of stakes and netting, the third hammering in the stakes with the tent mallet. The shape of the main pen at the outset was a horseshoe and we found that it was adequate for one side of the mouth to have a short wing, only four or five yards long. At the other side the netting was doubled back inside to form a small ' catching cage ' about 4 yards long by $1\frac{1}{2}$ yards wide. If sufficient netting was available two additional ' keeping-cages ' were set up, one for adults, one for goslings, in order to keep families together for simultaneous release without the risk of the goslings being

trodden on by the heavier adults. When the gaggle had been moved slowly down into the main pen, the wing was brought across to close the circle. The size of this circle varied with the size of the catch (which was usually underestimated by eye). For a catch of up to 600 geese a circle of 10–12 yards diameter was found suitable, but the two catches of over 3000 required all 60 yards of our doubled netting, making a circle of about 20 yards diameter.

Once the geese were enclosed the rings were unpacked and the strings of 100 each were laid out in numerical sequence, the ponies were taken down into the marsh to graze, sedge was brought up in sacks to feed the geese while they were waiting to be ringed, and the party had lunch (for after a big drive it was usually three or four o'clock in the afternoon and there were many hours of work ahead). The captured geese remained extraordinarily quiet, many goslings falling asleep, while others fed. It was therefore about 45 minutes before ringing began. Then groups of between 30 and 50 geese were gently edged round into the small ' catching-cage.' We found it possible to segregate the goslings to a large extent at this stage so as to avoid the possibility of the adults treading on them.



Arrangement of nets. The main cage and wings can be made of one length of net. The keeping cages are made from a separate length.

Three members of the team stood inside this catching cage with the birds within reach near their feet, which obviated any chasing before picking them up and saved a great deal of time. They picked the geese up either two or three at a time and held them so that three others standing outside the cage could put on the rings. Each ringer had two current strings of 100 rings, one slung round his shoulder, the other hanging on a stake of the net. From one string he ringed adults, from the other goslings, and he was, we found, able to deal with about 120 birds per hour including the time taken to bring a fresh group into the catching cage. The seventh member of the team wrote down the ring numbers of repeats and recaptures[1] and recorded whenever a ringer started on a new

[1] A *repeat* is a bird taken in the same area as that in which it was ringed and within one month. A *recapture* is any other bird caught which is already carrying a ring. (A *recovery* is a dead bird whose ring has been recovered.)

TABLE I

List of Catches made in Þjórsárver, July–August 1953

Date	Locality	Adults			Goslings		Total Catch	Total Newly Ringed
		Newly Ringed	Recaptured*	Repeats	Newly Ringed	Repeats		
10 July	Ptarmigan Lake ..	3	1	—	9	—	12	12
10 July	Nautalda	5	—	—	11	—	16	16
11 July	N. crest Oddkelsalda	9	1	—	14	—	24	23
13 July	Snowy Owl Ground	—	—	—	1	—	1	1
13 July	Hnifá Airport ..	2	—	—	16	—	18	18
13 July	Nr. S'd'per Lake ..	1	—	—	—	—	1	1
13 July	Sandpiper Lake ..	3	—	—	4	—	7	7
14 July	Bolstaður Hill ..	3	—	—	11	—	14	14
14 July	Round-up Hill ..	1	—	—	8	—	9	9
14 July	Little Hnifá ..	4	—	—	25	—	29	29
14 July	Near Hnifá.. ..	3	—	—	10	—	13	13
16 July	Ptarmigan Lake ..	6	—	—	8	—	14	14
16 July	Nautalda	57	1	—	101	—	159	158
16 July	Nauthagi wave ..	2	—	1	14	1	18	16
17 July	N. crest Oddkelsalda	61	5	—	112	—	178	173
17 July	Arnafellsalda ..	244	23	—	270	—	537	514
19 July	Round-up Hill ..	5	—	—	16	—	21	21
19 July	Hnifá mouth ..	2	—	—	6	—	8	8
19 July	Little Hnifá ..	7	—	1	9	2	19	16
19 July	Krókur	23	—	—	41	1	65	64
19 July	Eyvafen	—	—	—	8	—	8	8
19 July	Penseur Hill	3	2	—	21	—	26	24
20 July	Philsvatn Hill	90	7	13	109	18	237	199
21 July	Hjartarfellsalda ..	1293†	84	137	1535	117	3167†	2828†
25 July	Nautalda	34	2	20	37	25	118	71
26 July	N. crest Oddkelsalda	164	17	104	293	97	675	457
28 July	Bolstaður Hill ..	8	1	—	13	1	23	21
28 July	Near Bolstaður ..	—	—	—	3	—	3	3
28 July	Round-up Hill ..	7	—	—	42	12	61	49
29 July	Arnafellsalda ..	1360	77	245	1233	200	3115	2593
1 August	Hjartarfellsalda ..	127	16	160	275	428	1006	402
2 August	Oddkelsalda ..	101	6	196	150	268	721	251
3 August	S. of Söðulfell ..	2	—	—	21	5	28	23
4 August	Gaesaþufa	245	17	769	386	475	1892	631
5 August	Round-up Hill ..	9	—	1	47	6	63	56
6 August	Round-up Hill	—	—	—	2	2	4	2
	Total	3884 (+1)	259	1647	4861	1659	12310	8745 (+1)

Recoveries	259
Total number of individual Geese handled	9,005

*Birds in this column were ringed before the expedition (either in Britain or in Iceland 1951). Repeats are birds ringed earlier in the expedition.

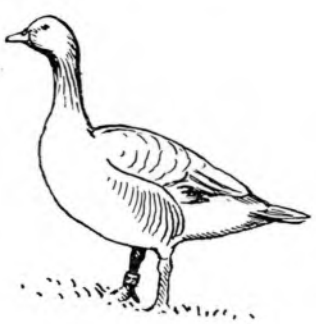
† Plus one Barnacle Goose.

string ; and the eighth moved round the main pen to see that pressure did not build up against the net at any place so that there was danger of birds being trampled on, or getting their heads stuck through holes in the net.

After being ringed the geese were put down in the ' keeping-cages '—adults in one, goslings in the other, and released from time to time in groups of 200 or so. There was not always sufficient netting for these ' keeping-cages ' and indeed it is doubtful whether they were really necessary. The goslings on being released outside the main pen usually hung around trying to get in again for some time, and then wandered down into the marsh below and began to feed. Here, when the adults were also released, a most efficient sorting process took place, in which it appears, from the recaptures made both in Iceland and in Britain, that a high proportion of families were reunited. Those goslings which did not find parents banded themselves into crèches and went about in company. They were well enough grown at this stage to be completely independent of brooding by the female.

MARKING METHODS

In 1951 wing-tags, which clipped through a part of the patagium on the leading edge of the wing, were used to mark small goslings whose legs were not yet large enough to carry rings. The recapture and recovery rates of the tags although at first comparable with those of rings fell off more rapidly, indicating that the tags did not last so well. In addition, when dealing with large catches of geese it was found difficult to be certain that no wing-tags had been overlooked. Finally serious corrosion had obliterated some of the numbers on one tag which was recovered. For all these reasons and also because it was thought that the tags might be a source of irritation to the birds, it was decided that no further wing-tags should be used in 1953.



In any event the arrival of the expedition had been so timed that the majority of goslings could be marked at once with rings, and in only a very small number of late hatched goslings were the legs still too small for ringing.

The rings used in 1951 which bore the legend ' Mus. Nat. Reykjavík, Iceland ' had been made in Sweden and were of rather thin gauge aluminium with a clip. Several of these on geese recaptured in 1953, after only two years wear, were already badly eroded, and in others the softness of the metal had allowed the clips to loosen, so that the rings looked likely to fall off. The numbers and address remained quite legible but it looked as if some rings might already have been lost altogether.

For the 1953 expedition 5000 rings were made in England to the same pattern as those used during rocket-netting, but bearing the Icelandic address, and a series of numbers allocated by Dr Finnur Guðmundsson. These rings were of the non-clip type in which the metal was believed to be thick enough and hard enough not to open when once it had been closed round the bird's leg and the two edges carefully butted against each other. It has since been discovered that at least some of these rings are lost by the geese, presumably by opening, but the proportion cannot be at all high.

