

STATUS OF THE ALIEN VASCULAR FLORA OF SOUTH GEORGIA

By D. W. H. WALTON and R. I. L. SMITH

ABSTRACT. A check list is given of all alien phanerogams recorded from South Georgia during the period 1902-72. Details of location and performance of extant populations are reported, and the species are divided into three groups—transient, persistent and naturalized—with 20, 16 and 15 species, respectively. Reference is also made to some unidentified material of transient aliens. The island's alien flora is compared with similar floras on other sub-Antarctic islands.

SOUTH GEORGIA has a total of 24 native phanerogams (Greene, 1964a) of which approximately half are abundant and widespread in the coastal areas of the island. A number of alien species have been accidentally introduced probably by sealers and whalers when they imported building materials and livestock, e.g. sheep, cattle, horses, pigs and poultry, together with the appropriate foodstuffs. Earlier assessments of the alien flora (Philcox, 1962; Greene, 1964a; Longton, 1965) have shown that most species are restricted to the immediate vicinity of the whaling stations or the former Government station at King Edward Point.

Shore-based whaling was undertaken for varying periods at a number of stations (Bannister, 1964), but ceased in 1965 although some buildings at Grytviken were maintained until early 1971. A small Government staff remained at King Edward Point until late 1969 when the settlement was taken over by the British Antarctic Survey.

Between 1967 and 1971 a detailed survey of the status and general ecology of the introduced plants on South Georgia was made and the purpose of this paper is to provide an account of the distribution and methods of reproduction of the alien populations to establish a base line against which future changes can be assessed. The area around Grytviken whaling station and King Edward Point received the most detailed survey, whilst the stations at Husvik, Stromness, Leith Harbour and Ocean Harbour were visited briefly.

Greene (1964a) established two groups of alien species, namely *naturalized* and *transient aliens*. The authors accept these categories but consider that a third group, *persistent aliens*, can now be recognized. The definition of these groups, two of which are modifications of those given by Greene, is as follows:

Transient aliens: species which have survived as one or a few individuals in artificial habitats created by Man's activities, for only 1 or 2 years.

Persistent aliens: species which have survived as one or a few individuals for many years, either in artificial habitats or amongst native vegetation.

Naturalized aliens: species which have survived as one or more populations for many years in one or more localities, and which have spread into and successfully competed with or displaced the native vegetation.

Within the last category, two sub-groups have been recognized:

- i. Species with a *restricted distribution* forming one or a few small populations within a limited area in which spread is almost always vegetative and, although flowers may be produced, no viable seed is set.
- ii. Species with a *widespread distribution* forming numerous populations at many sites in which spread may be both vegetative and by seed.

For some non-naturalized species it is not immediately clear whether they should be classed as transient or persistent aliens. Where individuals of a species have been recorded only once at a single locality and have not been re-discovered in another season, it may be assumed that the species did not survive and is unquestionably of transient status. However, it is possible that more individuals of a transient species may be located at a new site in another season, but which do not persist. For instance, *Stellaria media* has persisted on the island for many years, not as the same individual plant or population, but as one or more plants recurring at different sites in each season. Since the closure of the whaling stations, when multiple introductions were possible, such plants are most likely to be annuals arising each year from the production of viable seed in the previous season or from seed which has lain dormant

in the soil for many years. On the other hand, an annual species such as *Capsella bursa-pastoris*, which reappears each season at the same site, is classed as a persistent alien. One or more individuals of *C. bursa-pastoris* have been noted during a single season at new sites, usually close to the persistent populations. In such instances these plants behave as transient aliens. Transient aliens may be either annuals or perennials but if the latter, they are not sufficiently adapted to persist more than 1 or 2 years. Strictly speaking, persistent aliens must be perennials, but there may be exceptions, such as *C. bursa-pastoris*, i.e. annuals capable of re-colonizing the same site year after year.

TRANSIENT ALIENS

Details of all species belonging to this category are summarized in Table I which includes several unpublished records from the British Antarctic Survey herbarium. Of the species listed *Alchemilla monticola*, *Avena fatua*, *Brassica* cf. *napus*, *Lolium temulentum*, *Phleum pratense*, *Rumex* cf. *alpinus*, *Thlaspi arvense*, *Urtica urens* and *U.* cf. *dioica* have been recorded once only from a single site. Although *Stellaria media* was represented by varying numbers of annual colonies at two localities from 1967 to 1971, it is still considered a transient species as it only occurs sporadically and does not persist at these sites.

The following four species were recorded for the first time during the 1967-71 survey:

Cerastium arvense. A single plant with several flowers was seen in January 1970 but by the following year seven plants, including the original, had spread into an area of c. 50 m. by 10 m.; three of the plants were flowering.

Cotula scariosa. The single plant noted in December 1969 had by March 1971 increased in size and measured c. 15 cm. across, although it was largely overgrown by *Poa annua* and *Acaena decumbens*. The plant did not flower. This species is locally common in the Falkland Islands and was probably introduced in soil imported from there for horticultural purposes.

Lamium purpureum. Several specimens, only one of which produced flowers, were seen between December 1969 and March 1971.

Urtica cf. *dioica*. The small clump of this species recorded in 1967 was not seen in December 1970 when the area was re-examined.

A number of transient aliens remain unidentified as they occurred as seedlings or sterile plants. Two species of Cruciferae, one of Compositae and one of Leguminosae were collected from the whaling stations in March 1961 (personal communication from S. W. Greene), while the authors observed two plants with glabrous glossy rounded leaves with crenate margins growing among *Acaena decumbens* and *Deschampsia antarctica* at the edge of the track close to the curing house at Grytviken in March 1971. An attempt to cultivate one of these plants failed. In addition, a single plant of a species of Compositae, tentatively referred to *Lactuca*, was found on an earthen bank near the Grytviken kitchens in January 1970. Although the plant bore a number of multiple flowering heads, the latter did not appear to open normally or set seed and the plant itself was not seen the following summer.

During the occupation of the whaling stations several attempts were made to cultivate vegetables and to introduce various species of trees and shrubs but none met with success, although two species of *Brassica* produced flowers at Grytviken in 1963-64 (Longton, 1965) and three plants of radish had flowers on King Edward Point in 1971.

PERSISTENT ALIENS

Table II summarizes available details of the first records on South Georgia of all species currently classed as persistent aliens.

Allium schoenoprasum. Initially a single large plant was seen amongst *Poa annua* and *P. flabellata*, but this remained healthy from 1969 to 1971 and flowered each season. A second plant with flowers was seen in January 1971 c. 2 m. away from the first.

TABLE I. DETAILS OF TRANSIENT ALIENS RECORDED FROM SOUTH GEORGIA

Species	Locality	Date recorded	Habitat or other details	Reference or Source
<i>Alchemilla monticola</i> Opiz	Husvik	January 1964	Stony ground behind station	Longton (1965)
<i>Alopecurus geniculatus</i> L.	Husvik	March 1949	Sandy waste ground between manager's house and station	Philcox (1962)
	Grytviken	January 1968	Gravelly ground in front of manager's house	Walton 520 (AAS)
<i>Avena fatua</i> L.*	Grytviken	March 1961	With <i>Poa annua</i> on waste ground near piggery	Greene 2096 (AAS)
<i>Brassica</i> cf. <i>napus</i> L.*	Grytviken	March 1961	Amongst <i>Poa annua</i> on waste ground near piggery	Greene 2100 (AAS)
<i>Carum carvi</i> L.	Husvik	March 1961	Waste ground in station	Greene (1964a)
	Husvik	January 1964	Waste ground in station	Longton (1965)
<i>Cerastium arvense</i> L.	Grytviken	January 1970	Dry barren ground at verge of track between guano shed and kitchens	Walton 844 (AAS)
<i>Cotula scariosa</i> (Cass.) Franchet.*	King Edward Point	December 1969	Loamy soil behind magistrate's house	Walton 895 (AAS)
<i>Lamium purpureum</i> L.	King Edward Point	December 1969	Loamy soil behind magistrate's house and close to easternmost bungalow	Field record 4417 (AAS)
<i>Lolium temulentum</i> L.	Leith Harbour	March 1961	Waste ground in station	Greene (1964a)
<i>Matricaria matricarioides</i> (Less.) Porter	Grytviken	March 1961	With <i>Poa annua</i> on waste ground near piggery	Greene 2097 (AAS)
	Grytviken	January 1964	Waste ground near wharf in station	Longton (1965)
	Grytviken	April 1967	Five sterile plants in an open cold frame by manager's house	Field record 4397 (AAS)
<i>Phleum pratense</i> L.	Husvik	March 1961	Waste ground in station	Greene (1964a)
<i>Pisum sativum</i> L.	Leith Harbour	March 1949	Two small non-flowering clusters growing to c. 12 cm. high in station	Philcox (1962)
	Grytviken	March 1961	Bare stony ground near Slop Chest	Greene (1964a)
<i>Rumex</i> cf. <i>alpinus</i> L.*	Leith Harbour	March 1961	Bare stony path in graveyard	Greene 3552 (AAS)
<i>Senecio vulgaris</i> L.	Husvik	March 1961	Waste ground in station	Greene (1964a)
	King Edward Point	April 1967	Stony ground near food store	Field record 4394 (AAS)
<i>Solanum tuberosum</i> L.*	Stromness	March 1961	Waste ground in station	Greene (1964a)
	Grytviken	March 1967	An attempt by F. Sannes (personal communication) to cultivate potatoes in 1966-67 in a plot of natural loamy soil cleared of native vegetation near the power station resulted in plants up to 10 cm. high which produced tiny tubers up to 1 cm. in diameter	Field record 4395 (AAS)
<i>Stellaria graminea</i> L.*	Husvik	March 1961	Waste ground in station	Greene (1964a)
	Husvik	January 1964	Waste ground in station	Longton (1965)
<i>Stellaria media</i> (L.) Vill.	King Edward Point	March 1961	Gravelly soil	Greene (1964a)
	Grytviken	April 1967- March 1971	Numerous plants in and close to open cold frame by manager's house and single plant near kitchens in 1967	Field record 4396 (AAS)
	King Edward Point	January 1968- March 1971	Numerous colonies of one to five plants close to magistrate's house, four bungalows and Shackleton House	Walton 539 (AAS)
<i>Thlaspi arvense</i> L.*	Husvik	March 1961	Waste ground in station	Greene (1964a)
<i>Urtica</i> cf. <i>dioica</i> L.*	Leith Harbour	December 1967	Sheltered situation beside manager's house	Walton 433 (AAS)
<i>Urtica urens</i> L.*	Grytviken	March 1961	With <i>Poa annua</i> on waste ground near piggery	Greene (1964a)

