STUDIES IN *Colobanthus quitensis* (Kunth) Bartl. AND *Deschampsia antarctica* Desv.:
V. DISTRIBUTION, ECOLOGY AND VEGETATIVE PERFORMANCE ON SIGNY ISLAND

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ABSTRACT. The detailed distribution of *Colobanthus quitensis* and *Deschampsia antarctica* on Signy Island is presented together with an account of their ecology at the principal sites. Differences in vegetative performance between localities are compared with observed changes after artificial modifications of the micro-environment. It is suggested that the present distribution of both species on the island is a reflection of the sequence of deglaciation and that new localities are colonized primarily by vegetative dispersal via biological agencies, particularly cape pigeons.

IN the third paper in this series, Greene and Holtom (1971) reported on the status of *Colobanthus quitensis* (Kunth) Bartl. and *Deschampsia antarctica* Desv. throughout the maritime Antarctic, but they excluded Signy Island from their discussion to allow a detailed treatment of the information available from this island. The present paper is concerned with the distribution and vegetative performance of these species on Signy Island and, following a general account of their ecology, an assessment is presented of their status on the island.

The first report of a vascular plant in the South Orkney Islands was given by Weddell (1825) but no further sightings were recorded within the next 100 years, although shore-based and pelagic whalers operated around Signy Island between 1911 and 1930. Marr (1935) stated "disregarding Weddell's doubtful record of 'a patch of short grass' at Cape Dundas in 1823, neither of the two flowering plants . . . have as yet been found in the South Orkneys". However, within the next 2 years both species were collected at Factory Cove, Signy Island, during a visit by R.R.S. *Discovery*. In 1947 the Falkland Islands Dependencies Survey occupied a station near Berntsen Point and since that date a large number of localities for *D. antarctica* and *C. quitensis* has been discovered. Holdgate (1964) was the first to publish a map of known localities for *D. antarctica* on Signy Island and several other workers have amplified his data.

PRESENT DISTRIBUTION

Most areas of Signy Island have now received a comprehensive survey for *Deschampsia antarctica* and *Colobanthus quitensis* and although single cushions and small groups of plants may have remained unnoticed, certainly all extensive areas of both species have been located. The present known distribution patterns (Figs. 1 and 2) were compiled from field records and notes, preserved as unpublished reports in the Survey's Botanical Section library, made by: M. W. Holdgate (1961–62), A. D. Bailey (1962–65), C. A. Howie (1964–65), R. I. L. Smith (1964–67) and the author (1967–70). Data from specimens and records collected by earlier expeditions are also included. A list of specimens examined and a table summarizing all field records and specimens by localities is given in the Appendix.

D. antarctica is locally abundant at three main areas on the west coast (Fig. 1). On the eastern side of the island the grass is more widely distributed but only becomes abundant around Factory Cove and on the northern slopes of Observation Bluff, where it is particularly common near the cliffs and the large petrel colonies. A similar situation exists on the north-west coast between Spindrift Rocks and North Point, where grass is invariably found on the north sides of the numerous small promontories. At Thulla Point, both species occur around the inland rock outcrops rather than the coastal cliffs, and at Port Jebsen most areas with vascular plants are situated at the top of the screes and peat banks which occur below crags of the ridge. Most of the grass sites immediately east of Jebsen Rocks are small and occur inland below nests of giant petrels (*Macronectes giganteus*) above the small lake. At North Point and Gourlay Peninsula, *D. antarctica* is restricted to seaward slopes in areas least disturbed by penguins from the nearby colonies. At the northern edge of Moraine Valley and in Three Lakes Valley the grass is usually only present as small isolated patches on gentle slopes showing much solifluction and frost heave. Larger swards are found around Tern and Starfish Coves, where there is less patterned ground and small colonies of petrels.

C. quitensis is known from six main localities (Fig. 2), all of which are close to areas with a high density of grass patches. At Observation Bluff and Factory Cove the cushions of *C. quitensis* are commonly interspersed amongst grass swards, a situation which also exists at the other four sites. But at Observation Bluff and Port Jebsen *C. quitensis* is also found as a pioneer species, colonizing stony ground and not associated with *D. antarctica*, although invariably the grass occurs nearby.