In addition to these 5000 rings the expedition took in a further 2000 Icelandic rings which had been made in the United States, and later 3000 more of these American rings were flown in. They were of slightly larger diameter than those made in England and the metal appeared to be a trifle harder. Because the legend was printed in smaller type the abbreviation ' Mus. Nat.' had been expanded by the manufacturers to ' Museum Natural ' (which bears no relation to the correct Icelandic or Latin). These rings had very sharp edges and minor abrasion was observed on the hind toes of some of the goslings which were recaptured after wearing the rings for a week or so. Thereafter the lower edge was chamfered off with one of the handles of the pliers before being put on. Birds which had shown abrasion from sharp-edged rings were found to have suffered no permanent injury when recaptured in Britain the same autumn. By then erosion had worn the sharp edge off the ring and there were no signs of any damage to the hind toe even in the form of a callous or a scar. Nevertheless it is desirable that the process by which the metal is cut for making rings should not leave a sharp edge on the inside.

Rings put on in earlier years were at first replaced if they showed any signs of wear. Later, however, it was decided to add a new ring to the other leg in such cases, in the hope that some measure of the rate of loss of earlier rings might be obtained. It was in fact this latter technique which disclosed the loss of non-clip rings. Certain individuals were later recaptured on which the older clip-type ring remained, but the newer non-clip ring was missing. Recaptures of birds which do or should carry two rings have now been sufficiently frequent to indicate the incidence of ring loss, which may be of the order of 5% although there are insufficient data to enable these losses to be properly understood (there is no evidence as yet of increasing rate of loss with time, as has been found for rings used on several kinds of sea-birds). It still cannot be explained how such losses occur without damage to the bird's leg, but the fact remains that they do.

THE SIZE OF THE BREEDING COLONY

In 1951 attempts were made to estimate the number of nests in the colony from sample transects. These were not repeated in 1953. The late date of arrival of the expedition would have added to the uncertainties of the method, because it was difficult in some cases to decide whether the nests found had been used in 1953, and the achievement of a reliable result would have needed more time than could be spared from the principal object of goose-catching. For the determination of colony size, therefore, only information from ringing and recaptures is available, although this is much greater in quantity than in 1951. 4144 adults and 4861 goslings were captured during the expedition. These numbers provide lower limits for the colony size. There were 1646 adult and 1661 gosling repeats during the expedition. (A *repeat*, in this context, is

a second capture of a goose in the course of the expedition, to be distinguished from a *recapture* of a goose ringed in the colony in 1951, or in Britain in 1950–52.) Several different techniques for employing these repeats to estimate the numbers of geese in the colony have been tried, but none has proved entirely satisfactory. The difficulty is due to the incomplete mixing of marked and unmarked geese and of geese marked at one point with geese marked at other places. The successful employment of capture-recapture methods requires either that no immigration or emigration is occurring or that the rates of movement remain unchanged and these requirements are not met. There is no evidence of either immigration or emigration from the colony as a whole during the course of the catching period, but the repeats encountered in successive catches in particular areas show that the probability of repeating is not equal for all individuals.

In the circumstances the best measure of colony-size appears to be given by using the ' Lincoln index ' relation (discussed in Scott, Fisher and Guðmundsson 1952 (p. 98), with respect to the 1951 data) applied to groups of catches. If a individuals are caught, marked and released at time t_1 and n are caught at time t_2, of which r were marked on the first occasion, then the maximum-likelihood estimate ($\hat{x}$) of the total population (x) at time t_1 is $\hat{x} = \frac{an}{r}$. The results of applying this relation to the grouped data are shown in Table II. Adults and goslings are treated separately, because they are not equally liable to capture, or recapture. Various other groupings of the catches, and single catches, have been used to give alternative estimates. These range from 4800–15,600 for the adult population and from 6500–19,700 for the number of goslings. The theoretical estimates of the variances of many of the estimates are quite small, but the wide range of the subsidiary values of x shows that these theoretical estimates are inappropriate.

TABLE II

Estimation of the Pinkfoot Population at Þjórsárver við Hofsjökul, July 1953, from repeats of marked geese

(t_1) = all catches from 10 to 21 July, inclusive.
(t_2) = all catches from 29 July to 4 August, inclusive.

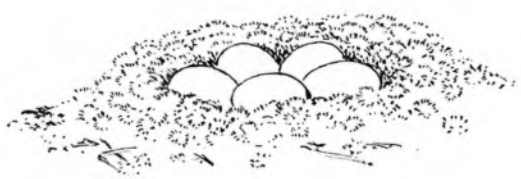
	Marked at t_1	Caught at t_2	Repeats	Total Population at t_1
	a	n	r	$\hat{x}$
Adults	1751	2612	558	8200
Goslings	2359	2970	686	10,200

Both the adult and the gosling figures are higher than the corresponding estimates for 1951 (adults 8200 in 1953, 5500 (or 6700 from repeat data only) in 1951 ; goslings 10,200 in 1953, 7500 in 1951), but the lack of precision of all the estimates does not justify any inferences about changes in colony size, except that the actual numbers of geese are most unlikely to have decreased in the two-year interval. The question of the proportion of non-breeding

birds amongst the adults is considered at p. 78. It may be noted that the assertion made in 1951 that the adult population estimate from repeats was too high because of the ' trap-shyness ' of once-caught birds was found to be unjustified in 1953, when adults were found to repeat slightly more readily than goslings. The date to which the population estimate refers is (approximately) 18 July. Adult deaths on the breeding ground are apparently very few (one British ring was found with 26 gosling rings at the fox-earth in Oddkelsver, but no dead adults were encountered elsewhere), so that the use of a precise date for this class is unimportant.

PINKFOOT NESTS

In 1951 16 nests of the season were found in an area of about 40 acres round the Base Camp at Bolstaður. More than half of these were already hatched when the party arrived on 26 June, but six still had eggs which were on the point of hatching. Three of these deserted owing to the proximity of the camp which had been pitched before it was known that the goose nests were so close. Of these three deserted nest sites two had evidently not been used since though the third one had. All the remaining nest sites revisited (about a dozen) had been occupied in 1953. Another nest some distance away which had been deserted in 1951 had also apparently not been used since. Thus of four desertions three sites were still unused two years later. In view of the prevalence of the habit of nesting in traditional nest sites many of which have evidently been used for generations it is of interest that two new nests were found in places where the position of nests had previously been particularly noted. Beside the ruined wall of one of the old goose folds there had been in 1951 two occupied nests about four yards apart. Now in 1953 a third was placed so as to form an equilateral triangle. Beside the hot springs at Nauthagi, which were carefully mapped in 1951, there were then only two nest sites, but in 1953 there were three.



LOCALISATION AND MOVEMENTS OF RINGED BIRDS

The persistence of traditional nest-sites encourages the belief that breeding geese return to their ' own ' sites year after year and might be expected to become attached to particular ' neighbourhoods ' within the oasis. Unfortunately, the method of catching geese by relatively long-distance drives employed in 1953 is most unsuitable for learning about behaviour of this kind. The early, small, catches, which were most likely to produce striking results did not really do so. An adult (Ring No. 2813), ringed at the south-east of Philsvatn on 29 July 1951

was recaptured by the same lake on 20 July 1953, and seven geese ringed on Arnarfellsalda on various dates in 1951 were recaptured there on 17 July 1953, but seven other recaptures in the early drives (before 20 July) were far from the places where they had first been marked.

The big catches of 21 July and after can only provide rather gross information on the localisation of marked geese, and the very large numbers of repeats obtained in 1953 do not enable any satisfactory picture of the normal wanderings of geese about the oasis to be drawn. But if all the recaptures of 1951-ringed geese are examined some points of interest emerge. The results of the Arnarfellsalda catch of 17 July noted above indicate the probability that homing to limited areas within the colony does take place. Since nearly two-thirds of the geese ringed in 1951 were caught on or near Oddkelsalda or Arnarfellsalda, our information about homing relates largely to these two localities, which, though only about three miles apart, were the collecting points for geese driven mainly from more remote areas. Table III summarises the distribution of recaptures. The numbers of recaptures from Oddkelsalda and Arnarfellsalda bear a similar proportion to the numbers marked in these localities. Only 7 of the 65 Oddkelsalda-ringed recaptures were from that area, while 27 of the 37 Arnarfellsalda-ringed birds were found there again. But, looking at the column totals, we see that 7 of 13 recaptures at Oddkelsalda were of geese ringed there, a greater proportion of ' residents ' than at Arnarfellsalda (where there were 27 in 64). The interpretation of these results is complicated by the different numbers of adults caught at Arnarfellsalda (2880) and Oddkelsalda (664) in 1953. If allowance is made for this, it appears that the chance of recapture ' where ringed ' was very similar for both localities, and that this chance was substantially greater than for birds marked at other places. Thus the evidence supports the idea that geese tend to return to, and remain in, relatively limited parts of the oasis.