All species, except those marked with an asterisk (*), have flowered on South Georgia.
AAS. British Antarctic Survey herbarium, at present housed in the Department of Botany, University of Birmingham.

TABLE II. FIRST RECORDS OF PERSISTENT ALIENS AT VARIOUS SITES ON SOUTH GEORGIA

Species	Locality	Date recorded	Habitat or other details	Reference or source
<i>Allium schoenoprasum</i> L.	King Edward Point	March 1967	Amongst <i>Poa flabellata</i> , c. 1 m. from main track opposite magistrate's house	Field record 4384 (AAS)
<i>Anthriscus sylvestris</i> (L.) Hoffm.	Husvik	January 1964	In stone wall forming bank of stream in station	Longton (1965)
	Grytviken	April 1967	Edge of gravelly track near kitchens	Field record 4385 (AAS)
<i>Artemisia</i> sp.*	Grytviken	April 1967	Edge of gravelly track near kitchens	Field record 4391 (AAS)
<i>Capsella bursa-pastoris</i> (L.) Medic.	? Grytviken	1910	No details available	Greene (1964a)
	Husvik	March 1961	Waste ground in station	Greene (1964a)
	King Edward Point	March 1961	Peaty soil by cold frame near Discovery House	Greene (1964a)
<i>Carex aquatilis</i> Wahlenberg*	Husvik	January 1964	<i>Rostkovia magellanica</i> bog behind manager's house	Longton (1965)
<i>Epetrum rubrum</i> Vahl ex Willd.	Hestesletten	February 1971	Amongst short <i>Festuca erecta</i> and associated cryptogams	Smith (1973)
<i>Nardus stricta</i> L.	Leith Harbour	December 1970	Near cinema on grass track leading to dam	Field record 4419 (AAS)
<i>Plantago media</i> L.	Husvik	January 1964	Waste ground in station	Longton (1965) as <i>P. major</i>
	Grytviken	April 1967	Associated with <i>Poa annua</i> and <i>Deschampsia antarctica</i> at verge of dry gravelly tracks	Field record 4386 (AAS)
<i>Poa</i> sp.	Discovery Point	February 1971	Peaty soil amongst <i>Poa flabellata</i> near elephant seal wallow	R. Smith 1502 (AAS)
<i>Ranunculus acris</i> L.	Grytviken	March 1968	Open stony ground behind freezing store	Walton 642 (AAS)
<i>Rorippa islandica</i> (Oeder) Borbás	Grytviken	December 1967	Dry gravelly ground close to bakery	Walton 545 (AAS)
<i>Rumex crispus</i> L.	Husvik	March 1949	Close to manager's house	Philcox (1962)
	Grytviken	February 1958	On gravelly track in front of church near stream	Philcox (1962)
<i>Sagina procumbens</i> L.	Husvik	January 1964	Waste ground in station	Longton (1965)
	Grytviken	April 1967	Edge of gravelly track near kitchens	Field record 4387 (AAS)
<i>Trifolium</i> cf. <i>hybridum</i> L.	Grytviken	April 1967	Edge of gravelly track near kitchens	Field record 4389 (AAS)
<i>Trifolium repens</i> L.	Grytviken	February 1957	Near steam-heated fuel tank	Philcox (1962)
	Husvik	March 1961	Waste ground in station	Greene (1964a)
<i>Veronica persica</i> † Poir.	? Grytviken	1910	No details available	Greene (1964a)

All species, except those marked with an asterisk (*), have flowered on South Georgia.

AAS. British Antarctic Survey herbarium, at present housed in the Department of Botany, University of Birmingham.

† See Addendum.

Anthriscus sylvestris (Fig. 1a). The single large plant 105 cm. in height and with many umbels, growing in Grytviken in 1967, was observed to be healthy each succeeding summer up to and including 1970-71, while B. G. Bell (personal communication) noted the same plant during 1971-72. Every year the plant flowered prolifically but no ripe seeds were recorded and no seedlings have been seen. The plant recorded at Husvik in 1964 has not been seen again.

Artemisia sp. A single plant, believed to be a species of *Artemisia*, growing with several other alien species at Grytviken, has been recorded in each successive summer since 1966-67 up to 1970-71, by which time it had not increased significantly in size and had not flowered.

Capsella bursa-pastoris. According to Greene (1964a), the species was first collected by C. A. Larsen on South Georgia in 1910, and was re-collected during 1960-61 from two localities (Table II) but it was not seen during 1963-64 (Longton, 1965). The species was locally abundant on King Edward Point in early April 1967 when a particularly large population of several hundred plants with flowers was noted on dry stony ground in front of the magistrate's house and on the stony verge of the main track; a single flowering specimen was also seen near the manager's house in Grytviken. In 1967-68 several plants were noted near the magistrate's house but from then until 1970-71 only a few plants were recorded each year growing in open stony ground by the track in front of that house and close to a nearby bungalow. Nevertheless the species has been reported as flowering profusely each year and setting considerable quantities of seed. The species has not been seen at Husvik in recent years.

Carex aquatalis. What is believed to be the sterile population reported by Longton (1965) was examined during 1967-68 and again in April 1972 when the stand was c. 12 m. by 9 m. (personal communication from B. G. Bell). No inflorescences have been seen in the field but living material planted in Birmingham by R. E. Longton in May 1964 has flowered in cultivation thus permitting a positive identification of the species.

Empetrum rubrum. A detailed account of the single occurrence of this shrubby heath-like plant on Hestesletten, about 3 km. south-east of Grytviken, has been provided by Smith (1973).

Nardus stricta. The only plant known on South Georgia possessed several spikes of the current, as well as of the previous, season's growth. It has been classed as a persistent alien since it is assumed that the plant became established prior to the closure of the Leith Harbour station in 1965. Also the size of this plant suggests that it must be several years old.

Plantago media (Fig. 1b). Only a single flowering specimen of this species has been seen at Husvik (Table II). In 1967 eight plants were recorded in three localities in Grytviken; several were flowering and two had inflorescences persisting from the previous season. Only three of these plants, one with about ten inflorescences, were seen at two of the sites in December 1969 and these were still healthy in 1970-71. A flowering specimen, noted close to the bakery in February 1968, was observed between 1969 and 1971 to be accompanied by four additional plants which were obviously seedlings derived from it.

Poa sp. In addition to the Discovery Point collection (Table II), two other plants believed to be the same taxon were observed amongst *P. flabellata* on a slope behind the raised beach a little to the north of Sörling Valley, Barff Peninsula. Each plant had broad, deeply keeled leaves which were strongly discoloured by a dark reddish purple pigment, although this largely disappeared in the plant from Discovery Point when grown in a pot treated occasionally with a nutrient solution. Many large inflorescences on very short culms were present on all plants and it was noted that anthesis commenced almost immediately the panicles became exerted from their sheath. Morphologically, the plants resemble a diminutive form of *Poa flabellata*, particularly with regard to the structure of the inflorescence, yet they bear the deeply keeled leaves characteristic of *P. annua*. These characters and the presence of sterile



a



b



c



d

Fig. 1. Alien vascular plants on South Georgia.

