THE SURVIVAL OF FALKLAND ISLANDS TRANSPLANTS AT SOUTH GEORGIA AND SIGNY ISLAND, SOUTH ORKNEY ISLANDS

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ABSTRACT. Transplants of a number of species from the Falkland Islands were tested between 1967 and 1971 in local soil and a non-limiting medium on South Georgia and Signy Island. It was found that on both islands species varied in their ability to survive and to flower. The best vegetative performance occurred on South Georgia but overwintering survival was very poor due to damage to the study site. Although 11 species survived for 2½ years on Signy Island, there was a substantial reduction in their vegetative and reproductive performance suggesting that none of them was likely to become naturalized.

THE success of alien flowering plants in high southern latitudes has interested scientists for a long time, the first experimental introduction being made by the German South-Polar Expedition of 1882–83 at Royal Bay, South Georgia (lat. 54°20′S., long. 36°00′W.). According to Neumayer (1891), Will grew rye, barley and wheat mostly of Swedish origin in an area *c.* 4 m.^{2} near their station. Only the rye developed inflorescences, but at the end of March a violent thunderstorm stopped further development. Potatoes were also tried and the plants grew to a height of *c.* 10 cm., but did not flower although some young tubers, about the size of hazel nuts, were formed. Cress, grown in a sand and dung mixture, was successful and used in salads.

Brown (1912) sent seeds and bulbs of 22 Arctic species to Laurie Island, South Orkney Islands (lat. 60°44′S., long. 44°37′W.); all of these failed to germinate out of doors, although some grew in natural soil when placed in a warmer environment indoors (Brown, 1927).

Taylor (1913) reported an attempt to grow temperate plants at Granite Harbour, Victoria Land (lat. 76°53′S., long. 162°44′E.) during the British Antarctic Expedition of 1910–13 and, although a dozen seeds of sea kale (*Crambe maritima*) germinated in the field, all the seedlings died within 10 days. Holdgate (1964) described Lamb's introduction of Falkland Islands species to Port Lockroy, Antarctic Peninsula (lat. 64°49′S., long. 63°30′W.) in 1944, and reviewed an attempt in 1935 to establish plants at the Argentine Islands (lat. 65°15′S., long. 64°17′W.). Holdgate concluded that further experiments in other Antarctic areas were desirable, particularly as Corte (1961) had discovered colonies of the alien grass, *Poa pratensis*, at Cierva Cove, Danco Coast (lat. 64°09′S., long. 60°53′W.) during 1954–55 growing in soil imported from Ushuaia, Tierra del Fuego, with six *Nothofagus* trees which had died.

R. I. L. Smith (personal communication) planted *Rostkovia magellanica*, *Empetrum rubrum*, *Cortaderia pilosa*, *Poa flabellata*, *Oreobolus obtusangulus* and *Gunnera magellanica* from the Falkland Islands and *Saxifraga oppositifolia* and *Alchemilla alpina* from the Cairngorm Mountains, Scotland, on Signy Island in 1965 but all died during the first year. Rudolph (1966*a*) tested seed from several flowering plant species in natural soil at Cape Hallett, Victoria Land (lat. 72°19′S., long. 170°18′E.), all of which failed to germinate under external climatic conditions, but when brought indoors germination took place and the plants grew well and flowered. In a later experiment at the same study site, Rudolph succeeded in germinating seeds of *Poa pratensis* in the prevailing climatic conditions (Rudolph, 1965, 1966*b*) but the plants never developed beyond the two-leaf stage. Seeds of *Diapensia lapponica* were also tested but failed to produce healthy seedlings either indoors or in the field.

The present paper describes the introduction of adult plants from the Falkland Islands to South Georgia, a sub-Antarctic island, and Signy Island, an Antarctic island, and their subsequent performance. In accordance with the requirements of the Antarctic Treaty, all introduced material was destroyed at the end of the experiments.

MATERIALS AND METHODS

Material was collected from the Falkland Islands in the neighbourhood of Mount Challenger, on 17 November 1967 (Tables I and II), and was kept at 0° C until transplanted on South Georgia on 1 December 1967 and on Signy Island on 23 and 24 December 1967. A second collection of plants was made on 6 November 1968 from the vicinity of Port Stanley and

Sapper Hill, Falkland Islands (Table III), and these were transported to Signy Island at air temperature, the material being kept in open boxes on the upper deck of R.R.S. *John Biscoe*. They were re-planted on Signy Island between 2 and 4 December 1968.

Transplants on South Georgia

The material was carefully subdivided into individual plants of each species which were then planted in natural soil and in a non-limiting medium, i.e. vermiculite with a nutrient solution.