TABLE III

Recaptures in Þjórsárver in 1953 of Pinkfeet marked there in 1951. 108 Geese were recaptured: the total of records is larger because some were caught several times and each recapture has been used

Where Ringed	No. Ringed 1951	Recaptured 1953			Total Recaptures
		Oddkelsalda	Arnafellsalda	Other Localities	
Oddkelsalda ..	420	7	21	37	65
Arnafellsalda ..	299	1	27	9	37
Other localities ..	452	5	16	1 where ringed 10 elsewhere	32
Total ..	1151	13	64	57	134

The proportion of recaptures from marking elsewhere is substantially smaller. This is probably due to the different catching sites used in 1951 and 1953. For example, in 1951, 55 geese were caught in Þufuver, on the east bank of the Þjórsá, which remained unvisited in 1953, because the expedition could not cross the river. Accordingly, these recaptures in many different areas are of little value in determining degrees of localisation.

WHEN DO PINKFEET FIRST BREED?

The age at which sexual maturity is attained by the Pinkfoot is not yet known. If analogies with other species may be relied on, it is probably three years in most cases, though some individuals may breed at two years old. This is the case with several species of *Anser* and *Branta* in captivity. Kossack (1950) found that at least one-fifth of the two-year-olds in a semi-captive flock of Canada Geese nested. More recent studies of wild Canada Geese nesting in California (Naylor 1953, Naylor and Hunt 1954) and Wyoming (Patterson and Ballou 1953), have led to the belief that " some of the non-breeders pair in their second year of life but do not breed until the third year " (Naylor *loc. cit.*). Observations on White-fronted Geese have led to rather similar inferences (Boyd 1954 and unpublished notes). For example, in January, 1952 some three-fifths of the second-winter Whitefronts at Slimbridge were paired ; but no two-year-old parents with families have yet been found in winter flocks.

Since few people have ever visited the breeding places of the Pinkfoot early in the breeding season, it is scarcely surprising that no direct observations on birds of known age are available. The members of the 1951 expedition reported in the following terms : " Yearlings and two-year-olds which are not yet sexually mature may be found in the breeding area, although in this case so few as to indicate a separate moulting area for sexually immature birds " (Scott, Fisher and Guðmundsson 1952). This generalisation was based on the relatively small numbers of adult geese seen in flocks without goslings, together with the fact that one of two British-ringed birds recaptured had been in its first winter when caught in December 1950. In 1953 flocks of full-grown geese without accompanying goslings were again infrequent and small (those seen totalled about 750) ; but the number of recaptures of marked birds was much greater and more informative than in 1951. These recaptures consisted of 108 birds ringed in Iceland in 1951 and 155 British-ringed birds, classified by date of first capture and age at ringing in Table IV. For the present purpose the very low proportion of one-year-old recaptures is not important, although it confirms that geese of this age-class may not all return to, or do not remain throughout the summer in, the breeding colonies. The proportion of two-year-olds (i.e. geese ringed in 1951) is the chief point of interest. There is an apparent conflict between the return of Iceland-ringed and British-ringed birds. In considering the number of recaptures to be expected from each age-class, it is convenient to use the symbols e for the annual adult survival factor, e_1 for the first-year survival factor of birds ringed in their first autumn, e_g for the survival factor of goslings between marking in July and entry into the British population in October, and m_a for the number of marked geese in any class. Then if all surviving marked geese were equally liable to recapture the expected numbers in each class would be proportional to their different rates of survival, as indicated in Table IV. Evidently, the marked birds are *not* all equally likely to occur in Þjórsárver : the proportion of 1951-marked adults marked in Þjórsárver and recaptured there is three times as great as that of adults marked in Britain in the same year. It may be supposed that the ratio $\frac{\text{2 year-old}}{\text{more than 2 years old}}$ in the recaptures of British-ringed birds was determined by the ratio $\frac{e_1 e}{e^2}$, or $\frac{e_1}{e}$. Using $e = 0{\cdot}74$, $e_1 = 0{\cdot}59$ (the values of the annual survival factor obtained

TABLE IV

Recaptures in Þjórsárver, 1953, of Pink-footed Geese ringed in Þjórsárver, 1951, and in Britain 1950–52

Where and when ringed	Þjórsárver 1951		Britain 1950–Mar. 1951		Britain 1951		Britain 1952	
Age at marking	Adult	Gosling	Adult	First Winter	Adult	First Winter	Adult	First Winter
Total marked	382	769	354	275	384	141	903	226
Number of recaptures	71	37	32	21	23	7	68	4
$\frac{\text{Recaptured}}{\text{marked}}$ %	18·3	4·7	9·0	7·6	6·0	5·0	7·5	1·8
Expected proportion of recaptures	me^2	$m\,e_g\,e_1\,e$	me^3	$me_1\,e^2$	me^2	$me_1\,e$	me	me_1

from recoveries (see pp. 102–103)) the value of $\frac{e_1}{e}$ is found to be 0·80. This is in quite close agreement with the values obtained from the recapture ratios $\frac{\text{marked as first winter}}{\text{marked as adults}}$ both for the 1951 sample $\left(\frac{R_1}{R} = 0{\cdot}83\right)$ and that of 1950 $\left(\frac{R_1}{R} = 0{\cdot}84\right)$, from which it may be concluded that two-and three-year-olds are as likely to be found in the captures on the breeding-grounds as birds of older age-groups. By analogy, amongst the recaptures of Iceland-ringed birds $\frac{R_1}{R}$ should be approximately equal to $\frac{e_g e_1}{e}$. If $e_g = 0{\cdot}65$ (see pp. 82–87) $\frac{e_g e_1}{e} = \frac{0{\cdot}65 \times 0{\cdot}59}{0{\cdot}74} \simeq 0{\cdot}52$, whereas $\frac{R_1}{R} = 0{\cdot}26$, from which it appears that only about half the expected number of Iceland-ringed two-year-olds were recaptured. The reconciliation of these two findings seems to require either that the $\frac{R_1}{R}$ ratio for the British 1951 ringing be rejected (perhaps on the ground that the number of first-winter geese marked was very small), or that the estimated value of e_g be reduced to about 0·32, or that some biological reason be found for the discrepancy. The rejection of the 1951 British $\frac{R_1}{R}$ ratio seems unreasonable, in view of its agreement both with expectation and with the 1950 data. It is unlikely that the gosling losses from marking to arrival in Britain were as much as 68% in 1951, since the results from the 1953 ringing appear to agree with those of 1951 in suggesting losses of only half this amount. But there is a possible resolution of the discrepancy on biological grounds, although it can only be regarded as tentative. Pair formation in geese takes place in the autumn and winter as much as in the spring and so occurs away from the breeding-grounds. Since in its winter range members of the species from many breeding colonies occur in the same flock it is quite likely that the prospective mate is

selected from amongst geese bred elsewhere. Pairs once formed normally persist throughout life (although there is evidence of merely temporary alliances between some birds in their second year, at least in *A. anser* and *A. albifrons* (K. Lorenz personal communication ; Boyd 1954 and unpublished notes)) and recently-paired birds may be assumed to return to the breeding-place of one of them. The effect of any considerable proportion of Þjórsárver-bred birds pairing with, say, Greenland birds in their second winter would be to reduce the return-rate of these birds to Þjórsárver in the following summer. But no comparable reduction in the occurrence there of British-ringed two-year-olds would be anticipated if pair-formation does take place as suggested. In support of this explanation it may be noted that in other colonial-nesting species it has generally been found that extra-colonial matings are frequent, so that although individuals that have once bred in a colony will continue to return, birds hatched there are relatively unlikely to return.

Further evidence on the occurrence of two-year-olds in breeding colonies is provided by the distribution of recaptures amongst the various catches made

TABLE V

Occurrence of Two-year-Old Pink-footed Geese amongst Recaptures in Þjórsárver, July–August 1953. (Geese captured in more than one locality are listed wherever found)

Locality	Ringed Iceland 1951		Ringed Britain 1950–51		Total		2 Years Old
	2 Years Old	More than 2 Years Old	2 Years Old	More than 2 Years Old	2 Years Old	More than 2 Years Old	Total %
Arnarfellsalda	16	23	4	35	20	58	25·6
Gaesaþaufa	7	16	5	17	12	33	26·7
Oddkelsalda	4	9	0	17	4	26	13·3
Hjartarfellsalda	18	40	2	29	20	69	22·5
Others	1	2	0	6	1	8	11·1
Total	46	90	11	104	57	194	22·7

Date	Iceland-ringed		British-ringed				2 Years Old
	2 Years Old	More than 2 Years Old	2 Years Old	3 Years Old	More than 3 Years Old	More than 2 Years Old	Total %
11–17 July	5	9	1	1	3	9	25·0
19–21 July	12	32	2	8	18	34	17·5
25–26 July	2	4	0	4	3	9	13·3
29 July	10	20	3	5	12	29	21·0
1–4 August	10	30	5	11	10	25	21·4
Total	39	95	11	29	46	106	20·0

in different parts of Þjórsárver in 1953. The relative frequency of two-year-olds and of older birds shows no significant variation either with locality or by date (Table V). Thus there does not seem to be any justification for asserting that two-year-olds are especially likely to be found in non-breeding flocks. Indeed the relative homogeneity of their occurrence indicates the opposite, that they are scattered through the colony in the same way as older birds. This makes it possible that these birds breed, but is not evidence of their doing so. The problem can only be solved by the examination of the reproductive systems of a large series of two-year-old females. This can perhaps be achieved in the autumn of 1955, when the goslings marked in 1953 will be of appropriate age.