Some of the more inaccessible areas east of Robin Peak, around Cummings Cove, Pandemonium Point and Paal Harbour, have not been so thoroughly examined while the offshore islands have been visited infrequently, but there has been no record for either species on these apart from the occurrence of *D. antarctica* on the largest of the Thule Islands. The Oliphant Islands, Shagnasty Island and Moe Island, together with Jebsen, Spindrift and Billie Rocks, were all visited by the author during the early part of 1970 but there was no trace of either species, although apparently suitable sites were present, especially on the larger islands. Shagnasty Island and the unnamed island on which Confusion Point is situated support large populations of sea birds, and intensive biotic disturbance certainly restricts cryptogamic vegetation and probably accounts for the absence of vascular species. It appears likely that most of the small low-lying islands, such as Outer Island, are too exposed and too wave-swept to favour the development of angiosperm communities. The same is probably true for Mariholm which, when visited by the author in the winter of 1969, was seen to consist of largely vertical cliffs and, on the eastern side, overhanging slabs of rock.

In passing it may be mentioned that some new localities for *D. antarctica* have been discovered on the south coast of Coronation Island, near Cape Hansen and at Shingle Cove, which are additional to those reported by Greene and Holtom (1971). *C. quitensis* was also present at these sites and so this species can now be reported for the first time from Coronation Island. The details of these new localities are given in the Appendix.

Site Characteristics

Altitude and aspect

Both species are restricted to lowland coastal areas of Signy Island where there is little ice or permanent snow. Neither species occurs more than 1 km. from the sea and most of the sites are within 100 m. of the coast. In this coastal zone, *D. antarctica* is found from sea-level up to *c.* 170 m. while *C. quitensis* does not extend above *c.* 100 m.

Holdgate (1964) first recognized that both vascular species grew at sites which were well placed to receive maximum sunshine and thus act as radiation traps. These usually face north-west through north to north-east, although *D. antarctica* is not uncommonly found on east- and west-facing slopes which are open to the north. *C. quitensis*, on the other hand, appears to be restricted to north- to north-west-facing sites, although cushions transplanted by the author to east- and south-facing slopes in 1967–68 were still in an apparently healthy condition two seasons later. Table I gives some physiognomic details of various angiosperm sites studied by the author as well as measurements made earlier on Signy Island by M. W. Holdgate.

Soils

At most sites the ground is sloping and is invariably irrigated by percolating water which brings additional minerals and nutrients into the area. The soils at most sites are waterlogged for a period after the spring melt and a few areas of *D. antarctica* remain in a moist condition for most of the season, although the majority overlie stony well-drained ground and soon dry out. A general discussion of soil types on Signy Island has been presented by Allen and Northover (1967), while Holdgate and others (1967) have dealt in some detail with those developed under grass.

The relatively large amounts of available nutrients present in soils under the two vascular species are shown in Table II, sodium, magnesium and phosphorus being especially abundant when compared with soils from more closed vascular plant communities on South Georgia (personal communication from S. W. Greene). *C. quitensis* is commoner on steeper slopes than *D. antarctica* and on coarser inorganic soils with a higher clay content, which are less rich in

Table I. Physiognomic characteristics of sites with *Deschampsia antarctica* and or *Colobanthus quitensis* on Signy and Coronation Islands