- a. *Anthriscus sylvestris* growing near the disused kitchens in Grytviken whaling station. The knife is c. 25 cm. long. 5 April 1967.
- b. *Plantago media* growing amongst native grasses in Grytviken whaling station. The scale object is 5 cm. in diameter. 5 April 1967.
- c. Stands of *Carex nigra* (light-coloured area in foreground) measured 6-7 m. in diameter growing amongst wet *Rostkovia magellanica* bog to the north-west of the former whaling station, Ocean Harbour. 9 March 1971.
- d. *Deschampsia caespitosa* growing on the bank of stream to the north-west of the former whaling

anthers suggest that the South Georgian plants may be of hybrid origin. If these plants persist for a longer period and their hybrid origin can be confirmed then their status as an alien species will have to be re-considered.

Ranunculus acris. The single plant with flowers observed by S. W. Greene was still healthy and flowering in early 1971, although much of the surrounding area had been invaded by *Deschampsia antarctica* and other native species.

Rorippa islandica. The single fertile plant seen in 1967 was again flowering in December 1969 and was accompanied by two non-flowering smaller plants. By January 1971 the number of plants had risen to five of which several were seedlings; three were flowering.

Rumex crispus. The plant first seen by W. J. L. Sladen in 1949 at Husvik was reported again in 1963-64 (Longton, 1965) but it has not been seen since. A second plant, recorded by J. Smith in 1958 at Grytviken, was seen again in March 1961 (Greene, 1964a), in 1963-64 (Longton, 1965) and by the authors between 1967 and 1971. An isolated flowering plant growing in a closed stand of *Acaena decumbens* was located close to a stream behind the church at Grytviken in March 1961 by S. W. Greene (personal communication), whilst another, also flowering, was observed in January 1970 amongst *Festuca erecta* on a hillock behind the football pitch at Grytviken. Each plant was healthy and flowering profusely in March 1971 but it is not known if they set viable seed and no seedlings have been observed.

Sagina procumbens. The plant reported from Husvik has not been seen again but in 1967 two well-established plants in Grytviken were flowering and were accompanied by several first-year seedlings. By December 1969 only one survived which by early 1971 was being rapidly overwhelmed by *Acaena decumbens*. A second Grytviken population, which in January 1968 consisted of several small plants on dry gravelly ground close to the bakery, had increased to between 30 and 40 plants in an area of c. 10 m.² by March 1971. Most of these plants were flowering and seedlings were numerous.

Trifolium cf. *hybridum*. Two circular colonies, which measured respectively 60 cm. and 100 cm. in diameter in 1967, were healthy in early 1968 and in December 1969. By early 1971 one of them had apparently been displaced by *Acaena decumbens* while the remaining colony was dying in the centre. Both produced many flowers each season but no seed or seedlings have been recorded.

Trifolium repens. The plants recorded by W. N. Bonner at Grytviken in 1957 and by S. W. Greene at Grytviken and Husvik in 1961 were seen again in 1963-64 (Longton, 1965) but not in subsequent years. The Grytviken colony was recorded as flowering by Greene. In March 1967 two other colonies, measuring c. 15 cm. and 30 cm. in diameter, were noted at the edge of the gravelly track near the kitchens in Grytviken. By December 1969 one had disappeared although the other was still healthy in March 1971. Neither colony was seen flowering.

Veronica persica.* According to Greene (1964a), a plant was collected in 1910 by C. A. Larsen but the species was not noted again until March 1967 when a single plant with flowers and several persistent seed cases was seen at the edge of a gravelly track near the kitchens in Grytviken. This plant has not been seen again but a small group of plants in flower was discovered c. 40 m. to the north of the kitchens in February 1968 by S. W. Greene (personal communication) on an earth bank amongst *Poa pratensis*, *Deschampsia antarctica* and *Acaena decumbens*. This population has continued to flower each year until last observed in March 1971. Another plant in flower with two seedlings was located in December 1969 on gravelly ground near the bakery in Grytviken; it flowered again in the following summer when the seedlings still appeared healthy.

* See Addendum.

NATURALIZED ALIENS

The authors consider 15 species of aliens to be naturalized, eight having a restricted distribution (Table III) and seven being more widespread (Table IV). Of these, 11 have been reported previously from the island, although only eight were treated as naturalized by Longton (1965).

Species with restricted distribution

Achillea millefolium. The population observed by W. N. Bonner in 1957 was re-examined in March 1961 (Greene, 1964a), in 1963–64 (Longton, 1965), in February 1968 and in 1969–71 when the stand measured c. 2 m. by 1 m. and was successfully invading the surrounding *Acaena decumbens*. Many of the young leaves contained a red pigment. Although inflorescences were not produced in each year that it was observed, several were noticed in 1961, about five were noted in 1969–70 and about 20–30 in 1970–71. A second, small non-flowering colony was located in February 1968 about 12 m. from the main population amongst *Acaena decumbens* and *Deschampsia antarctica* and by March 1971 it was c. 30 cm. in diameter.

Achillea ptarmica. The population of sterile plants seen by S. W. Greene (personal communication) at Husvik in 1961 was noted by R. E. Longton (personal communication) in January 1964. However, neither the Husvik nor the Stromness populations have been seen in recent years. Abundant sterile plants were observed growing in and close to the old cemetery at Leith Harbour in December 1967, and many had intermingled with *Acaena decumbens* and other native species. By December 1970 this population had increased considerably, covering almost half of the small cemetery with many plants occurring nearby and up to c. 50 m. away. There was no evidence that any of the plants had flowered, but material grown in Birmingham produced many inflorescences which permitted positive identification of the species.

Agropyron repens. The single population of this grass has been observed sporadically over a period of 10 years since it was first recorded in 1961. It was observed in 1963–64 by Longton (1965) and by early 1971 it occupied an area of at least 15 m.², having spread into the surrounding vegetation of *Poa annua*, *P. pratensis* and *Acaena decumbens*. Greene (1964a) considered this species a transient alien which would probably vanish when the habitat was no longer heated, but it has persisted and competed successfully with natural vegetation long after the whaling station closed and the pipes were no longer heated.

Carex nigra (Fig. 1c). Seven widely separated circular populations of this sedge were discovered on wet ground behind the ruined buildings to the north-west of Ocean Harbour in 1971. Each colony was well established and was invading or locally displacing the native *Rostkovia*-dominant vegetation. The largest stand, which was almost pure *C. nigra*, measured 7.05 m. by 6.0 m. and was flowering abundantly around its periphery. The most important associates were *Drepanocladus uncinatus*, *Calliergon sarmentosum* and several species of hepatic, particularly a species of *Riccardia*. The six smaller populations, several of which were flowering, ranged in size from 130 cm. by 112 cm. to 55 cm. by 55 cm. The smallest stand was situated c. 75–100 m. from the main population. This species has been classed as a naturalized alien since it almost certainly became established before the Ocean Harbour station closed in 1920. The assumed age of the populations is suggested by their large size.

Festuca rubra. This was first collected in 1961 at Husvik and Stromness (Greene, 1964a) and was noted again at the former locality in January 1964 (Longton, 1965), but the authors have been unable to confirm whether these plants still exist. Two flowering populations were discovered in and near Grytviken in March 1970, the largest of which covered an area of c. 10 m. by 3 m. on an earth bank near the kitchens where it had invaded stands of *Acaena decumbens*, *Deschampsia antarctica*, *Poa pratensis* and several other species. A smaller population occurred in a damp *Acaena decumbens*–*Tortula robusta* community on the north-facing slope above the power station to the south of Grytviken. Both populations were well established

TABLE IV. FIRST RECORDS OF WIDESPREAD NATURALIZED ALIENS ON SOUTH GEORGIA

<i>Species</i>	<i>Locality</i>	<i>Date recorded</i>	<i>Habitat or other details</i>	<i>Reference</i>
<i>Agrostis capillaris</i> L. (= <i>A. tenuis</i> Sibth.)	Grytviken	March 1949	In cemetery and near shore on south side of King Edward Cove	Greene (1964a)
	Husvik	March 1949	Wet ground	Greene (1964a)
	Stromness	March 1949	Wet ground	Greene (1964a)
<i>Cerastium fontanum</i> Baumg.	Grytviken	March 1949	In cemetery and along track by shore beyond cemetery	Philcox (1962)
	Husvik	March 1949	Waste ground behind station and on sandy waste ground in front of manager's house	Philcox (1962)
<i>Deschampsia caespitosa</i> (L.) Beauv.	Grytviken	March 1961	Amongst <i>Acaena decumbens</i> association on bank of stream in front of church	Greene (1964a)
	Husvik	March 1961	Waste ground in station	Greene (1964a)
	Stromness	March 1961	Waste ground in station	Greene (1964a)
<i>Poa annua</i> L.	near Grytviken	May 1902	Between King Edward Cove and Moraine Fjord	Skottsberg (1905)
<i>Poa pratensis</i> L.	Grytviken	March 1927	No data available	Greene (1964a)
<i>Rumex acetosella</i> L.	Grytviken	March 1927	No data available	Greene (1964a)
<i>Taraxacum officinale</i> Weber	Grytviken	March 1949	Two colonies by track near shore beyond cemetery	Greene (1964a)
	Husvik	March 1949	Sandy waste ground in front of manager's house	Greene (1964a)

All species have flowered on South Georgia.