PREDATION ON PINK-FOOTED GEESE

In 1951 we had been surprised that so large a colony of breeding-geese should have attracted so small a number of predatory animals. In 1953 predators were even less in evidence, but the fact that fewer Great Black-backed Gulls and Iceland Falcons and no White-tailed Eagles were seen may perhaps have been due to the much later arrival of the party in the oasis. In 1951 we had arrived on 26 June whereas in 1953 we arrived on 9 July. By that date most of the goslings were at least two weeks old, and it may well be that predatory birds like the gulls not tied to the oasis by nests or young move away as soon as the goose's eggs are hatched or at least as soon as the goslings are capable of escaping.

A comparison of the numbers of predatory species is shown in Table VI.

TABLE VI

Species Predatory on Pink-footed Geese in Þjórsárver

Species	1951	1953
White-tailed Eagle ..	One	None
Iceland Falcon	One or two pairs. Individuals seen on at least 12 occasions	Individuals seen only twice
Arctic Skua	*c.* 10 pairs	*c.* 10 pairs
Great Black-backed Gull	*c.* 40	Less than 10
Snowy Owl	Probably one seen twice ..	Probably one seen five times, but possibly two
Raven	None	One only, seen once
Arctic Fox	One seen, one heard ; no earths occupied	Vixen and one cub seen at earth (11 July).

Arctic Skua

The role of the Arctic Skua as an enemy of unattended goslings was clarified. It seems that healthy goslings without parental protection can be killed by these Skuas. Attacks which would have resulted in the destruction of a gosling but for human intervention were observed on two occasions.

Because the geese are very much more numerous than other birds in the Þjórsárver oasis it has been suggested that their dominance limits the number of prey species and hence of predators, but this effect has not been established.

GOSLING MORTALITY

The 1951 expedition found brood size at hatching (late June) to be 4·5 (19 broods), the mean of ten broods in the first half of July to be 4·4, and that of eight on 21 July to be 4·2. These figures indicated a low mortality rate during the first month. In 1954, Blurton Jones and Gillmor (see p. 153), found the mean brood-size of families in the Ásgarð area, north-west from Þjórsárver, to be 3·1 in the period 20 August–1 September. There was no observable decline in size during this period and it appears that mortality in that interval must have been small, but the difference between this mean of 3·1 and that of 4·5 at hatching in 1951 suggests that losses during the fledging period may be considerable. Brood counts made by Løvenskiold (1954) in Spitsbergen in 1952 help to confirm this. The mean size of nine broods seen between 7 and 11 July, soon after hatching, was 3·6. By 17 July the mean of 11 was 3·0. Five broods on 14 and 18 August again averaged 3·0.

Brood counts are not a very satisfactory measure of gosling losses, unless large numbers of families can be seen, and where this happens, as in Þjórsárver, the tendency of families to aggregate in large flocks makes it impossible to distinguish reliably between broods, especially as it is common for goslings to attach themselves to broods other than their own at any time during the fledging period. The 1953 expedition abandoned the attempt to count broods after 14 July. Between 8 and 14 July 94 goslings in 22 families had been seen, with a mean brood size of 4·3.

Another, rather similar, method of estimating losses is to compare the ratio of goslings to adults in successive catches. On the assumption that adult mortality and emigration in July and August are negligible, the rate of fall of the proportion of goslings should indicate the magnitude of the losses during fledging. Captures made by chasing family groups, used for most of the 1951 expedition, must be excluded from consideration, because this technique often results in the escape of the adults, leading to quite unrepresentative gosling/adult ratios. The data in Table VII are restricted to the large catches made between 16 July and 6 August 1953. No steady trend is apparent. The preponderance of adults in the catches of 29 July and 4 August was probably due to the presence of flocks of non-breeders in the areas driven. By grouping the early and late catches as shown, a decrease in the proportion of goslings is indicated, but the magnitude of this decrease can be considerably altered by regrouping the data. The choice of groups is quite arbitrary, so that the method fails to provide a satisfactory measure of gosling loss, but it suggests that losses in *late* July are comparatively slight.

TABLE VII

Gosling : Adult Ratios in Large Catches of Pink-footed Geese, Þjórsárver, July–August 1953

	Date of Catch									
	16 July	17 July (2)	21 July	25 July	26 July	29 July	1 Aug.	2 Aug.	4 Aug.	Total
Goslings	101	382	1652	62	390	1433	703	418	861	6002
Adults	58	333	1515	56	285	1682	303	303	1031	5566
Goslings per 100 Adults	174	115	109	111	137	85	232	138	84	108
	←—124—→			←—133—→			←———121———→			
	←———112———→					←———103———→				

Gosling mortality may also in principle be estimated from repeats in Þjórsárver by means of capture-recapture methods, using chains of three or more samples, but in practice these methods cannot provide even an indication of the order of magnitude of gosling losses. This is because the methods do not distinguish between deaths and emigration or births and immigration. Though there is probably no large-scale emigration from the colony as a whole before mid-August, the movements of flocks about the oasis produce nonsensical results from the data, (such as large apparent birth-rates at a time when all goslings are at least three weeks old).

A possible method of computing gosling losses is by comparing the recoveries in Britain in winter of goslings ringed early in July with those of goslings not ringed until August. For, although the age at marking is not known, the

average age of goslings first marked on (say) 16 July must have been less than the average age of those marked on 4 August. Thus, other things being equal, if mortality between these dates was substantial the proportion of early-marked goslings found subsequently in Britain should be less than the proportion of late-marked ones. The data on this point from both the 1951 and the 1953 expeditions are set out in Tables VIII and IX.

TABLE VIII

Numbers of Recoveries and Recaptures in Britain and Iceland of Goslings marked in Iceland, June–August 1951

Date of Marking	Number Marked	Number since Reported	$\frac{\text{Reported}}{\text{Marked}}$ %
28 June–7 July	56	7	12·5
11–15 July	55	11	20·0
17–22 July	99	18	18·2
25–26 July	189	50	26·5
28 July	177	36	20·3
31 July–1 August ..	187	46	24·6
Total	763	168	22·0

TABLE IX

Numbers of Recoveries and Recaptures in Britain, 1953–54, of Goslings marked in Iceland, July–August, 1953

Date of Marking	Number Marked	Recovered	Recaptured	Total Reported	$\frac{\text{Reported}}{\text{Marked}}$ %
10–18 July	614	32	11	43	7·0
19–21 July	1745	113	46	159	9·1
25–26 July	330	24	7	31	9·4
29 July	1233	87	36	123	10·0
1–3 August	446	31	10	41	9·2
4–6 August	435	32	8	40	9·2
Total	4803	319	118	437	9·1

Some grouping of smaller catches has been used. The argument for determining losses in the second half of July is as follows :

$$\frac{[(\text{early-ringed})—(\text{deaths before late ringing})]—(\text{deaths before arrival in Britain})}{(\text{late ringed})—(\text{deaths before arrival in Britain})} = \frac{\text{British recoveries of early-ringed}}{\text{British recoveries of late-ringed}}$$

On the assumption that the proportion of casualties after the last ringing date and before arrival in Britain is the same for both groups, the equation may be rewritten as :

$$[(\text{early-ringed})—(\text{deaths before late ringing})] = \text{late-ringed} \times \frac{\text{early-ringed recoveries}}{\text{late-ringed recoveries}}$$

Substituting the rather small numbers of recoveries of 1951–ringed goslings in this equation we find from the first two rows of Table VIII (markings in 28 June–7 July and 11–15 July) that losses of marked goslings in the first half of July may have been of the order of one-third, although additional losses in the second half of July may not have exceeded one-sixth of the survivors at the middle of the month. If we assume that losses in the last week of June were at the rate indicated for early July and that those in August, up to fledging, resembled those in late July, the estimated total losses of goslings during the fledging period in 1951 were of the order of three-fifths of the number hatched. (From evidence to be discussed later, there is no good reason to think that the losses were due to the activities of the expedition.)