Site	Species present *D. antarctica*	Species present *C. quitensis*	*Altitude* (m.)	*Slope* (mean of 10 readings (°))	*Azimuth* N	NE	E	SE	S	SW	W	NW	*Aspect*
Signy Island													
1. Mooring Point	+	—	3	18·6	0	0	2	14	16	11	9	4	N
2. Berntsen Point	+	—	3	11·3	0	4	18	17	20	8	2	0	NNE
3. Starfish Cove	+	—	5	24·6	2	0	6	16	23	21	9	9	NE
4. The Wallows	+	—	8	8·4	4	4	11	4	5	11	9	11	N
5. East side of Factory Cove	+	—	12	18·8	0	3	12	21	63	35	11	4	NE
6. Port Jebsen	+	—	12	26·5	0	14	22	42	35	28	5	0	NW
7. North of Spindrift Rocks	+	—	15	21·3	4	9	18	15	8	1	0	4	NNW
8. Berry Head	+	—	15	22·5	0	0	8	19	28	17	18	17	N
9. North slope of Observation Bluff	+	—	27	16·3	0	0	4	17	31	19	14	0	NNE
10. West side of Factory Cove	+	+	5	22·4	0	5	10	29	52	30	15	9	N
11. Thulla Point	+	+	6	16·5	3	7	15	21	29	18	10	0	NNE
12. South-west of North Point	+	+	9	32·4† 37·8	6	15	46	77	74	12	3	7	NW
13. Between Spindrift Rocks and North Point	—	+	15	28·0	5	16	26	24	21	11	0	2	NW
14. North slope of Observation Bluff	+	+	23	24·8	0	0	0	12	25	30	24	11	NNE
15. North of Spindrift Rocks	+	+	24	25·4	6	8	19	26	25	16	11	3	N
Coronation Island													
16. Shingle Cove	+	—	9	23·5	12	6	1	13	24	36	24	5	NE
17. Point east of Shingle Cove	+	+	15	20·8	12	8	4	7	11	17	23	10	ENE
Mean values													
Of 16 *D. antarctica* sites			11·1	20·8	3·1	5·2	12·2	21·8	29·3	19·4	11·6	5·9	N
Of 28 *D. antarctica* sites 1961–62*			17·3	26·0	5	8	15	27	31	23	14	8	N
Of 7 *C. quitensis* sites			12·0	25·1	2·7	8·4	17·1	28·0	33·9	19·1	12·3	6·0	N
Of 4 *C. quitensis* sites 1961–62*			10·5	35·2	4·2	4·5	8·2	28·2	32·2	25·2	11·8	3·5	N–NNE

* Data collected by M. W. Holdgate.
† Upper figure for *D. antarctica*, lower for *C. quitensis*.

+ Present. — Absent.

TABLE II. ANALYTICAL DATA FOR SAMPLES OF SOIL FROM VARIOUS ANGIOSPERM SITES ON SIGNY ISLAND
(All samples from 0–10 cm. and all results except pH expressed on dry basis.)

Sample site	*Altitude* (m.)	*pH* 0–1 cm. deep	3–4 cm. deep	6–7 cm. deep	*Loss on ignition* (550°[illegible] (per ce[illegible]	*Extractable cations* N[illegible]	K	Ca (mg./100 g.)	Mg	P	*Total* N (per cent)	*Percentage total volume of particles within each size groups* <9·5 (mm.)	9·5–4·8 (mm.)	4·8–2·0 (mm.)	2·0–0·2 (mm.)	0·2–0·05 (mm.)	<0·05 (mm.)
Deschampsia antarctica																	
Berntsen Point	3	4·5	4·5	4·3	65·6	25	29·0	66	71	3·6	3·8	1·6	1·0	4·7	74·2	18·5	+
Factory Cove	10	—	—	—	44·7	26	18·0	65	35	7·9	0·64	3·4	2·3	25·3	57·5	11·5	—
Gourlay Peninsula	10	—	—	—	63·5	34	14·0	37	40	5·0	3·4	19·6	1·7	2·8	54·2	21·7	+
North of Spindrift Rocks	10	6·1	6·5	6·7	18·2	42	6·6	152	55	34·0	2·3	17·5	10·5	5·5	52·5	14·0	+
Port Jebsen	30	5·7	6·0	6·1	16·4	31	7·3	109	38	11·0	0·75	45·1	6·0	6·4	27·0	15·5	+
Observation Bluff, northern slopes	30	5·6*	5·4*	5·4*	15·5	43	3·7	101	75	2·9	0·63	14·8	3·4	5·4	42·2	34·2	+
Observation Bluff, northern slopes	45	5·1	4·9	4·6	27·3	34	5·4	121	83	4·5	1·14	0	0·3	7·4	56·8	35·5	+
Colobanthus quitensis																	
North of Spindrift Rocks	10	—	—	—	21·7	46	18·0	126	65	15·0	0·86	76·5	2·1	4·3	11·9	5·2	—
Observation Bluff, northern slopes	30	—	—	—	11·9	31	4·1	101	56	4·5	0·50	57·7	5·9	5·6	19·7	11·1	—
Port Jebsen	35	—	—	—	6·1	26	13·0	497	41	17·0	0·28	19·8	8·3	17·8	42·9	11·2	—

Chemical analyses by Chemical Section, The Nature Conservancy, Merlewood Research Station (September 196[illegible]
For pH, each figure is the mean of three samples, except those marked * which are the mean of six.