The natural soil site was in a well-developed north-facing grassland, dominated by *Festuca erecta*, at an altitude of *c.* 85 m. near Grytviken (GR 132 124). Approximately 15 m.^{2} of the natural vegetation was removed and the underlying soil dug over before planting (Fig. 1). The transplants in pots filled with vermiculite were placed at the lower edge of the cleared plot, partly submerged in the earth and partly surrounded by stones (Fig. 2). All the transplants were watered every other day, those in natural soil with water from a nearby stream and those in vermiculite with a non-limiting solution, made up as follows:

Macro-nutrients	g./l.	*Micro-nutrients*	mg./l.
KNO_3	0·51	H_3BO_3	2·86
$Ca(NO_3)_2 \cdot 4H_2O$	1·18	$MnCl_2 \cdot 4H_2O$	1·81
$MgSO_4 \cdot 7H_2O$	0·49	$ZnSO_4 \cdot 7H_2O$	0·22
KH_2PO_4	0·14	$CuSO_4 \cdot 5H_2O$	0·08
		$H_2MoO_4 \cdot 4H_2O$	0·02
		$FeSO_4$ chelated in EDTA	2·49

All transplants were examined at approximately 14 day intervals until the end of March 1968, any change, vegetative or reproductive, being noted. The experiment using plants in the non-limiting medium was terminated at the end of the 1967–68 season, but plants in native soil were left to test their capacity to survive the winter. The site was visited on 19 November 1968 by one of us (J.A.E.) and the few surviving plants were recorded. All the introduced material was finally destroyed on 12 January 1969.

Transplants on Signy Island, 1967

The transplant site chosen in 1967 was a steep rocky slope in Factory Cove, Borge Bay (GR 1039 0451), and the transplants were divided in the same way as those on South Georgia. To minimize disturbance of the natural vegetation, the natural soil transplants were situated in an eroding *Polytrichum alpestre* bank separated from the vermiculite transplants by a small ridge. An area 1 m.^{2} was dug over and the greener parts of the bank removed. As this yielded an insufficient depth of soil, *c.* 15 kg. of stony soil from a *Deschampsia antarctica* sward, *c.* 7 kg. of soil from below the nests of cape pigeons (*Daption capensis*) and *c.* 40 kg. of a fine brown peaty alluvium from the side of a snow-melt pool were mixed with the peat. The pH of the final soil mixture was 4·2 and still very peaty in character, resembling the Signy Island peat soils described by Holdgate and others (1967), but it was probably richer in nitrogen. The transplants faced north-north-east on a 20° slope and were *c.* 13 m. a.s.l. The vermiculite pots could not be sunk to ground level because of the stony nature of the terrain but they were supported by stones on a rather unstable 50° slope between two areas of *Deschampsia antarctica*. The pots faced north-north-west at *c.* 10 m. altitude and were *c.* 25 m. from the sea.

The transplants were watered and supplied with nutrient solution with the same frequency as on South Georgia. Watering was discontinued for transplants in soil after a month as natural precipitation was adequate. The transplants were examined once a month when the numbers of healthy leaves and shoots were recorded to give an indication of the perfomance of each species. The experiment was abandoned in November 1968, all of the plants having died.

Transplants on Signy Island, 1968

In species which form dense carpets, separation into individual plants causes disruption of the natural growth form. To overcome this difficulty, single large pieces of undisturbed vegeta-

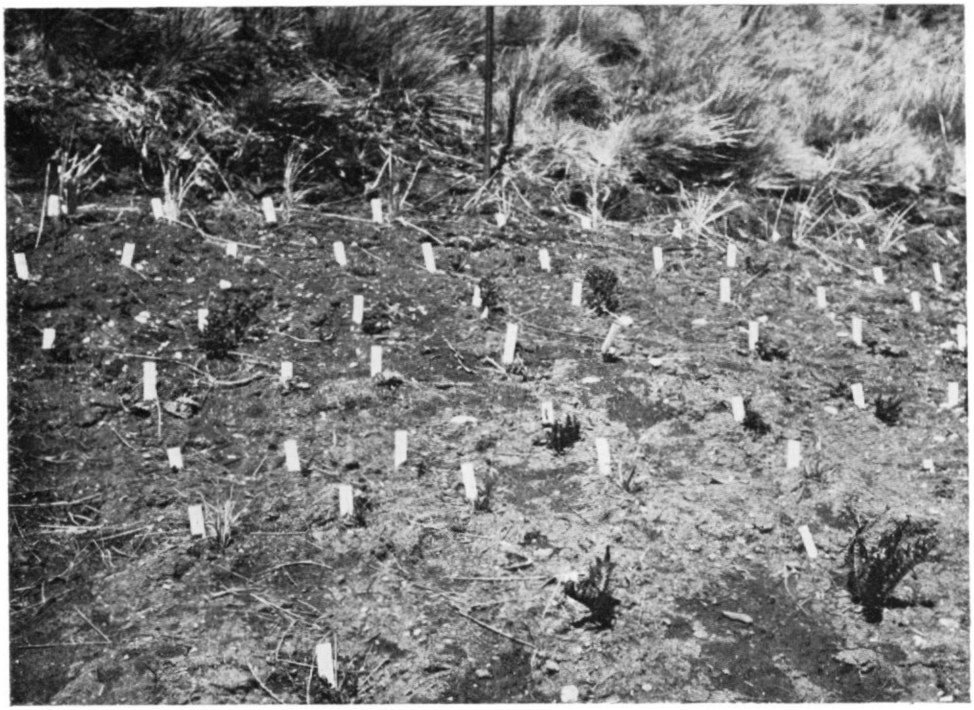

Fig. 1. Natural soil site at South Georgia, February 1968.