TABLE III. FIRST RECORDS OF RESTRICTED NATURALIZED ALIENS ON SOUTH GEORGIA

<i>Species</i>	<i>Locality</i>	<i>Date recorded</i>	<i>Habitat or other details</i>	<i>Reference or source</i>
<i>Achillea millefolium</i> L.	Grytviken	February 1957	Bank of stream in front of church	Philcox (1962)
<i>Achillea ptarmica</i> L.*	Husvik	March 1961	Along bank of stream behind station	Greene 3187 (AAS)
	Stromness	March 1961	Waste ground in station	Greene 3179 (AAS)
<i>Agropyron repens</i> (L.) Beauv.	Grytviken	March 1961	Stony ground by steam-heated pipes between oil storage tanks at south-west side of station	Greene (1964a)
<i>Carex nigra</i> (L.) Reichard	Ocean Harbour	February 1971	<i>Rostkovia magellanica</i> bog to north-west of former station	R. Smith 1503 (AAS)
<i>Festuca rubra</i> L.	Husvik	March 1961	Waste ground in station	Greene (1964a)
	Stromness	March 1961	Waste ground in station	Greene (1964a)
<i>Juncus filiformis</i> L.	Grytviken	December 1969	Cindery sparsely vegetated waste ground in front of magistrate's house	R. Smith 1504 (AAS)
<i>Poa trivialis</i> L.	Grytviken	February 1971	Amongst <i>Acaena decumbens</i> and other native species on damp hillside west of cemetery	Walton 886 (AAS)
<i>Ranunculus repens</i> L.	Leith Harbour	March 1949	Two colonies on waste ground at south-west edge of station; one colony in cemetery and one colony close to cemetery	Greene (1964a)

All species, except that marked with an asterisk (*), have flowered on South Georgia.

AAS. British Antarctic Survey herbarium, at present housed in the Department of Botany, University of Birmingham.

and had certainly persisted for many years, but each appeared to be spreading by rhizome rather than by seed.

Juncus filiformis. The small plant of this rush, seen with flowers in 1969 at Grytviken, had increased in size by March 1971. In February 1971, 12 almost circular populations, most of which were flowering, were discovered on damp ground dominated by *Rostkovia magellanica* and *Juncus scheuchzerioides* north-west of the ruined buildings at Ocean Harbour. The largest colony measured 1.95 m. by 1.80 m. and all but three were greater than 1.25 m. across. This species has an arctic-alpine distribution in the Northern Hemisphere and, although it has been recorded from Patagonia (Macloskie, 1904), it has not been seen there in recent years (Barros, 1953). The South Georgian plants had somewhat depauperate inflorescences and most closely resembled material from Greenland and Arctic Norway. As with the newly discovered *Carex nigra* at the Ocean Harbour locality, the *Juncus* must have existed there for a considerable number of years and almost certainly became established during the period when the whaling station was in operation, i.e. between 1909 and 1920.

Poa trivialis. About 12 well-established small circular stands of this grass were found in 1971 at c. 12 m. a.s.l. on the damp hillside west of the Grytviken cemetery. These colonies measured from c. 25 cm. to c. 1 m. in diameter. Most plants in each stand were flowering and appeared to be spreading vegetatively, thus competing successfully with the native vegetation. This grass has been included as a naturalized alien on account of the size and spread of the populations.

Ranunculus repens. Four colonies, each consisting of several plants with buds, were seen at Leith Harbour by W. J. L. Sladen in 1949. It was later recorded by J. Smith in February 1957 at Grytviken, and at Husvik and Grytviken in March and April 1961 (Greene, 1964a). S. W. Greene (personal communication) also noted three or four flowering colonies amongst *Deschampsia antarctica* on terraces above the shore at Prince Olav Harbour in February 1961. It was seen at Ocean Harbour in January 1964 (Longton, 1965), and between 1967 and 1971 the authors observed two plants at Grytviken and many very small plants in an area of c. 5 m. by 3 m. at Ocean Harbour. The largest and most profusely flowering plant in Grytviken was by the side of the piggery and was the same plant as S. W. Greene (personal communication) observed in 1961. In early April 1967 it was c. 25 cm. high and c. 40 cm. in diameter and had over 100 flowers but damage by domestic hens reduced the plant to a procumbent growth form, although it still produced abundant flowers and had increased in diameter to c. 75 cm. by March 1971. In early April 1967, another plant in flower was also noted close to the kitchens but by December 1969 it had disappeared. The other persistent flowering plant at Grytviken occurred amongst dense *Acaena decumbens* in front of the power station. The Ocean Harbour population, growing amongst *Poa annua*, was heavily grazed by reindeer but flowers were present on several of the plants which appeared to be spreading vegetatively. No seed or seedlings have been observed and it appears that spread is entirely vegetative (Greene, 1964a).

Species with widespread distribution

Agrostis capillaris (= *A. tenuis* Sibth. (Widen, 1971)). W. J. L. Sladen collected this grass in 1949 from near Husvik, Stromness and Grytviken, while further material was collected by J. Smith in March 1957 also from Grytviken. However, these early specimens had been erroneously identified as *A. stolonifera* (Greene, 1964a). Populations were subsequently recorded at King Edward Point and around each of the four principal whaling stations in March 1961 (Greene, 1964a) and at Ocean Harbour in January 1964 (Longton, 1965). The presence of *Agrostis capillaris* in several habitats at each of the above localities was confirmed between 1967 and 1971.

The grass is one of the most successful aliens on South Georgia (Fig. 3) and both Greene (1964a) and Longton (1965) noted that it had extended into several communities of native vegetation. By early 1971 the authors observed that it was competing successfully with the

native vegetation at all its known localities. Scattered populations were recorded more than 0.5 km. from former habitation, e.g. around Gull Lake on the south side of King Edward Cove, in Bore Valley and in the valleys behind Husvik, Leith Harbour and Ocean Harbour. Small colonies occurred at c. 140 m. above the north side of King Edward Cove and to c. 100 m. above Ocean Harbour. It appears to be most abundant around Grytviken where it occurred both amongst wet communities dominated by *Acaena decumbens*, *Rostkovia magellanica*, *Juncus scheuchzerioides* and *Tortula robusta*, and in drier situations where *Festuca erecta*, *Acaena decumbens* and a wide variety of bryophytes predominated. Because of the radial growth of the rhizome system, each population is almost circular in form and in some of the wetter habitats exceeded 20 m. in diameter, although this may represent the coalescence of two or more stands. Almost all populations produced abundant inflorescences, although it is not certain whether viable seed is set.

There was a considerable degree of morphological variation between populations even within a small area. The colour of the leaves and inflorescences ranged from deep reddish purple through bright green to a pale yellow-green. The height of the tallest plants in each colony varied from c. 10 cm. to 35 cm. and the width of the leaves varied from c. 2 mm. to 8 mm. An extremely slender-leaved procumbent form, believed to be the same species, was observed at Ocean Harbour in February 1971, its growth form being thought to be a response to grazing by the introduced reindeer.

Cerastium fontanum. The first collections were made by W. J. L. Sladen in 1949 from Grytviken and Husvik (Philcox, 1962). Sladen noted it as being well established and very frequent at the latter locality where it produced abundant flowers, seeds and seedlings. Further collections were made at Grytviken by W. N. Bonner in December 1956 and by J. Smith in January 1957, while J. Smith also noted the species growing on the low headland between Mercer and Harpon Bays in Cumberland West Bay about 8 km. from the nearest habitation at Grytviken (Greene, 1964a). Bonner also noted *Cerastium fontanum* as being "widely distributed in the neighbourhood of Ocean Harbour, having spread to above 650 ft. (c. 200 m.) in the pass connecting that harbour with Cumberland East Bay" (Greene, 1964a). It was later seen by S. W. Greene in March 1961 at Stromness, while in 1967-68 it was recorded around the southernmost of the Hamburg Lakes south of Grytviken and close to Norden-skjöld Glacier on Barff Peninsula (Greene, 1969) as well as on stony ground to the south-east of Moraine Fjord (personal communication from G. C. S. Clarke). Between March 1967 and early 1971 it was noted to be locally abundant in and near all four principal whaling stations as well as around Ocean Harbour. By February 1971 it was also abundant on the fluvio-glacial outwash debris and lateral moraine adjacent to the north-east corner of Norden-skjöld Glacier up to an altitude of 30 m., while numerous plants were also seen up to at least 230 m. a.s.l. on shingle along the margins of streams and small lakes in both Sörling Valley and the valleys leading from Ocean Harbour to Cumberland East Bay. A number of plants occurred on the gravelly shore of the northernmost of the Hamburg Lakes near Hestesletten as well as on the banks of Penguin River and on the outwash fan below Junction Valley west of Hestesletten. It has now been recorded from 11 of the 5 km. grid squares, making it the third most widely distributed alien on the island (Fig. 2).