The much larger number of goslings marked in 1953 might be expected to produce more reliable results. Table IX shows that there is a difference between the recovery-rates of goslings ringed 10–18 July and those marked later. This difference is statistically significant. It appears that few deaths can have occurred in the last ten days of July or in early August but that earlier in July the weekly rate of loss may have been as high as one-quarter. If such a rate was sustained throughout the first three weeks of the fledging period it would, together with the small number of later losses, result in the death of almost three-fifths of the goslings hatched. The interpretation of the discrepancy in the proportion of subsequent recoveries in terms of rate of loss is much hampered by the necessity of grouping the early-ringed birds in order to provide a large enough sample for comparison with the later catches. If, as appears, the rate of loss decreased rapidly in the middle of July the choice of groupings may importantly affect the estimated rate of mortality. Examination of the recoveries from each catch shows that chance variations in the reporting of recoveries are sufficient to obliterate any differences in British recovery-rates resulting from losses between 10 and 20 July.

Ten of the 39 ringed goslings found at the fox-earth in September or by the expedition in August were birds ringed before 20 July, a proportion significantly greater than would be expected from the comparatively small numbers marked by that date. This supports the hypothesis that losses (to predators, from bad weather and by accidents) are heavier in the first half than the second half of the fledging period.

In an investigation of the dynamics of the British Pinkfoot population (Boyd, in press), the model for the estimation of first-year death-rate included a factor affecting the expectation of recovery of goslings ringed in Iceland in July 1951 as compared with that of juveniles ringed in Britain in October 1951. The evaluation of this factor led to the conclusion that the losses of goslings between marking in Iceland and entering the British population were about 35%. Losses of the same order in 1953 are indicated independently by two different methods.

The first method uses the relative proportion of goslings and adults marked in Iceland and caught again in Britain in October 1953. On the assumption that marked adults and goslings were equally liable to capture, the following relation should hold :

$$\frac{\text{number of Iceland-marked goslings recaptured in Britain}}{\text{number of Iceland-marked adults recaptured in Britain}} = \frac{\text{number of goslings marked}}{\text{number of adults marked}} \times \frac{\text{gosling survival factor (Aug.–Oct.)}}{\text{adult survival factor (Aug.–Oct.)}}$$

On the assumption that all the marked adults survived until mid-October (when rocket-net catching began), the estimated gosling survival factor is

$$\frac{86 \text{ goslings recaptured}}{92 \text{ adults recaptured}} \times \frac{3{,}884 \text{ adults marked}}{4{,}861 \text{ goslings marked}} = 0{\cdot}75$$

The adult survival factor will certainly not have been 1·0. However, there are very few adult recoveries in August and September and, even allowing for the fact that losses on the breeding-ground and on migration are relatively unlikely to be reported, it seems improbable that the adult survival factor for August-October is less than 0·90. The reduction of the adult survival factor to this lower limit would result in a corresponding reduction of the gosling survival factor, from 0·75 to 0·67. Thus these 1953 recapture data suggest gosling losses in the period between marking and recapture in Britain of between one-third and one-quarter of the total marked.

The recaptures in October 1953 of Iceland-ringed goslings also provide the second method of estimating losses between July and mid-October, the use of the Lincoln index. This is a method of estimating total numbers at the time of first capture (t_1) from the proportion of recaptures on a second occasion (t_2) of birds marked at t_1. (This method is discussed briefly in an earlier section of this paper dealing with the estimation of the size of the Þjórsárver colony.) The special condition for its use in this context is that goslings marked in the summer of 1953 should have had the same probability of being caught in Britain in October 1953 as all other goslings bred in Iceland and Greenland. The ratios of $\frac{\text{marked goslings}}{\text{unmarked goslings}}$ found in the different catches in October varied, but not more than might be expected in random sampling. Thus it seems justifiable to use the relation

$$\frac{\text{total gosling population summer 1953}}{\text{goslings marked in summer 1953}} = \frac{\text{number of goslings caught in October 1953}}{\text{number of marked goslings caught in October 1953}}$$

to estimate the gosling population of Iceland and Greenland in mid-July 1953 at $4861 \times \frac{363}{69}$, or about 25,600. The juvenile population in Britain at the end of October 1953 was estimated at about 15,300 (Boyd, in press) suggesting losses between July and late October of 10,300 or about two-fifths. The two latter measures of gosling casualties before entering the British population assume that the marking in each summer was carried out in one operation, instead of over a period of several weeks. The measures used earlier indicate that losses in late July and early August are comparatively small. Thus it seems likely that many of the casualties detected by these recapture methods occurred on migration or after arrival in Britain but before rocket-netting began, rather than on the breeding-grounds.

Reviewing the results of these various estimates, we find that they are not wholly consistent. This is not surprising, in view of the practical difficulties in the observational methods and the sampling hazards inherent in the indirect ones. Brood counts indicate losses of 6·7% in the first $3\frac{1}{2}$ weeks in 1951, of perhaps 31% in the whole fledging period in 1954, and of 16·7% in the fledging period in Spitzbergen in 1952. The $\frac{\text{gosling}}{\text{adult}}$ ratios in the catches in Þjórsárver

in 1953 yield estimates varying from about 1% to 4% per week in late July, confirming that losses in this period are relatively small, but providing no information on losses in the critical first three weeks. The method of comparing British recovery-rates of early and late-ringed goslings suggests total losses during the fledging period of about 60% in both 1951 and 1953. The comparison of calculated first-year death-rates for Iceland-ringed goslings and British-ringed juveniles shows a loss of about 35% between marking in Iceland and recapture in Britain in October 1951 : and the two indirect methods applied to the 1953 marked goslings show losses of similar magnitude (about 30%, and about 40%) in the corresponding interval in that year.

It may be concluded with confidence that gosling mortality must be substantial. The proportion of losses sustained may well vary considerably from year to year, and differ in the smaller colonies elsewhere in Iceland and Greenland from that in Þjórsárver. Losses in some of the small colonies are probably substantially greater, because predators are more numerous there. But the provisional use of the estimate from this colony as representative seems justifiable, especially since it probably contributes at least two-fifths of the annual increment to the British population. For the purpose of calculation, the annual mortality of goslings between hatching and entering the measured British population (i.e. to mid-October) will be taken to be 60%. It seems unlikely to be less than 50% and may be as much as 70%. About a quarter of these losses probably occur after fledging, either on the first southward migration or immediately on arrival in Britain. (Many geese will have been ' at risk ' in Britain for several weeks before catching begins in October.)

Very little is known about gosling mortality in other species. Hanson (in Hanson and Smith 1950) writes that juvenile mortality in Canada geese ' appears to be small,' but his evidence was derived from brood counts and recent intensive studies have shown this method to be valueless for that species (e.g. Munro 1948, Miller and Collins 1953, Naylor and Hunt 1954). Almost all other nidifugous species—ducks, gulls, terns, gallinaceous birds, waders, coots—which have so far been studied suffer severe losses between hatching and fledging (Lack, 1954). It would be surprising to find an Arctic-breeding species like the Pinkfoot providing an exception.

In a correspondence in *The Times* in the autumn of 1953 several critics, dismayed by the success of the expedition, asserted that the mass capture of goslings must have produced very large numbers of casualties. It now seems clear that no large losses resulted from the goose-drives. As already noted, few dead goslings were found in Þjórsárver. There is a more striking confirmation of our belief that the assertion of harm caused by ringing was quite unjustified. Since the Þjórsárver colony contributes at least two-fifths of the total juvenile population in Britain, the effects of mass destruction there would surely have been apparent in a fall in the proportion of juveniles in the autumns following the expeditions of 1951 and 1953. The proportion of juveniles in each year from 1951 to 1954 is known from rocket-netting catches. In 1951 and 1953 the proportions of juveniles were 27·0% and 32·5% of the catch. For the years 1952 and 1954 (i.e., those when the colony was undisturbed by ringing operations) the proportions were 19·9% and 32·8%. Clearly, the proportion is highly variable but, equally clearly, there is no ground for belief that disturbance of the Þjórsárver colony led to abnormal losses of goslings.