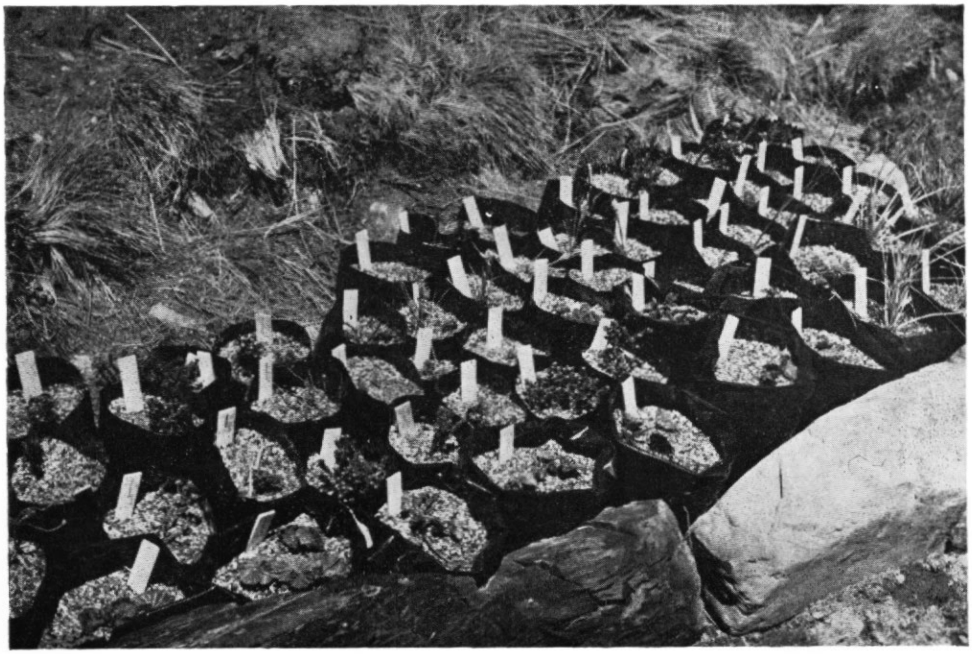

Fig. 2. Plants growing in pots watered with non-limiting solution, South Georgia, February 1968.

tion were used as transplants in the 1968 experiment. While the majority of these pieces consisted of only a single species, some had one or more associates as indicated in Table III. The majority of the samples were planted into natural soil as this had proved a more successful medium the previous summer than vermiculite. The samples were watered and observed as in the 1967 experiments.

Different transplant sites were chosen as those of the previous year were rather exposed and windswept. The natural soil site (Fig. 3) was below the peat bank used in 1967, *c.* 8 m. a.s.l.

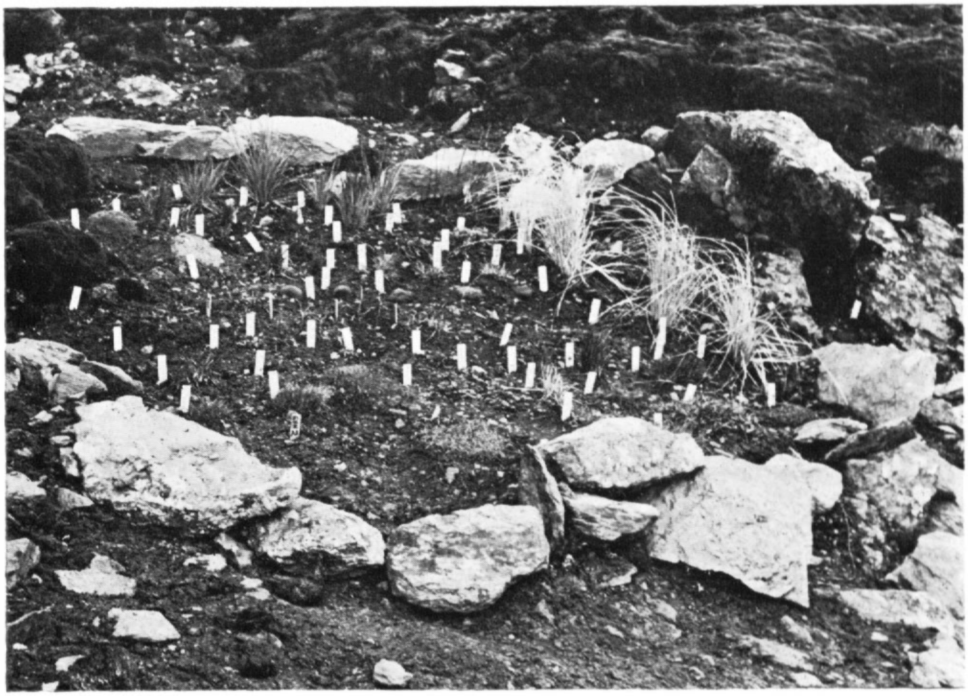

Fig. 3. The 1968–69 native soil site on Signy Island at the end of the first summer.