Cerastium fontanum readily colonizes sparsely vegetated moist to dry, well-drained gravelly or stony substrata, but it does not appear to compete very successfully with closed native vegetation, although occasional plants have become established amongst *Acaena decumbens*, *Deschampsia antarctica* and the alien grasses *Poa annua* and *P. pratensis*. Flowers and viable seed are produced in profusion throughout each summer and it appears to establish readily by seed which is dispersed by natural agents. At Grytviken, pigeons were frequently observed feeding on the seeds of this species, while on Barff Peninsula and around Stromness Bay it is possible that the plants are grazed by the introduced reindeer. Individual plants vary considerably in size according to age, the degree of shelter and the aspect of the habitat, some growing close to buildings having been seen with over 100 flowering shoots which occasionally reached 25 cm. in length.

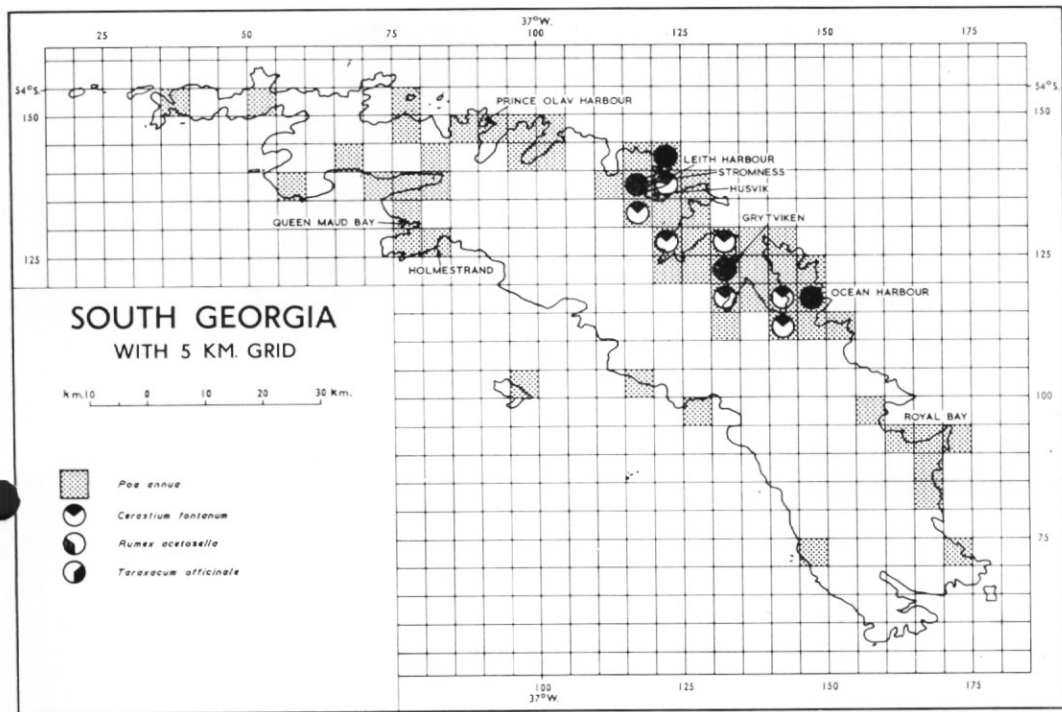


Fig. 2. Distribution on South Georgia by 5 km. grid squares of the widespread, naturalized alien dicotyledons *Cerastium fontanum*, *Rumex acetosella* and *Taraxacum officinale* in relation to the distribution of *Poa annua*.

Deschampsia caespitosa (Fig. 1d). This grass was reported in 1961 at Grytviken, Stromness and Husvik (Greene, 1964a), at Ocean Harbour in January 1964 (Longton, 1965) and at Leith Harbour in December 1970 (Fig. 3). At each locality *D. caespitosa* has become well established, forming large tussocks which produce abundant inflorescences amongst native vegetation on fairly dry ground; in Grytviken numerous plants have coalesced to form closed stands of c. 15–20 m.². It is particularly abundant at Ocean Harbour where scattered plants occur up to 0.5 km. from former habitation, the largest closed stand measuring 4 m. in diameter. Here the tussocks were very luxuriant with large numbers of spikes reaching 75 cm. in length and, although the foliage was grazed by reindeer, the inflorescences were generally untouched. In slightly more exposed situations, such as above the south side of King Edward Cove near Grytviken, where it occurs up to c. 70 m., the grass was seldom fertile. At the latter locality *D. caespitosa* was noted to have been grazed by rats. No seedlings have been seen at any of the known localities and spread appears to be restricted to vegetative means.

Poa annua. This was the first alien recorded on South Georgia, being collected in 1902 between "Pot Harbour" (King Edward Cove) and Moraine Fjord (Skottsberg, 1905). A. Berggren collected the grass at Leith Harbour in January 1927 and by 1961 it was known from all whaling stations as well as numerous other localities on the north coast, from Holmestrand and from the north side of Undine South Harbour on the south-west coast (Greene, 1964a). Subsequent surveys by the authors, by B. G. Bell (personal communication) and J. R. Tallwin (personal communication) have revealed many other localities, particularly on or near the beaches where sealers of the nineteenth century had their encampments, making *Poa annua* the most widespread and abundant alien species on the island (Figs. 2 and 3).

The majority of plants are apparently perennial and in some situations the leaves and inflorescences are frequently discoloured with a strong reddish purple pigmentation. In all

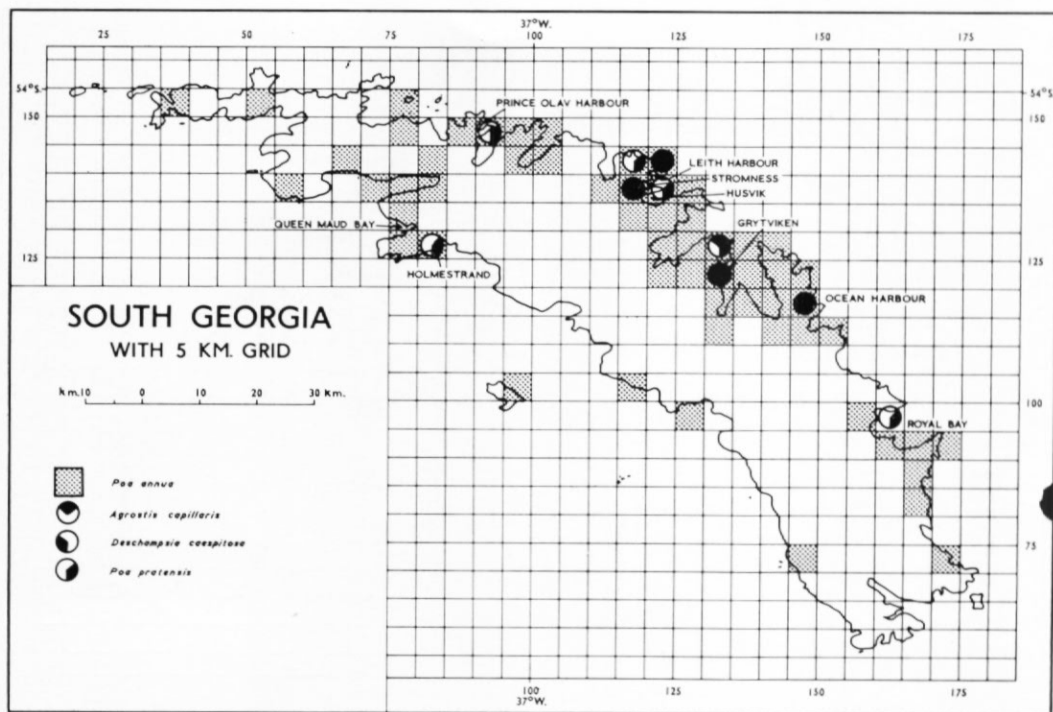


Fig. 3. Distribution on South Georgia by 5 km. grid squares of the widespread, naturalized alien monocotyledons *Agrostis capillaris*, *Deschampsia caespitosa* and *Poa pratensis* in relation to the distribution of *Poa annua*.

localities the species flowers abundantly throughout the summer, commencing almost as soon as it is uncovered from the winter snow (early October) and continuing until covered by snow around mid-April. Its seed is highly viable, innumerable seedlings occurring in spring, especially at lower altitudes.

It is most frequent on dry to damp gravelly ground, outwash fans, and moraines, particularly near the shore, and it appears to colonize barren ground in such areas with great ease. It is not usually common in wet communities and has a distinct preference for mineral soils, although in areas heavily grazed by reindeer it will colonize and dominate the peaty stools and intervening ground where tussock grass (*Poa flabellata*) has been killed. It is also an early colonizer on the bare ground around the edges of elephant seal wallows and it has been noted to be abundant close to gentoo penguin colonies on moraines in Queen Maud Bay. Occasional plants of *P. annua* have been recorded up to c. 300 m. a.s.l. and as far as 4 km. inland.