Flightless Pinkfoot

WING-MOULT

Some adult geese were already flightless when the party arrived on 9 July 1953, but not many. (In 1951 the first flightless adults had been seen on 4 July.) The first flightless adult was *caught* on 10 July (12 July 1951). On 15 July, however, so many adults could still fly that the drives were not satisfactory, and they only became really effective on 17 July. The last bird was seen flying on old primaries on 26 July and the first on new primaries on 28 July, (the same date as in 1951). By 4 August it was noted that 60% of the adult geese, in a catch which included 1049 adults, were able to fly on release after ringing. By 6 August most of the geese in the oasis could fly. These dates conform very closely with similar observations in 1951 yet the larger samples enable a clearer picture to be obtained and it is felt that the estimate of 28 days of flightlessness for any individual goose may be too long. It seems possible that the average flightless period may be as little as 25 days.

That it was possible on 4 August to drive 60% of the adults (some 600 geese) which could in fact fly into nets which were only three feet high, and keep them there for several hours needs some explanation. These birds had flight feathers which were not yet completely grown out, and could therefore only fly with an effort if hard pressed. During the assembly of the geese no such pressure was exerted, and once the birds had formed a tight gaggle the necessary space to spread wings and take a long run was not available to them. In addition they evidently found some sense of security from being in the gaggle and were not particularly anxious to leave it. Furthermore once the netting circle had closed around them there was not a long enough run for take-off while their primaries and secondaries were not yet fully developed. But on release, with space for a long run, they were able to achieve flying speed and subsequently to rise quite high into the air.

As an example of the reluctance of birds to leave the gaggle (or their families), during the big catch of 21 July one bird, which had not yet moulted and retained

New wing feathers beginning to grow

the *full* powers of flight, remained with the gaggle for six hours when it suddenly decided to fly out of the pen, which it had, of course, no difficulty in doing. After 11 hours, and when the last birds were being handled a second goose decided to do the same thing.

Once more it was noted that geese became unable to fly before the flight feathers were actually cast. On 14 July in a small drive four adult geese were caught. Three of these had complete flight feathers. Before capture they made no attempt to fly, but after release they flapped off with the advantage of a moderate breeze blowing up the bare slope of the hill. In spite of that, however, *they were unable to become airborne*. Under similar conditions at another drive on the same day a bird which flapped away shed its flight feathers as it went, whereas on the previous day a bird already lacking several primaries had successfully taken off from a hill-top. Loss of the power of flight before the actual loss of wing area is difficult to explain. Even if the bird knew by the feel of the feathers that flightlessness was imminent, it could still fly off low without danger of any serious injury should the feathers be cast in flight. It is possible that some pain is involved and that the bird dare not put full weight behind the wing beats because of this, but it would be surprising if such a consideration were to take precedence over the escape urge. The arrangement of the overlapping primaries and secondaries do not allow the possibility of each feather twisting and thus ' spilling ' the air, nevertheless we are forced to the conclusion that when the feathers are loose a few hours before they are actually cast some mechanical weakness in the structure of the wing prevents the bird from obtaining lift from it.

In 1951 it appeared that non-breeders moulted their flight feathers about a week earlier than the parents of broods. The flocks of non-breeders seen in 1953 were mostly capable of flight by 29 July when few parents were yet flying. A similar phenology has been observed in at least four other species of geese.

The conclusion reached from observations in 1951 that female Pinkfeet moult before the ganders was perhaps premature. In 1953 some families were seen in which the females were flightless while the ganders could still fly. But a number of adults caught in the period 17–20 July were sexed and this sample (admittedly small) failed to confirm this distinction. 13 of 14 ganders were flightless, but only 16 of 24 females were unable to fly. The point needs further study, because it is possible that these figures are influenced by a greater willingness of ganders to desert their families when being pursued.

VARIATIONS

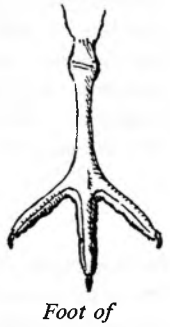
In a sample of 9000 birds it is not surprising that several abnormal or freak specimens were found. The most striking was a biscuit-coloured gosling (Ring No. 14000). The markings were dimly discernable, but there was evidently a shortage of black pigment. The irides were normal but the bill and legs were already pink, whereas in normal goslings of this age they were still slate grey. This particular abnormality is well known in this species, and in most winter seasons at least one such bird has been observed in Britain. The degree of paleness seems to vary, some specimens being rather whiter than this gosling, some darker. In one season (1940–41) no less than three such leucistic Pinkfeet were present in one flock, indicating that they were probably fairly closely related.

Four goslings showed schizochromic plumage, with patches of white. One

Schizochromic Pinkfoot

(Ring No. 27362) had these patches on the scapulars but as these were the only feathers yet grown it might have shown greater extents of white later. A second (Ring No. 14350) had a large white patch under the chin. (This bird was shot in Kinloss in November 1953.) The third (Ring No. 26795) had its right wing-tip completely white, the first two primaries of the left wing white, and a white patch mainly on the right side of the breast. The fourth (Ring No. 28979) was not noticed as abnormal in Iceland, but was found to have a white left wing-tip and a white bar across the breast when recaptured four months later in Scotland on 23 November 1953.

Two others aslings captured together on 1 August (Ring Nos. 13400 and 211500) were found to have no webs to their feet—evidently a congenital deformity which has been observed now four times in the 14,800 Pinkfeet examined. One, caught in October 1954 in the rocket-nets, is now in the Trust's collection. Of the adult geese at least three had bright orange legs and bill markings instead of the usual pink. This is not to be confused with the yellowish legs of some immatures, nor with the orange stain which sometimes gives a yellowish suffusion to the skin of the leg and foot, but is a definite bright orange pigmentation invariably associated with a similar bill colour. Others may have been overlooked as some of the adults in the large catches were handled in twilight. This is an abnormality which has been seen five times in the 8040 adult birds handled. The Icelandic examples were Ring Nos. 12673, 27204 and 27769. The two British captured specimens are now in the Trust's collection.



Foot of Henfooted Gosling

NOTES ON THE BIRDS OF ÞJÓRSÁRVER VID HOFSJÖKUL

A full list was given in Scott, Fisher and Guðmundsson (*loc. cit.*) of the birds seen in 1951. Only three species were added to this list in 1953 :

Mallard (*Anas platyrhynchos*)

A pair was seen in the marsh just north of Arnarfellsalda on 29 July, and a single bird in flight at the same place on 4 August.

Merlin

Merlin (*Falco columbarius*)

A male was seen in Tjarnarver on 10 July and the call was heard from the Base Camp on 12 July.

Raven (*Corvus corax*)

One was seen and heard near the Base Camp on 9 July.

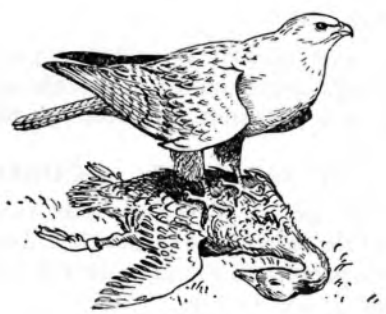
Apart from these new species some further observations were made of birds recorded in 1951.

Snowy Owl (*Nyctea scandiaca*)

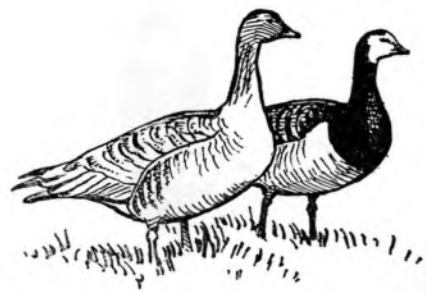
An adult male was seen on 9, 13, 19 July and 4 and 5 August. It was in the same area near the Hnifá (where one was also seen in 1951) on four of the dates, but on 4 August one was seen some six miles away and may perhaps have been a different bird.

Iceland Falcon (*Falco rusticolus*)

This species was seen only twice (substantially fewer times than in 1951). On 16 July in the early morning an Arctic Skua mobbed a falcon and the two passed directly over the Base Camp. The falcon was quite unconcerned at the skua's attacks and flew straight as a die towards the Kerlingarfjöll. On 19 July an Iceland falcon was sighted eating a gosling near the mouth of the Hnifá. As the party approached it tried to carry away its prey but could not quite lift it. Instead it stayed with it until we were about 50 yards away, then flew to a nearby mound where it looked superb against a background of the blue waters of Þjórsá and Hnifá at their junction. After that it flew round four times, its yellow legs shining in the sun. The plumage was beige-grey and there appeared to be no trace of moustaches. Its victim was a gosling ringed nearby a few hours earlier.