and sloped 10° to the north-east. There were fewer green fragments in this soil which contained considerable amounts of fine peat brought down from the surrounding slopes by a small stream. More soil from the surrounding area was added to increase the depth and the final soil pH was 4·0. The plants in the non-limiting medium were placed among *Deschampsia antarctica* at Factory Cove below the site used the previous year.

Performance of 1967 Transplants

Vegetative success

Survival of the 1967 transplants on South Georgia and Signy Island is summarized in Table I, which shows that there was little difference between the two islands except that both species of *Blechnum* failed during the first summer on Signy Island. In performance, however, the majority of the transplants were more successful on South Georgia. On the latter island most of the species produced new vegetative growth in both soil and the non-limiting medium with the exception of *Abrotanella emarginata* and *Pernettya pumila* where the old growth gradually decreased and *Empetrum rubrum* where only plants in the non-limiting medium produced new growth. *Blechnum magellanicum* and *B. penna-marina* showed little difference in performance between the two media but the remainder of the species had an enhanced success in the non-limiting medium, except *Sisyrinchium filifolium* where the soil transplants showed most

Table I. The percentage survival of the 1967 Falkland Islands transplants on South Georgia and Signy Island

Species	*Number of transplants tested*				*Percentage apparent vegetative survival*											
	South Georgia		*Signy Island*		*March 1968 South Georgia*		*March 1968 Signy Island*		*April 1968 Signy Island*		*November 1968 South Georgia*		*November 1968 Signy Island*		*Jan. 1969 S. Georgia*
	Soil	*Non-limiting medium*	*Soil*	*Non-limiting medium*	*Soil*	*Non-limiting medium**	*Soil*	*Non-limiting medium*	*Soil*	*Non-limiting medium*	*Soil*	*Non-limiting medium**	*Soil*	*Non-limiting medium*	*Soil*
Abrotanella emarginata	5	5	1	5	100	100	100	100	100	100	0	—	0	0	0
Azorella lycopodioides	5	5	1	5	100	100	100	100	100	100	0	—	0	0	0
Baccharis magellanica	5	5	1	5	80	80	0	100	0	80	0	—	0	0	0
Blechnum penna-marina	5	5	—	5	80	80	—	0	—	0	0	—	—	0	0
Blechnum magellanicum	5	5	1	5	80	100	100	60	0	0	0	—	0	0	0
Empetrum rubrum	5	5	1	5	100	100	100	100	100	80	0	—	0	0	0
Enargea marginata	—	—	1	—	—	—	100	—	0	—	—	—	0	—	—
Gaultheria antarctica	—	—	1	—	—	—	100	—	0	—	—	—	0	—	—
Gunnera magellanica	10	10	1	5	100	100	100	100	100	80	0	—	0	0	0
Hierochloë redolens	10	5	1	5	100	100	100	60	100	40	50	—	0	0	30
Luzula alopecurus	5	5	—	5	40	80	—	40	—	40	0	—	—	0	0
Oreobolus obtusangulus	—	—	2	—	—	—	50	—	50	—	—	—	0	—	—
Pernettya pumila	10	5	1	5	100	60	0	100	0	100	0	—	0	0	0
Sisyrinchium filifolium	5	5	—	5	80	100	—	80	—	40	80	—	—	0	80

* All plants in the non-limiting medium on South Georgia were harvested in April 1968.
— Denotes that no plants of this species were transplanted.

growth. *Gunnera magellanica* was particularly successful in both soil and the non-limiting medium, producing an abundance of new leaves and some new branches.

On Signy Island, most species failed to produce new leaves and gradually died, those in soil surviving longest. *Azorella lycopodioides*, *Baccharis magellanica*, the two species of *Blechnum*, *Luzula alopecurus* and *Oreobolus obtusangulus* gradually became moribund as more leaves turned brown but *Abrotanella emarginata*, *Pernettya pumila* and *Sisyrinchium filifolium* remained green and apparently healthy. Only *Gunnera magellanica* and *Hierochloë redolens* continued to produce new leaves.