At Grytviken, between 1967 and 1971, pigeons were observed feeding on the seeds of *P. annua* and were probably responsible for some local dissemination of the species around the Grytviken and King Edward Point areas. Elsewhere it is eaten by rats, which are well established in many coastal areas of South Georgia. Reindeer may also be an important biotic agent in the dispersal of its seed within the restricted range of these animals. Where native species, e.g. *Acaena decumbens*, *Deschampsia antarctica*, *Phleum alpinum* and *Poa flabellata*, have been virtually eradicated by the reindeer, "replacement swards" of *P. annua* have become established in their place. Such swards occur up to c. 200 m. a.s.l. and reach 20 m.² in area, although at low altitudes closed swards of *P. annua* cover several hundred square metres, while the sandy links at Ocean Harbour are dominated by a continuous close-cropped sward of mixed *P. annua* and *P. pratensis*. The grass appears to be tolerant of heavy grazing and trampling by reindeer. It is also capable of forming closed swards in other artificial

habitats, particularly in the whaling stations and on King Edward Point, where such swards are locally extensive. It is considered that its success in spreading around South Georgia is due to multiple introductions rather than to colonization outwards from a single site.

Poa pratensis. The earliest collection of this grass was made in 1927 from Grytviken (Greene, 1964a). Between 1949 and 1961 it was found in and near all the whaling stations as well as on King Edward Point, at the site of the 1882-83 German International Polar-Year Expedition at Moltke Harbour in Royal Bay, and behind the sealing beach at Holmestrand (Greene, 1964a) (Fig. 3). Between 1967 and 1971 it was observed to be locally abundant at the four principal whaling stations, the station at Ocean Harbour and on King Edward Point.

P. pratensis produces copious inflorescences, flowering commencing about 1 month later than in *Poa annua* and generally ceasing before the end of the summer. Stands are seldom extensive since it does not appear to be as successful in colonizing bare ground or becoming established amongst native vegetation as is *P. annua*, but by virtue of its rhizomatous growth form it gives rise to large circular colonies. It is frequently associated with stands of *Acaena decumbens* and *Tortula robusta* and to a lesser extent with *Deschampsia antarctica* and *Festuca erecta*. It is usually found at low altitudes close to the shore but scattered populations occur at c. 75 m. a.s.l. on the shore of Gull Lake and at c. 60 m. a.s.l. in Bore Valley where there is a stand c. 20 m. in diameter. At Ocean Harbour it is very abundant on the sandy links where it has become established on many of the former *Poa flabellata* stools following the elimination of the latter by intensive reindeer grazing. Here also *P. pratensis* has formed extensive mixed swards with *P. annua* which are heavily grazed but apparently without deleterious effect.

Rumex acetosella. A plant was collected at Grytviken in 1927 (Greene, 1964a), and later records were made at that station, at Husvik and at Stromness between 1949 and 1961 (Philcox, 1962; Greene, 1964a), and at Ocean Harbour in January 1964 (Longton, 1965) (Fig. 2). Two populations were located in December 1970 at the edge of a track at Leith Harbour and in February 1971 many scattered plants were seen on the stony banks of streams and in open *Festuca erecta* grassland behind Ocean Harbour where the species occurred up to c. 75 m. a.s.l. Two large, widely separated populations have persisted near Grytviken, the largest occurring amongst *Festuca erecta* grassland on a dry hillside behind the football pitch and probably representing the same population seen by J. Smith in February 1958. The second colony has spread from an eroded gravelly crest of a knoll with scattered *Festuca erecta* into an adjacent mixed stand of *Polytrichum* spp. above and to the west of the cemetery. W. J. L. Sladen recorded a single plant growing in a rock cleft close to this site in March 1949. At all localities *R. acetosella* was flowering and numerous seedlings were seen at each site.

Taraxacum officinale. This species was first collected in 1949 by W. J. L. Sladen at Husvik and at the edge of a track east of the cemetery at Grytviken (Greene, 1964a). Between 1956 and 1961 it was seen again at these stations and also at Leith Harbour, Ocean Harbour and King Edward Point where it was reported to have spread considerably from the latter locality to Horse Head in the vicinity of Grytviken (Greene, 1964a) (Fig. 2). In 1964, R. E. Longton recorded a single plant of *T. officinale* amongst *Acaena decumbens* at an altitude of c. 100 m. near Gull Lake together with a small population of nine plants in a *Rostkovia magellanica* bog on Hestesletten (Longton, 1965). This latter site, a little to the north of the northernmost of the Hamburg Lakes, was examined in March 1971 and a total of over 60 mature flowering plants and sterile seedlings was counted amongst *Acaena decumbens*, *Phleum alpinum*, *Rostkovia magellanica* and *Tortula robusta*.

By February 1971 the population near the derelict jetty at the north-west corner of Ocean Harbour consisted of a large number of small almost procumbent plants in flower which were obviously grazed by reindeer, while scattered plants occurred throughout the station. Several small flowering colonies were also observed in December 1970 at Leith Harbour, whilst J. R. Tallwin (personal communication) noted many plants at Husvik in April 1972.

By early 1971 no plants were to be found near Horse Head or Gull Lake, but the species was very abundant and widespread amongst *Acaena decumbens*, *Deschampsia antarctica*, *Poa annua* and *P. pratensis* in the area from within the Grytviken cemetery to around the

radio hut and on the nearby storm beach. It was at this latter site that W. J. L. Sladen had noted in 1949 the largest population of *T. officinale* as being c. 3 m. by 2 m. in area. Seedlings were also very abundant and some older plants, growing in sheltered situations, reached 30 cm. in height, while one plant was observed to produce two double-headed inflorescences on a fasciated peduncle consisting of two fused stems. Another population was well established on and near the east side of the football pitch and a third small population occurred in front of the hospital. Occasional plants were seen scattered throughout Grytviken, while one was observed near the site of a hen house on King Edward Point and another at c. 92 m. a.s.l. in a south-east-facing rock crevice above Hope Point on the slope of Mount Duse. Most plants in each population were flowering profusely and seed was set each year. In 1970 some plants overwintered with immature inflorescences of the previous season but none of these developed in the following summer. The earliest new inflorescences opened about mid-November, 1 month after the melt had uncovered the plants.

DISCUSSION

The present survey of the alien vascular flora of South Georgia, carried out since the evacuation of the last operational whaling stations at Grytviken and Leith Harbour in 1965, has revealed the presence of over 20 previously unrecorded species. Of these, eight have been classed as transient aliens, nine have been treated as persistent aliens and four are considered as naturalized species. Excluding a few deliberately introduced plants and several individuals which have not been identified, the total number of transient aliens which can be reported is 20, with 16 persistent aliens and 15 naturalized species (Table V).

Whereas the transient aliens appear for short periods in artificial habitats, the persistent aliens have been observed over a number of years even though, in almost all instances, there has been little apparent spread or increase in the number of individuals. Most of the persistent aliens are single plants (e.g. *Anthriscus sylvestris*, *Artemisia* sp., *Empetrum rubrum*, *Nardus stricta*, *Ranunculus acris*) or small groups of several plants (e.g. *Carex aquatilis*, *Rorippa islandica*), while a few species are represented by one or more plants at several sites (e.g. *Plantago media*, *Rumex crispus*, *Sagina procumbens*, *Trifolium repens*). Several of the species have been recorded amongst natural vegetation, the *Empetrum rubrum* and *Poa* sp. occupying localities c. 3 km. or more from the nearest whaling station.

By way of contrast, the 15 naturalized aliens are represented by well-established populations which have spread into and competed successfully with the native vegetation. Three species, *Achillea millefolium*, *Agropyron repens* and *Festuca rubra*, regarded by Greene (1964a) as transient aliens, have been raised to the status of naturalized aliens on account of their success in invading native vegetation. Although the present populations of *Festuca rubra* have been known for only 2 years, *Agropyron repens* and *Achillea millefolium* have been observed over a period of 10 and 15 years, respectively. The only naturalized species seen more than 1 km. from human settlements were those reported by Longton (1965), namely *Cerastium fontanum*, *Poa annua*, *P. pratensis* and *Taraxacum officinale*.

Figs. 2 and 3 illustrate the distributions of the seven widespread alien species. Only *Poa annua* has become widely distributed around the island, having been recorded in 58 of the 5 km. grid squares (Fig. 2); it occurs in a wide range of habitats to an altitude of over 300 m. a.s.l. The success of this species is undoubtedly due to its prolific production of viable seed throughout the growing season, to its wide ecological amplitude, to its tolerance of competition from native vegetation and to its ability to exist as a perennial rather than an annual. Of the other six species, all except *Cerastium fontanum* (Fig. 2) and *P. pratensis* (Fig. 3) are restricted to the immediate vicinity of whaling stations.