Wildfowl Trust



Barnacle Goose (*Branta leucopsis*)

A single Barnacle gander was rounded-up in the three thousand catch on 21 July and ringed No. 28142. Part of this drive passed close to the place where on 29 June 1951 a Barnacle gander was found mated to a female Pinkfoot sitting on four eggs. It seems possible therefore that this was the same bird. No goslings in the catch could be identified as hybrids, though the differences in colour or markings would not have been great at that stage of plumage development. No such hybrids have been seen since—although a Barnacle × Whitefront hybrid was seen in the winter of 1953–54 at Slimbridge and another (almost certainly a different bird) in Wexford. The Slimbridge bird reappeared in the winter of 1954–55 (see p. 19). It is probable therefore that a brood of hybrid Barnacle × Pinkfoot goslings would have been identified during the winter, had they reached Britain.

Arctic Tern (*Sterna macrura*)

Only a very few pairs were seen in 1951 but in 1953 there appeared to be a marked increase. Whether these birds had been breeding it was not possible to establish but the species was certainly substantially more numerous than it had been two years before.

Great Black-backed Gull (*Larus marinus*)

In 1951 it was estimated that between 30 and 40 were living in the oasis, feeding on the eggs and goslings of the Pinkfeet, though they were thought not to be breeding in the area. In 1953 the bird was seen even less frequently and it is thought that there were not more than ten of them in the oasis. On the other hand it is possible that there had been more during the incubation and hatching periods of the geese when food was plentiful, and that they had departed before the arrival of the expedition (about 17 days after the probable peak of the hatching date).

Ptarmigan (*Lagopus mutus*)

Only three broods were seen in 1951 but 1953 was evidently a ' Ptarmigan year.' The species was much more numerous. Although no record was kept of the number of broods seen, it cannot have been less than 15.

HOT SPRINGS AT NAUTHAGI : A CORRECTION

In the sketch map of this system of springs (5th Annual Report, p. 111) a scale is given at the left of the map of a distance described as ' about a hundred yards.' The distance was paced and found to be 140 yards. The sketch map should therefore be scaled up accordingly.

PLANTS OF THE ÞJÓRSÁRVER VIÐ HOFSJÖKUL

A LIST of 108 species of vascular plants collected by Finnur Guðmundsson in 1951 was given in the previous paper (5th Annual Report, p. 112). With this list as a guide Sladen made a further collection which also included 37 mosses and 8 liverworts.

The following plants given in the 1951 list were not refound :—

Stellaria crassifolia Ehrh.
Ranunculus reptans L.
Empetrum nigrum L.
Erigeron boreale (Vierh.) Simm.

It seems probable that the record of *Ranunculus reptans* was a misidentification and that the species was in fact *R. hyperboreus*, since the latter was found at specific sites from which the former had been recorded. *Empetrum* was abundant, but only one voucher specimen was collected in 1953 and this proved to be *E. hermafroditum*. *E. hermafroditum* and *E. nigrum* were probably both present.

Altogether 44 species, 5 varieties and 5 hybrids of vascular plants new to the area were found. Some of these (e.g. *Catabrosa*) being late flowers and found only during the last few days of our stay, might have been more widely distributed in the area than indicated by the frequency symbols. The list now represents over one-third of the total of vascular plants on the Iceland list.

No attempt was made at an exhaustive collection of the mosses and liverworts. They were collected from typical habitats and for their associations with the vascular plants.

The plant ecology of the area will be the subject of a more detailed paper to appear shortly in the Proceedings of the Linnean Society of London. The specimens collected, which represent every species, variety and hybrid listed below have been presented to the British Museum of Natural History, London.

PLANTS OF THE ÞJÓRSÁRVER VIÐ HOFSJÖKUL, JULY-AUGUST, 1953

*Not on 1951 list.
Frequency symbols:
a abundant.
f frequent.
o occasional.
r rare.
vr very rare (i.e., only seen once or twice).

	Frequency
Ophioglossaceae	
1. *Ophioglossum vulgatum* var. *polyphyllum* A.Br. ..	vr
2. *Botrychium lunaria* (L.) Sw.	o
Polypodiaceae	
*3. *Cystopteris fragilis* (L.) Bernh.	vr

Botrychium lunaria

		Frequency
	Equisetaceae	
4.	*Equisetum arvense* L. ..	a
*5.	„ *pratense* Ehrh...	vr
*6.	„ *palustre* L. ..	vr
*7.	„ *variegatum* Schleich. ex Weber and Mohr ..	f
*8.	„ *hyemale* L. ..	vr
	Selaginellaceae	
9.	*Selaginella selaginoides* (L.) Link	vr
	Potamogetonaceae	
10.	*Potamogeton alpinus* Balb.	vr
	Gramineae	
*11.	*Anthoxanthum alpinum* A. & D. Löve (*A. odoratum* s. Stefansson, pro parte)	vr
*12.	*Alopecurus aequalis* Sobol.	vr
13.	*Phleum commutatum* Gaud.	f
*14.	*Hierochlöe odorata* (L.) Beav.	o
*15.	*Milium effusum* L... ..	vr
16.	*Agrostis stolonifera* L. ..	f
17.	*Calamagrostis stricta* (Timm.) Koel. (*C. neglecta* (Ehrh.) G., M. & Sch.)	f
18.	*Deschampsia alpina* (L.) Roem. & Schult. ..	f
*19.	„ *flexuosa* (L.) Trin. ..	r
20.	*Trisetum spicatum* (L.) Richt.	f
*21.	*Catabrosa aquatica* (L.) Beauv.	vr
22.	*Poa glauca Vahl.*	f
23.	„ *alpina* L.	f
*24.	Var. *vivipara* L.	f
*25.	„ *pratensis* L. subsp. *alpigena* (Fr.) Hiit...	o
*26.	„ *subcaerulea* Sm. ..	o
27.	*Festuca rubra* L.	f
*28.	„ var. *mutica Hartm.*	a
29.	„ *vivipara* (L.) Sm...	f
	Cyperaceae	
30.	*Eriophorum scheuchzeri* Hoppe ..	a
31.	„ *polystachion* L. (*E. angustifolium* Honck.)	f
32.	*Kobresia myosuroides* (Vill.) Fiori & Paol.	f
*33.	*Carex maritima* Gunn. ..	o
34.	„ *curta* Gooden. (*C. canescens* auct.)..	o

Carex rariflora

		Frequency
35.	*Carex lachenalii* Schkuhr ..	r
36.	„ *rariflora* (Wahlenb.) Sm.	a
37.	„ *rostrata* Stokes ..	f
38.	„ *saxatilis* L.	o
39.	„ *nigra* (L.) Reich. (*C. Goodenoughii* Gay.)	a
40.	„ *lyngbyei* Hornem...	o
41.	„ *bigelowii* Torr. ex Schwein. (*C. rigida* Good.) ..	a
*42.	„ *rufina* Drej... ..	vr
*43.	„ *bigelowii* x *nigra* ..	o
*44.	„ *lyngbyei* x *nigra* ..	o
*45.	„ *bigelowii* x *lyngbyei*	vr
*46.	„ *bigelowii* x (hybrid)	vr
	Juncaceae	
47.	*Juncus arcticus* Willd. ..	f
*48.	„ *trifidus* L.	f
*49.	„ *triglumis* L. ..	o
50.	„ *biglumis* L... ..	f
51.	„ *articulatus* L. ..	vr
*52.	„ *bufonius* L... ..	vr
53.	*Luzula spicata* (L.) DC. ..	f
54.	„ *arcuata* Sw. ..	o
*55.	„ *confusa* (Hartm.) Lindeb.	o
*56.	„ *multiflora* (Retz) Lej	vr
	Liliaceae	
57.	*Tofieldia pusilla* (Michx.) Pers.	f