With the onset of winter, some of the transplants on Signy Island showed a sharp decrease in vigour, particularly *Blechnum magellanicum* and *Sisyrinchium filifolium* and by the following spring all had died. The overwintering success of the transplants on South Georgia was greatly reduced by the disruption of the natural soil site and by the absence of the plants in the non-limiting medium which were harvested at the end of the previous summer. When the site was visited in November 1968, only a single dead plant each of *Empetrum rubrum*, *Azorella lycopodioides* and the two ferns remained rooted in the lower part of the site but five living plants of *Hierochloë redolens* and four of *Sisyrinchium filifolium* were present at the top of the site. It appeared that most of the plants had been uprooted for some time, probably by a snow slip caused by the weight of snow on ground denuded of its vegetation. Three plants of *Hierochloë redolens* and all of the *Sisyrinchium filifolium* were alive and healthy when the experiment was terminated in January 1969.

Flowering success

Satisfactory conclusions cannot be drawn about the reproductive capacity of these transplants, since many of the plants were already in flower or had floral primordia when introduced. Table II shows that during the first summer on South Georgia most species with flowers

TABLE II. FLOWERING SUCCESS OF THE 1967 FALKLAND ISLANDS PHANEROGAMS ON SOUTH GEORGIA AND SIGNY ISLAND

Species	*Flowering when planted*		*Existing flowers developed further*		*New flowers formed 1967–68*		*New flowers formed 1968–69*	
	South Georgia	*Signy Island*	*South Georgia*	*Signy Island*	*South Georgia*	*Signy Island*	*South Georgia*	*Signy Island*
Abrotanella emarginata	+	+	—	—	—	—	—	—
Azorella lycopodioides	+	+	+	+	—	—	—	—
Baccharis magellanica	+	—	+	—	+	—	—	—
Empetrum rubrum	—	+	—	—	—	—	—	—
Enargea marginata	*	—	*	—	*	—	*	—
Gaultheria antarctica	*	+	*	—	*	—	*	—
Gunnera magellanica	—	+	—	—	+	—	—	—
Hierochloë redolens	+	—	+	+	—	—	—	—
Luzula alopecurus	+	+	+	—	—	—	—	—
Oreobolus obtusangulus	*	—	*	—	*	—	*	—
Pernettya pumila	+	—	+	+	+	+	—	—
Sisyrinchium filifolium	+	+	—	—	—	—	+	—

* Not tested. + Present. — Absent.

already present were able to continue development. In the case of *Sisyrinchium filifolium* flowering was complete for the 1967–68 season at the beginning of the experiment but after overwintering three of the four remaining transplants produced new flowers the next season.

The climate of Signy Island appeared to suppress floral development in *Abrotanella emarginata*, *Empetrum rubrum*, *Gaultheria antarctica*, *Gunnera magellanica*, *Luzula alopecurus* and *Sisyrinchium filifolium* as all were flowering when transplanted (Table II), but in each species these flowers died within 2 months without showing any further development. One new flower developed during January on a plant of *Pernettya pumila* but this and the other 12 flowers of this species withered and died in February. Inflorescences of *Hierochloë redolens* expanded slightly during the summer but turned white and moribund before the onset of winter. Only the flowers of *Azorella lycopodioides* kept their colour and those fruits which were present had swollen slightly by April but no mature or viable seed was set by any species on South Georgia or Signy Island. There were no sori present on any of the transplants of the two species of *Blechnum* and none developed.

Performance of 1968 Transplants

Vegetative success

These transplants were more successful than those of 1967 with 11 species surviving three summers and two winters (Table III). The performance of the transplants in soil was again better than those in the non-limiting medium but the ability to survive varied between species. *Blechnum penna-marina*, *Gaultheria antarctica*, *Isolepis cernua* and *Luzula campestris* died during the first summer while *Cortaderia pilosa* (Fig. 4) and *Lycopodium magellanicum* were almost completely dead at the onset of winter. *Baccharis magellanica* and *Bellis perennis* failed to survive the first winter, although both species appeared healthy at the end of the previous summer while *Deschampsia antarctica* and *Oreobolus obtusangulus* died during the second summer without new growth forming. *Gunnera magellanica*, *Pratia repens* and *Rostkovia magellanica*, although producing some new leaves, failed to survive a second winter and *Taraxacum officinale* died during the third summer after appearing relatively healthy during the previous two.

Of the plants alive in March 1971, those of *Astelia pumila* (Fig. 4), *Caltha sagittata*, *Carex flacca*, *Colobanthus quitensis*, *Juncus scheuchzerioides* and *Pernettya pumila* appeared moribund but the remaining five species (Table IV) were healthy and seemed capable of surviving for a further season. *Poa annua* and *Caltha appendiculata* were the healthiest species, the latter (Fig. 4) maintaining its leaves and colour unchanged during the 3 years and with no moribund areas appearing. *Poa annua*, on the other hand, produced new leaves each season to replace those which died and rotted during the winter, and one plant which had completely lost its foliage in November 1970 had produced new leaves by the following March. Two of the three cushions of *Bolax gummifera* gradually turned yellow and died during 1970–71 but the remaining plant was described by R. Webb (personal communication) as "very healthy" in March 1971. The upper portion of the leaves of *Marsippospermum grandiflorum* soon turned brown but the bases remained green and at least one new leaf was formed. *Cotula scariosa* retained its healthy appearance until the third summer when the condition of the plants deteriorated slightly.