Bannister (1964), who considered whaling stations on South Georgia as important centres for the introduction of weeds, has given details of the regular shipping routes used by the whalers when travelling to and from the island. The source of much of the alien flora is presumed to have been accidental introductions of seed in imported materials. Fodder was imported to feed livestock and poultry which were kept at the whaling stations from 1905 onwards (Allen, 1920; Matthews, 1931). Sheep, cattle and horses grazed on Hestesletten and the former were also kept in fenced areas at several stations. The last sheep to be kept on

TABLE V. CLASSIFICATION OF ALIEN SPECIES RECORDED FROM SOUTH GEORGIA

Transient aliens	Persistent aliens	Naturalized aliens	
		Restricted	Widespread
<i>Alchemilla monticola</i>	<i>Allium schoenoprasum</i>	<i>Achillea millefolium</i>	<i>Agrostis capillaris</i>
<i>Alopecurus geniculatus</i>	<i>Anthriscus sylvestris</i>	<i>Achillea ptarmica</i>	<i>Cerastium fontanum</i>
<i>Avena fatua</i>	<i>Artemisia</i> sp.	<i>Agropyron repens</i>	<i>Deschampsia caespitosa</i>
<i>Brassica</i> cf. <i>napus</i>	<i>Capsella bursa-pastoris</i>	<i>Carex nigra</i>	<i>Poa annua</i>
<i>Carum carvi</i>	<i>Carex aquatilis</i>	<i>Festuca rubra</i>	<i>Poa pratensis</i>
<i>Cerastium arvense</i>	<i>Empetrum rubrum</i>	<i>Juncus filiformis</i>	<i>Rumex acetosella</i>
<i>Cotula scariosa</i>	<i>Nardus stricta</i>	<i>Poa trivialis</i>	<i>Taraxacum officinale</i>
<i>Lamium purpureum</i>	<i>Plantago media</i>	<i>Ranunculus repens</i>	
<i>Lolium temulentum</i>	<i>Poa</i> sp.		
<i>Matricaria matricarioides</i>	<i>Ranunculus acris</i>		
<i>Phleum pratense</i>	<i>Rorippa islandica</i>		
<i>Pisum sativum</i>	<i>Rumex crispus</i>		
<i>Rumex</i> cf. <i>alpinus</i>	<i>Sagina procumbens</i>		
<i>Senecio vulgaris</i>	<i>Trifolium</i> cf. <i>hybridum</i>		
<i>Solanum tuberosum</i>	<i>Trifolium repens</i>		
<i>Stellaria graminea</i>	<i>Veronica persica</i> *		
<i>Stellaria media</i>			
<i>Thlaspi arvense</i>			
<i>Urtica</i> cf. <i>dioica</i>			
<i>Urtica urens</i>			

* See Addendum.

Hestesletten were slaughtered in 1957 (personal communication from K. S. Pierce-Butler). Although pigs were allowed to roam throughout some of the stations, they were generally kept in a piggery (personal communication from G. H. Elliot). Within their restricted range these introduced animals, together with the two large populations of reindeer, have almost certainly had some effect on the distribution of alien plants. This is exemplified by the establishment of almost pure swards of *Poa annua* and to a lesser extent of *P. pratensis* in areas of intensive reindeer grazing. Of particular interest is the occurrence of numerous populations of *Carex nigra* and *Juncus filiformis* at Ocean Harbour where reindeer from central Norway (Allen, 1920) were released in 1909 (Bonner, 1958). Both species are typical of wet habitats and the latter is a species of arctic-alpine distribution in the Northern Hemisphere. *Cotula scariosa* and *Lamium purpureum* have been seen only on deposits of greenhouse soil imported from the Falkland Islands, and discarded by the occupants of some of the houses on King Edward Point in November 1969.

It is of interest to note that Lindsay (1973a) has reported the occurrence of a number of apparently alien lichen species growing on timber at several localities on South Georgia. They are all of arctic-alpine or northern temperate distribution and it is likely that they originated as spores lodged in wood which is believed to have come from Norway or Germany. The only record of an alien moss has been the discovery of *Funaria hygrometrica* on sacking in a refuse dump in Stromness whaling station (personal communication from S. W. Greene).

While several of the alien species reported here for the first time from the whaling stations almost certainly became established during their occupation, a few species appear to have arisen from seed lying dormant for one or more years in the soil. This is illustrated by the sudden occurrence in 1969-71 of several prominent flowering plants of *Cerastium arvense* in Grytviken, and the annual recurrence of *Stellaria media* and *Capsella bursa-pastoris* at different sites at King Edward Point. Since these species demonstrate the longevity of viable seed under sub-polar conditions it is possible that other herbaceous plants may become temporarily established from time to time, particularly in the vicinity of the whaling stations and on King Edward Point.

Comparison of the South Georgian alien flora with that of other sub-Antarctic islands indicates that several of the more successful species are common to most of them. *Poa annua* appears to be naturalized on all the island groups, with the exception of Heard Island, while *Cerastium fontanum* and *Stellaria media* are also well established. The number of alien species reported from these other islands varies considerably. A list compiled from Schenk (1906) and Chastain (1958) provides a total of 30 alien species for Iles Kerguelen (Greene and Greene, 1963), but Cour (1958) regarded only four as naturalized. However, Lourteig and Cour (1963) listed only eight species as adventives for these islands. According to Huntley (1971), 13 alien species occur on Marion Island, although only *Cerastium fontanum*, *Poa annua* and *Stellaria media* appear to have become naturalized and widespread. B. J. Huntley (personal communication) also found particularly strong germination in seeds of *Cerastium fontanum*, *Poa annua*, *Rumex acetosella* and *Stellaria media* from Marion Island. He noted that *Poa annua* was the only species successfully competing with the native vegetation, although all the alien species flower and set seed.

C. fontanum, *P. annua* and *S. media* are included in the six aliens reported from Iles Crozet (Dreux, 1964), while the same three, together with one transient alien *Avena fatua*, are the only introduced plants recorded from Macquarie Island (Taylor, 1955). Although *Poa annua* and *Stellaria media* were reported from the Prince Edward Islands by Greene and Greene (1963), Huntley (1971) observed only the former species. No aliens have been recorded on Heard Island. The shelf islands of New Zealand possess a considerable introduced flora, presumably due largely to the introduction of various livestock and the establishment of large settlements. Cockayne (1909) reported 21 species, of which six were grasses, but he remarked that the list was probably incomplete. A more recent study of the Gramineae of these islands has increased the number of alien grasses to 14 (Zotov, 1965).

Of the alien vascular flora of the sub-Antarctic islands, the most successful plants are mainly weedy species native to northern temperate regions. This must be due largely to the predominance of northern nationalities in the early exploration and exploitation of these islands, and to the fact that much of the materials landed was derived directly from European ports. It is perhaps strange that there have apparently been no successful introductions of weedy species native to only North or South America considering the large number of sealing ships sailing from the former, and the re-provisioning of many ships even today in South American ports (Bannister, 1964). The occupation of Grytviken and Leith Harbour between 1963 and 1965 by two Japanese companies further increased the possibility of alien plants being introduced from Japan and from South Africa where these ships obtained supplies. However, no species native to these regions have so far been observed. Introductions of *Poa annua*, and even *P. pratensis*, *Cerastium fontanum* and *Stellaria media*, may have occurred from many different sources since these species are cosmopolitan in their distribution. *Poa annua* was reported as early as 1840 in the Auckland Islands but it may have been introduced there by natural agents rather than by Man (Zotov, 1965).

It would now seem clear that, whilst a considerable number of species have been introduced to the sub-Antarctic islands, more than half can be regarded as only transient. While the

remainder may persist under the prevailing sub-polar climate for a number of years, only *Poa annua*, *P. pratensis*, *Cerastium fontanum* and *Stellaria media* have been dispersed to almost all the islands and have succeeded in competing successfully with the native vegetation. The successful establishment and spread of alien species into native floras, particularly in polar regions where vegetation is slow to colonize, raises the question of the vulnerability of these floras to persistent pressure from aliens. So far on South Georgia, only *Agrostis capillaris*, and to a lesser extent *Deschampsia caespitosa*, appear to be aggressively invading and displacing natural plant communities. Like most aliens, these grasses have not yet spread much beyond the environs of the former whaling stations, while the two most widespread species, *Poa annua* and *P. pratensis*, are restricted largely to open areas devoid of native plants. However, the increasing destruction of the native vegetation by the introduced reindeer (Lindsay, 1973b) is causing significant floristic changes in several localities. On the Barff Peninsula, intensive grazing and trampling have caused local extermination of certain native species. Under these conditions *Poa annua*, and to a lesser degree *P. pratensis*, has developed close-cropped "replacement swards" from near sea-level to c. 200 m. a.s.l. The increased range of these reindeer in recent years (Lindsay, 1973b) is likely to lead to similar changes in the composition of certain communities in other parts of South Georgia. Elsewhere around the island, *P. annua* colonizes the heavily trampled ground around gentoo penguin colonies.

It is essential that natural vegetation is protected from further changes resulting from the accidental or deliberate introduction of aliens. Holdgate and Wace (1961) have recorded in some detail the effects on the native flora and fauna of Man's activities in these vulnerable ecosystems. The experimental use of aliens needs to be carefully controlled and should there be any indication of the spread of these species into native vegetation they should be quickly eradicated. Greene (1964b, p. 601) drew attention to the danger of natural vegetation being altered by the spread of alien plants and he suggested that "conservation proposals dealing with the dangers of uncontrolled introduction of alien animals [be] extended where appropriate to include references to alien plants as well." As yet no proposals to control plant introductions to the sub-Antarctic islands have been formulated.