		Frequency
	Orchidaceae	
*58.	*Gymnadenia albida* (L.) Rich. (*Leucorchis albida* (L.) E. Mey.)	vr
59.	*Coeloglossum viride* (L.) Hartm.	o
	Salicaceae	
60.	*Salix glauca* L.	a
61.	,, *lanata* L.	a
62.	,, *herbacea* L.	a
63.	,, *phylicifolia* L. ..	a
*64.	,, *herbacea* x *lanata* ..	r
	Betulaceae	
65.	*Betula nana* L.	o
	Polygonaceae	
66.	*Rumex acetosa* L.	f
67.	*Oxyria digyna* (L.) Hill. ..	o
68.	*Koenigia islandica* L. ..	a
69.	*Polygonum viviparum* L. ..	a
	Caryophyllaceae	
*70.	*Montia fontana* L. (*M. lamprosperma* Chamisso) ..	vr
71.	*Cerastium cerastoides* (L.) Britton ..	f
72.	,, *alpinum* L. ..	a
*73.	,, var. *glabratum* Retz.	vr
*74.	,, *holosteoides* Fr. (*C. caespitosum* Gilib.) ..	vr
75.	*Sagina intermedia* Fenzl. ..	vr
*76.	,, *procumbens* L. ..	o
77.	*Minuartia rubella* (Wahlenb.) Hiern. (glandular and glabrous forms) ..	f
78.	,, *biflora* (L.) Schinz. and Thell. ..	o
*79.	,, *stricta* (Sw.) Hiern. ..	vr
80.	*Arenaria norvegica* Gunn...	f
81.	*Viscaria alpina* (L.) G. Don	f
82.	*Silene maritima* With. ..	a
83.	,, *acaulis* (L.) Jacq. ..	a
	Ranunculaceae	
84.	*Ranunculus acris* L. ..	f
85.	,, *pygmaeus* Wahlenb. ..	o
*86.	,, *hyperboreus* Rottb. ..	o
*87.	,, *confervoides* (Fr.) Fr. ..	vr
88.	*Thalictrum alpinum* L. ..	a

		Frequency
	Cruciferae	
89.	*Draba norvegica* Gunn. (*D. rupestris* R. Br.).. ..	o
90.	*Cardamine polemonioides* Rouy (*C. pratensis* s. Stefansson)	f
91.	,, *bellidifolia* L...	vr
92.	*Arabis alpina* L.	o
93.	*Cardaminopsis petraea* (L.) Hiit.	a
	Crassulaceae	
*94.	*Sedum acre* L.	vr
95.	,, *villosum* L... ..	o
96.	,, *rosea* (L.) Scop. ..	f

Saxifraga cernua

	Saxifragaceae	
97.	*Saxifraga cespitosa* L. ..	f
98.	,, *hypnoides* L. subsp. *borealiatlantica* Engl. & Irmsch. ..	vr
99.	,, *cernua* L. ..	r
100.	,, *rivularis* L. ..	r
101.	,, *oppositifolia* L...	f
102.	,, *hirculus* L. ..	f
103.	,, *nivalis* L. ..	o
104.	,, *tenuis* (Wahlenb.) H.Sm. ..	o
105.	,, *stellaris* L. ..	f
106.	*Parnassia palustris* L. ..	o
	Rosaceae	
107.	*Sibbaldia procumbens* L. ..	o
108.	*Potentilla palustris* (L.) Scop. (*Comarum palustre* L.)	o

		Frequency
109.	*Potentilla crantzii* (Crantz) G. Beck.. ..	o
110.	*Dryas octopetala* L. ..	f
*111.	*Alchemilla alpina* L. ..	vr
*112.	„ *filicaulis* Buser	r
*113.	„ *wichurae* (Buser) Stefansson ..	vr
114.	„ *glomerulans* Buser	r
	Geraniaceae	
115.	*Geranium sylvaticum* L. ..	f
	Violaceae	
116.	*Viola palustris* L.	o
	Onagraceae	
117.	*Chamaenerion latifolium* (L.) Sweet	f
118.	*Epilobium palustre* L. ..	vr
119.	„ *anagallidifolium* Lam.. ..	f
120.	„ *lactiflorum* Hausskn.	r
*121.	„ *hornemanni* Rchb.	vr
	Hippuridaceae	
122.	*Hippuris vulgaris* L. ..	vr
	Umbelliferae	
123.	*Angelica archangelica* subsp. *norvegica* (Rupr.) Nordh. (*Archangelica officinalis* s. Stefansson)	f
	Pyrolaceae	
124.	*Pyrola minor* L.	o
	Ericaceae	
*125.	*Loiseleuria procumbens* (L.) Desv.	o
126.	*Cassiope hypnoides* (L.) D. Don	a
127.	*Vaccinium uliginosum* L. ..	f
	Empetraceae	
*128.	*Empetrum hermafroditum* (Lange) Hagerup ..	?a
	Plumbaginaceae	
129.	*Armeria maritima* (Mill.) Willd. (*A. vulgaris* Willd.)	a
	Gentianaceae	
130.	*Gentianella tenella* (Rottb.) H.Sm. (*Gentiana tenella* Rottb.)	o
131.	*Gentiana nivalis* L. ..	o
132.	*Menyanthes trifoliata* L. ..	vr
	Labiatae	
133.	*Thymus drucei* Ronn. (*T. arcticus* (E. Dur.) Ronn.)	f
	Scrophulariaceae	
134.	*Rhinanthus crista-galli* L. (*R. minor* Ehrh. non L.)	vr
135.	*Bartsia alpina* L.	f
*136.	*Euphrasia curta* (Fr.) Wettst.	f
*137.	„ var. *piccola Pugsl.*	-
*138.	„ cf. *frigida Pugsl.*	vr
139.	*Pedicularis flammea* L. ..	f
140.	*Veronica fruticans* Jacq. ..	o
141.	„ *alpina* L. ..	?vr
*142.	„ *pumila* All. (*V. alpina* var. *australis* Wg.) ..	f
	Lentibulariaceae	
143.	*Pinguicula vulgaris* L. ..	o
	Plantaginaceae	
*144.	*Littorella uniflora* (L.) Aschers.	vr
	Rubiaceae	
*145.	*Galium verum* L.	vr
146.	„ *pumilum* subsp. *islandicum* Sterner (*G. pumilum* s. Stefansson) ..	f
	Compositae	
147.	*Erigeron uniflorus* L. ..	o
148.	*Gnaphalium supinum* L. ..	f
*149.	„ *norvegicum* Gunn.	vr
*150.	*Leontodon autumnalis* var. *taraxaci* (L.) Hartm. ..	vr
*151.	*Taraxacum faeroëense* Dahlst.	vr
*152.	*Taraxacum croceum* Dahlst.	o
153.	*Hieracium alpinum* aggr...	o
*154.	„ *microdon* Dahlst.	vr
*155.	„ *nigrescens* aggr.	o

MOSSES

1. *Sphagnum teres* (Schimp.) Aongstr.
2. *Andreaea rupestris* Hedw.
3. *Polytrichum urnigerum* Hedw.
4. „ *juniperinum* Hedw.
5. „ *commune* Hedw.
6. *Aongstroemia longipes* (Sommerf.) Bruch and Schimp.
7. *Blindia acuta* (Hedw.) Bruch and Schimp.
8. *Dichodontium pellucidum* (Hedw.) Schimp.

9. *Dicranoweissia crispula* (Hedw.) Lindb.
10. *Tortula ruralis* (Hedw.) Crome.
11. *Desmatodon latifolius* (Hedw.) Bruch and Schimp.
12. *Grimmia apocarpa* Hedw.
13. „ *funalis* (Schwaeger.) Schimp.
14. *Rhacomitrium canescens* (Hedw.) Brid.
15. *Splachnum vasculosum* Hedw.
16. *Leptobryum pyriforme* (Medw.) Wils.
17. *Pohlia cruda* Hedw.
18. „ *drummondii* (C. Muell.) Andrews
19. „ *gracilis* (Schleich.) Lindb.
20. „ *ludwigii* (Spreng.) Broth.
21. *Mnium affine* Bland.
22. „ *punctatum* Hedw.
23. „ *cinclidioides* Hüben.
24. *Aulacomnium palustre* (Hedw.) Schwaegr.
25. *Paludella squarrosa* (Hedw.) Brid.
26. *Meesia uliginosa* Hedw.
27. *Bartramia ithyphylla* Brid.
28. *Conostomum tetragonum* (Brid.) Lindb.
29. *Philonotis fontana* (Hedw.) Brid.
30. var. *tomentella* (Mol.) Dixon
31. *Drepanocladus aduncus* (Hedw.) Warnst.
32. „ *revolvens* (Sm.) Warnst.
33. „ *uncinatus* (Hedw.) Warnst.
34. *Acrocladium stramineum* (Brid.) Richards and Wallace
35. „ *giganteum* (Schimp.) Richards and Wallace
36. *Camptothecium nitens* (Hedw.) Schimp.
37. *Brachythecium reflexum* (Starke) Bruch and Schimp.

LIVERWORTS

1. *Marchantia polymorpha* L.
2. *Fossombronia dumortieri* (Hook. and Genth.) Lindb.
3. *Lophozia ventricosa* (Dicks.) Dum.
4. „ *alpestris* (Schleich.) Evans
5. *Cephalozia bicuspidata* (L.) Dum.
6. *Pleuroclada albescens* (Hook.) Spruce
7. *Blepharostoma trichophyllum* (L.) Dum.
8. *Scapania curta* (Mart.) Dum.

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