Thus many of the transplated species failed to make any new growth on Signy Island while others, such as *Bolax gummifera* and *Marsippospermum grandiflorum*, were only able to produce a small number of new leaves (Table IV), possibly from stored food reserves. Relatively few species produced vigorous growth and of these *Gunnera magellanica* and *Taraxacum officinale* did so only for a short period before gradually dying. The transplants of the two species of *Caltha*, *Cotula scariosa* and *Poa annua* appeared to acclimatize most successfully to their new environment.

Flowering success

No reproductive organs were formed on any of the transplants of *Lycopodium magellanicum* or the two species of *Blechnum*. The flowering response of the phanerogams is summarized in

TABLE III. THE PERCENTAGE SURVIVAL OF FALKLAND ISLANDS TRANSPLANTS AT SIGNY ISLAND BETWEEN DECEMBER 1968 AND MARCH 1971

Species	*Number planted December 1968*	*Percentage survival*					
		February 1969	*March and April 1969*	*December 1969*	*April 1970*	*November 1970*	*March 1971*
Astelia pumila	1 (1)	100 (100)	100 (100)	100 (0)	100 (0)	100 (0)	100 (0)
*Baccharis magellanica**	1	100	100	0	0	0	0
Bellis perennis	7	100	86	0	0	0	0
*Blechnum penna-marina**	3	100	0	0	0	0	0
Bolax gummifera	3	100	100	100	100	100	66
Caltha appendiculata	1	100	100	100	100	100	100
Caltha sagittata	2	100	100	100	100	50	50
Carex flacca	3 (1)	100 (100)	100 (100)	66 (0)	33 (0)	33 (0)	33 (0)
Colobanthus quitensis	5 (3)	100 (100)	100 (100)	100 (100)	80 (33)	60 (0)	40 (0)
Cortaderia pilosa	5 (3)	80 (100)	60 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Cotula scariosa	1	100	100	100	100	100	100
Deschampsia antarctica	2	100	100	50	50	0	0
*Gaultheria antarctica**	3	33	0	0	0	0	0
Gunnera magellanica	2	100	100	50	50	0	0
Isolepis cernua	1	100	0	0	0	0	0
*Juncus scheuchzerioides**	3	100	100	33	33	33	33
Luzula campestris	1	100	0	0	0	0	0
Lycopodium magellanicum	2	50	50	0	0	0	0
Marsippospermum grandiflorum	1	100	100	100	100	100	100
Oreobolus obtusangulus	2	100	100	100	0	0	0
*Pernettya pumila**	1	100	100	100	100	100	100
*Poa annua**	5	100	100	40	40	20	40
*Pratia repens**	4	100	100	50	25	0	0
*Rostkovia magellanica**	3	100	66	33	33	0	0
Taraxacum officinale	2	100	100	1[illegible]	100	50	0

* Signifies plants growing in soil only as a subsidiary among a large colony of another species and hence subjected to some competition but also receiving some shelter.

Fig. 4. Moribund *Astelia pumila* (left), healthy *Caltha appendiculata* (centre) and completely dead *Cortaderia pilosa* (right) at native soil site, Signy Island, March 1971. (Photograph by R. Webb.)

Table V. *Astelia pumila*, *Cotula scariosa*, *Isolepis cernua*, *Luzula campestris* and *Oreobolus obtusangulus* were flowering when transplanted in 1968, but all of the flowers had withered by February 1969. Inflorescences were also present on *Cortaderia pilosa* when planted and these emerged slightly but soon turned chlorotic. *Baccharis magellanica* was in bud when planted and one flower opened by March 1969 but this, and the buds of *Gunnera magellanica* which also developed into flowers during the summer, failed to survive the winter. *Bellis perennis* which appeared very healthy during its first summer, had four plants in flower when planted, and these produced another seven capitula before winter, but all the plants were dead the following spring. The flowers present on *Caltha sagittata* when planted soon perished, but those of *C. appendiculata* developed slightly with the follicles of five flowering heads opening to expose greenish seeds *c.* 2 mm. long. After winter the follicles were dead containing dark brown seeds which had shrivelled.

Many of the plants of *Deschampsia antarctica* and *Colobanthus quitensis* were in poor condition on arrival at Signy Island and, although they never fully recovered vegetatively, flowers developed throughout the 1968–69 summer. *D. antarctica* inflorescences became almost fully exserted but no viable seed was produced. *C. quitensis* flowers matured and the capsules opened in March, exposing brown swollen seed which was viable, as seedlings were observed during the second summer around the bases of the parent plants and some germination occurred while seed was still in the capsules. A second set of small flowers was noted on some of the plants in native soil in April 1969, but these failed to develop fully.