ACKNOWLEDGEMENTS

We are grateful to Miss S. S. Hooper, Dr. C. E. Hubbard and Mrs. S. M. Philipps, of the Royal Botanic Gardens, Kew, and Mr. I. Hedge of the Royal Botanic Gardens, Edinburgh, for their assistance in the determination of some of the material. We also wish to thank Mr. G. H. Elliot and Mr. K. S. Pierce-Butler, former managers of Leith Harbour and Grytviken whaling stations, respectively, for providing information on the livestock kept at these stations. We should like to record our thanks to Professor J. G. Hawkes, Mason Professor of Botany, University of Birmingham, for facilities provided in the Department of Botany, and to Dr. and Mrs. S. W. Greene for much helpful advice in the preparation of this manuscript, and for permission to use some of their unpublished information.

S. received 16 March 1973

REFERENCES

- ALLEN, H. T. 1920. Fauna of the Dependencies of the Falkland Islands. (In *Report of the Interdepartmental Committee on Research and Development in the Dependencies of the Falkland Islands*. London, His Majesty's Stationery Office, 164 pp.)
- BANNISTER, J. L. 1964. Whaling stations in South Georgia. *Polar Rec.*, **12**, No. 77, 207-09.
- BARROS, M. 1953. Las Juncaceas de la Argentina, Chile y Uruguay. *Darwiniana*, **10**, No. 3, 279-460.
- BONNER, W. N. 1958. The introduced reindeer of South Georgia. *Falkland Islands Dependencies Survey Scientific Reports*, No. 22, 8 pp.
- CHASTAIN, A. 1958. La flore et la végétation des îles Kerguelen, polymorphisme des espèces australes. *Mém. Mus. natn. Hist. nat.*, Paris, Sér. B, **2**, No. 1, 136 pp.
- COCKAYNE, L. 1909. The ecological botany of the subantarctic islands of New Zealand. (In CHILTON, C., ed. *Subantarctic islands of New Zealand*. Wellington, John Mackay, Government Printer, **1**, 182-235.)
- COUR, P. 1958. A propos de la flore de l'Archipel de Kerguelen. *T.A.A.F.*, Nos. 4-5, 10-32.
- DREUX, P. 1964. Observations sur la flore et la végétation de l'île aux Cochons (Archipel Crozet). *Bull. Soc. bot. Fr.*, **111**, Nos. 7-8, 382-86.

- GREENE, S. W. 1964a. The vascular flora of South Georgia. *British Antarctic Survey Scientific Reports*, No. 45, 58 pp.
- . 1964b. Discussion: conservation. (In CARRICK, R., HOLDGATE, M. and J. PRÉVOST, ed. *Biologie antarctique*. Paris, Hermann, 599–603.)
- . 1969. New records for South Georgian vascular plants. *British Antarctic Survey Bulletin*, No. 22, 49–59.
- and D. M. GREENE. 1963. Check list of the sub-Antarctic and Antarctic vascular flora. *Polar Rec.*, 11, No. 73, 411–18.
- HOLDGATE, M. W. and N. M. WACE. 1961. The influence of Man on the floras and faunas of southern islands. *Polar Rec.*, 10, No. 68, 475–93.
- HUNTLEY, B. J. 1971. Vegetation. (In VAN ZINDEREN BAKKER, E. M., WINTERBOTTOM, J. M. and R. A. DYER, ed. *Marion and Prince Edward Islands. Report on the South African Biological and Geological Expedition, 1965–1966*. Cape Town, A. A. Balkema, 98–160.)
- LINDSAY, D. C. 1973a. Probable introductions of lichens to South Georgia. *British Antarctic Survey Bulletin*, Nos. 33 and 34, 169–72.
- . 1973b. Effects of reindeer on plant communities in the Royal Bay area of South Georgia. *British Antarctic Survey Bulletin*, No. 35, 101–09.
- LONGTON, R. E. 1965. Additions to the alien flora of South Georgia. *British Antarctic Survey Bulletin*, No. 5, 47–49.
- LOURTEIG, A. and P. COUR. 1963. Essai sur la distribution géographique des plantes vasculaires de l'archipel de Kerguelen. *C.N.F.R.A.*, No. 3, 63–70.
- MACLOSKIE, G. 1904. Flora Patagonica. *Pinaceae–Santalaceae*. (In SCOTT, W. B., ed. *Rep. Princetown Univ. Exped. Patagonia*, 8, Botany, Pt. 5, Sect. 1, 139–338.)
- MATTHEWS, L. H. 1931. *South Georgia, the British Empire's sub-Antarctic outpost*. Bristol, John Wright and Sons Ltd.; London, Simpkin Marshall Ltd.
- PHILCOX, D. 1962. Recent records for the flora of South Georgia. *Kew Bull.*, 16, No. 2, 243–45.
- SCHENCK, H. 1906. Die Gefässpflanzen der Deutschen Südpolar-Expedition 1901–1903, gesammelt auf der Possession Insel (Crozet Gruppe), Kerguelen, Heard-Insel, St. Paul und New Amsterdam. *Dt. Südpol.-Exped.*, 8, Botanik, No. 1, 97–123.
- SKOTTSBERG, C. [J. F.] 1905. Die Gefässpflanzen Südgeorgiens. *Wiss. Ergebn. schwed. Südpolarexped.*, Bd. 4, Lief. 3, 12 pp.
- SMITH, R. I. L. 1973. The occurrence of *Empetrum rubrum* Vahl ex Willd. on South Georgia. *British Antarctic Survey Bulletin*, Nos. 33 and 34, 173–76.
- TAYLOR, B. W. 1955. The flora, vegetation and soils of Macquarie Island. *A.N.A.R.E. Rep.*, Ser. B, 2 (Botany), 192 pp.
- WIDEN, K.-G. 1971. The genus *Agrostis* L. in eastern Fennoscandia. Taxonomy and distribution. *Flora fenn.*, No. 5, 1–209.
- ZOTOV, V. D. 1965. Grasses of the subantarctic islands of the New Zealand region. *Rec. Dom. Mus., Wellington*, 5, No. 15, 101–46.

ADDENDUM

Since this paper was written some additional information has become available. C. J. Barrow (personal communication) recorded three alien species in Stromness whaling station in early April 1973. A prolifically flowering colony of *Trifolium repens*, which covered an area 1.5 m. by 1.25 m. near the manager's house, is a new record for the station and must be assumed to have persisted for a considerable time since the station closed at the end of 1960–61. The *Achillea ptarmica* population seen in 1961 (Table III) appears to have spread, as it occupied an area c. 6 m. by 1.5 m. on the bank of a stream near a foot bridge between the station and some fuel tanks. Like the population at Leith Harbour, it showed no evidence of flowering although both populations have survived for over 12 years. Flowering plants of *Cerastium fontanum* were frequent on waste ground throughout the station. A single large flowering colony of *Festuca rubra* was recorded by J. R. Tallwin (personal communication) in 1973 for the first time on King Edward Point near the tennis court, suggesting that further alien species may still be introduced to the only populated area on the island.

The plants recorded between 1967 and 1971 as *Veronica persica* have since been re-identified as *V. serpyllifolia* L. The authors have not, however, seen the specimen collected by C. A. Larsen in 1910 reported as *V. persica*. Both species are very widely distributed in the Northern Hemisphere and are common in disturbed habitats.

During the austral summer of 1972–73 L. Davies (personal communication) recorded *Poa pratensis* and *P. annua* on Ile de la Possession in the Iles Crozet group. *P. pratensis* is widespread and abundant in most native grassland communities throughout the island whilst *P. annua* occurred only around the research station, thus contrasting strikingly with the situation on South Georgia where *P. annua* is widespread but *P. pratensis* is restricted

largely to areas of former habitation. Davies also noted that *Rumex acetosella* formed extensive dense stands actively displacing native grassland communities on well-drained slopes, a species reported by Dreux (1964) as abundant on Ile aux Cochons, another island of the Iles Crozet group. The populations of the *Rumex* on Ile de la Possession are much larger than those on South Georgia, and it is possible that the warmer wetter climate of the Iles Crozet group is an important factor in the enhanced success of *Rumex acetosella* and *Poa pratensis*. It is interesting to note that a recent survey of adventives in Greenland has shown that most of the alien species occurring on the sub-Antarctic islands are also highly successful weedy species in the Arctic (Pedersen, A., 1972. Adventitious plants and cultivated plants in Greenland. *Meddr Grønland*, **178**, No. 7, 1-99).

The success of *Poa pratensis* on Ile de la Possession and of *P. annua* on South Georgia raises afresh the question of whether these are, in fact, alien species introduced by Man. It is to be hoped that the results of current palynological studies on these islands will indicate whether or not these grasses have been present for longer than the 100-175 years of human activities and therefore must have been introduced by natural agencies.