Only two species produced flowers after they had overwintered on Signy Island. Four flowers were present on *Marsippospermum grandiflorum* when the plant was introduced but these withered without producing seed in January 1969. However, two new flower buds were noticed in February 1970, although they failed to open fully or produce seed. A clump of *Poa annua*, 7·5 cm. in diameter, with six inflorescences was planted in December 1968, and produced during three successive austral summers 37, 13 and *c.* 60 inflorescences, respectively. No seedlings were noted around the clump, although fertile seed appeared to be produced.

Discussion

The present experiments have confirmed that some introduced species are capable of surviving in Antarctic regions for one or more seasons. Not surprisingly, the transplants on South Georgia were more successful than those on Signy Island, but the experiments demonstrated that different species have varying capacities to survive in an alien environment. For example, some species withstood summer conditions but not those of winter, while others were eliminated by a particularly severe period even after growing for several seasons.

TABLE IV. NUMBERS OF APPARENTLY HEALTHY LEAVES OR LEAF ROSETTES PRESENT ON SOME FALKLAND ISLANDS TRANSPLANTS ON SIGNY ISLAND

Species	*Character*	*Date assessed* 14 Dec. 1968	14 Jan. 1969	17 Feb. 1969	17 Dec. 1969	3 Feb. 1970	16 Mar. 1970	18 Nov. 1970	3 Mar. 1971
Bolax gummifera	Number of leaf rosettes	25	30	38	15	49	*c.* 50	27	46
Caltha appendiculata	Number of leaves	>200	>200	>200	>200	>200	>200	>200	>200
Cotula scariosa	Number of leaves	50	*c.* 70	*c.* 70	5	42	*c.* 55	1	6
Marsippospermum grandiflorum	Number of leaves	29	31	30	28	28	29	25	24
Poa annua	Number of leaves	>80	>100	>100	13	>100	>100	8	>100

TABLE V. THE FLOWERING SUCCESS OF ALL FALKLAND ISLANDS PHANEROGAMS TRANSPLANTED TO SIGNY ISLAND IN 1968

Species	*Flowers present when planted*		*New flowers produced*	
	Failed to develop further	*Developed further*	*During first summer*	*After wintering*
Astelia pumila	+	—	—	—
Baccharis magellanica	—	+	—	—
Bellis perennis	—	+	+	—
Bolax gummifera	—	—	—	—
Caltha appendiculata	—	+	—	—
Caltha sagittata	+	—	—	—
Carex flacca	—	—	—	—
Colobanthus quitensis	—	+	+	—
Cortaderia pilosa	+	—	—	—
Cotula scariosa	+	—	—	—
Deschampsia antarctica	—	+	—	—
Gaultheria antarctica	—	—	—	—
Gunnera magellanica	—	+	—	—
Isolepis cernua	+	—	—	—
Juncus scheuchzerioides	—	—	—	—
Luzula campestris	+	—	—	—
Marsippospermum grandiflorum	+	—	—	+
Oreobolus obtusangulus	+	—	—	—
Pernettya pumila	—	—	—	—
Poa annua	—	+	+	+
Pratia repens	—	—	—	—
Rostkovia magellanica	—	—	—	—
Taraxacum officinale	—	—	—	—

+ Present. — Absent.

The differences between the performance of the 1967 and 1968 transplants are most likely to be due to the more sheltered sites for the second experiment, but it seems probable that the slightly better performance shown by the 1968 transplants in soil against those in the non-limiting medium was due to the plants in soil being continuously snow-covered throughout the winter. The transplants in the non-limiting medium were exposed or only lightly snow-covered for part of the period.

There seems little doubt that nutrient deficiencies on Signy Island are not the sole reason for the lack of phanerogamic vegetation, a conclusion that is almost certainly true for other parts of Antarctic regions. The study site on South Georgia was in an area bearing well-developed climax vegetation, but its soil is known to have very low concentrations of sodium, potassium, calcium, magnesium and phosphorus ions as well as low levels of total nitrogen. *Empetrum rubrum* was not particularly successful at this site but a plant of this species has since been found not far away, where it appears to have grown for a number of years in a habitat more closely related to its native habitat than the study site (personal communication from R. I. L. Smith).

When trying to draw conclusions from these experiments or comparing them with earlier work, various factors must be borne in mind. Vigorous healthy plants were taken in late spring when several were already flowering and were maintained for varying periods of time in cold storage or on the exposed deck of a ship before re-planting, all treatments which would be considered far from desirable in normal horticultural practice. In addition, species from several habitats in the Falkland Islands were all tested at a single study site on South Georgia and Signy Island under the same watering regimes. Even under optimum conditions not every individual transplanted would be expected to survive, those with a herbaceous habit being likely to be more successful than those with a woody habit. Also, in the present experiments the number of replicates was restricted to prevent undue disturbance of the native vegetation at the study sites. For these reasons, therefore, it would appear rash to assume that because a few individuals failed or did badly in the present or earlier experiments, a species is incapable of surviving at a test site. The performance of Falkland Islands transplants of *Deschampsia antarctica* and *Colobanthus quitensis* on Signy Island reinforces this conclusion since both species are native to that island (Greene and Holtom, 1971; Edwards, 1972), as is *Blechnum penna-marina* on South Georgia. Obviously the testing of larger samples of adult plants or a number of plants grown from seed would give a better assessment of the genetic capacity of a species to produce individuals capable of surviving at tests sites, particularly if the latter fall within or close to the ecological range of that species.

A few tests using seed have been carried out with very limited success (Brown, 1912; Rudolph, 1965, 1966*a*, *b*), but the introduction of some alien species is thought to have taken place in this way, for example around the whaling stations on South Georgia from seed introduced in animal feed (Longton, 1965). Most of these introductions have proved transient but already eight species have become naturalized on the island (Greene, 1964; Longton, 1965), all of them cosmopolitan. In this context it is interesting that *Poa annua* was the only species to produce flowers consistently each year on Signy Island. Since seed germination and seedling growth are likely to be slow, test sites must be maintained over a number of years to determine whether a species is capable of producing adult plants which can complete their life cycle and give progeny also able to survive at the sites. Such work will require great care to preserve the natural environment from excessive damage caused by clearing experimental areas or the escape of alien seed. Yet experiments of this type appear to be the best way of testing whether the floristic poverty of Antarctic regions is due to environmental constraints or dispersal barriers.

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REFERENCES

Brown, R. N. R. 1912. The problems of Antarctic plant life. *Rep. scient. Results Scott. natn. antarct. Exped.*, **3**, Pt. 1, 1–20.

————. 1927. *The polar regions. A physical and economic geography of the Arctic and Antarctic.* London, Methuen & Co. Ltd.

CORTE, A. 1961. La primera fanerógama adventicia hallada en el continente Antártico. *Contrnes Inst. antárt. argent.*, No. 62, 14 pp.

EDWARDS, J. A. 1972. Studies in *Colobanthus quitensis* (Kunth) Bartl. and *Deschampsia antarctica* Desv.: V. Distribution, ecology and vegetative performance on Signy Island. *British Antarctic Survey Bulletin*, No. 28, 11–28.

GREENE, D. M. *and* A. HOLTOM. 1971. Studies in *Colobanthus quitensis* (Kunth) Bartl. and *Deschampsia antarctica* Desv.: III. Distribution, habitats and performance in the Antarctic botanical zone. *British Antarctic Survey Bulletin*, No. 26, 1–29.

GREENE, S. W. 1964. The vascular flora of South Georgia. *British Antarctic Survey Scientific Reports*, No. 45, 58 pp.

HOLDGATE, M. W. 1964. An experimental introduction of plants to the Antarctic. *British Antarctic Survey Bulletin*, No. 3, 13–16.

———., ALLEN, S. E. *and* M. J. G. CHAMBERS. 1967. A preliminary investigation of the soils of Signy Island, South Orkney Islands. *British Antarctic Survey Bulletin*, No. 12, 53–71.

LONGTON, R. E. 1965. Additions to the alien flora of South Georgia. *British Antarctic Survey Bulletin*, No. 5, 47–49.

NEUMAYER, G. 1891. Die Expedition nach dem Moltke-hafen auf Süd-Georgien, deren Verlauf und Rückkehr. (*In* NEUMAYER, G. *Die Internationale Polarforschung 1882–83. Die Deutschen Expeditionen und ihre Ergebnisse*. Berlin, A. Asher & Co., Bd. 1, 91–144.)

RUDOLPH, E. D. 1965. Antarctic lichens and vascular plants: their significance. *Bioscience*, **1**, No. 4, 285–87.

———. 1966*a*. Lichen ecology and microclimate studies at Cape Hallett, Antarctica. (*In Biometeorology II. Proceedings of the third International Biometeorological Congress held at Pau, S. France, 1–7 September 1963*. Oxford, London, Edinburgh, New York, Toronto, Paris and Frankfurt, Pergamon Press, 900–10.)

———. 1966*b*. Terrestrial vegetation of Antarctica: past and present studies. (*In* TEDROW, J. C. F., *ed. Antarctic soils and soil forming processes*. Washington, D.C., American Geophysical Union, 109–24.) [Antarctic Research Series, Vol. 8.]

TAYLOR, [T.] G. 1913. The western journeys. (*In* HUXLEY, L., *ed. Scott's last expedition*. London, Smith, Elder & Co., **2**, 182–290.)