Table III: Percentage cover and percentage frequency of species recorded in 17 *Deschampsia antarctica* and *Colobanthus quitensis* stands

Species	1	2	3	4	5	6	7	8	Locality 9	10	11	12	13	14	15	16	17
Angiosperms																	
Deschampsia antarctica	9; 60	27; 84	28; 96	49; 88	36; 100	61; 100	20; 76	5; 40	30; 96	24; 92	5; 16	29; 84	—	37; 84	26; 84	18; 80	16; 88
D. antarctica, dead	2; 28	11; 80	7; 80	7; 56	4; 68	—	4; 40	<1; 8	5; 68	<1; 4	—	3; 44	—	8; 52	2; 40	6; 56	4; 80
Colobanthus quitensis	—	—	—	—	—	—	—	—	—	<1; 16	<1; 4	6; 40	6; 72	3; 72	5; 44	—	1; 32
C. quitensis, dead	—	—	—	—	—	—	—	—	—	—	<1; 4	1; 4	5; 56	—	<1; 12	—	2; 48
Mosses																	
Drepanocladus uncinatus	54; 88	22; 92	10; 80	<1; 4	4; 40	15; 70	26; 84	2; 32	16; 92	7; 84	3; 48	1; 36	14; 88	5; 76	18; 100	19; 68	22; 100
Brachythecium sp.	4; 20	—	1; 40	<1; 28	3; 32	2; 60	13; 80	—	7; 52	1; 20	1; 20	8; 96	12; 68	9; 80	16; 96	5; 76	3; 24
Bryum sp.	—	1; 36	2; 28	4; 60	5; 76	3; 30	<1; 4	9; 84	<1; 4	2; 60	3; 56	6; 80	—	<1; 4	—	<1; 12	<1; 16
Tortula fuscoviridis	—	—	2; 20	5; 52	—	9; 80	<1; 12	—	1; 4	<1; 4	4; 44	23; 100	2; 40	<1; 12	3; 76	—	—
Bartramia sp.	—	—	<1; 8	—	<1; 20	—	—	—	<1; 4	<1; 12	—	—	—	1; 20	<1; 4	—	<1; 12
Polytrichum alpinum	2; 12	1; 24	12; 72	—	7; 56	<1; 10	3; 40	1; 20	6; 64	20; 96	<1; 4	—	4; 32	7; 40	—	—	—
Polytrichum alpestre	—	—	—	—	<1; 4	—	—	—	—	1; 8	—	—	—	—	—	—	<1; 4
Calliergon cf. *sarmentosum*	13; 60	2; 20	—	—	—	—	—	—	—	—	—	—	—	—	—	3; 52	—
Liverworts																	
Cephaloziella varians	4; 28	4; 52	<1; 4	<1; 4	3; 32	1; 20	<1; 12	6; 56	2: 40	5; 40	1; 24	—	5; 84	5; 68	4; 52	—	6; 80
Marchantia berteroana	<1; 4	—	<1; 16	—	—	—	<1; 12	—	<1; 12	—	—	25; 92	2; 44	1; 32	6; 76	—	—
Algae and lichens																	
Prasiola crispa	1; 32	3; 88	1; 64	13; 88	10; 100	3; 80	1; 40	6; 88	2; 68	4; 88	—	—	<1; 16	<1; 20	<1; 12	10; 68	<1; 12
Moss encrusting lichen	1; 16	12; 68	1; 36	—	4; 68	4; 60	2; 36	13; 84	2; 24	2; 64	2; 48	1; 48	22; 100	2: 52	10; 88	1; 28	32; 100
Substrata																	
Stone and rock	11; 36	23; 84	36; 96	19; 92	23; 96	11; 100	22; 76	59; 100	10; 32	40; 100	73; 96	21; 88	22; 96	25; 72	16; 64	31; 76	29; 96
Bare soil	6; 40	8; 64	9; 84	6; 52	7; 68	16; 70	15; 92	2; 56	11; 56	4; 68	9; 56	6; 64	4; 48	7; 68	5; 72	3; 60	1; 28

Figure before semi-colon is percentage cover; figure after semi-colon is percentage frequency.
Data based on 25 quadrats per locality, except for locality 6 which was based on 10.
For details on localities see Table I.

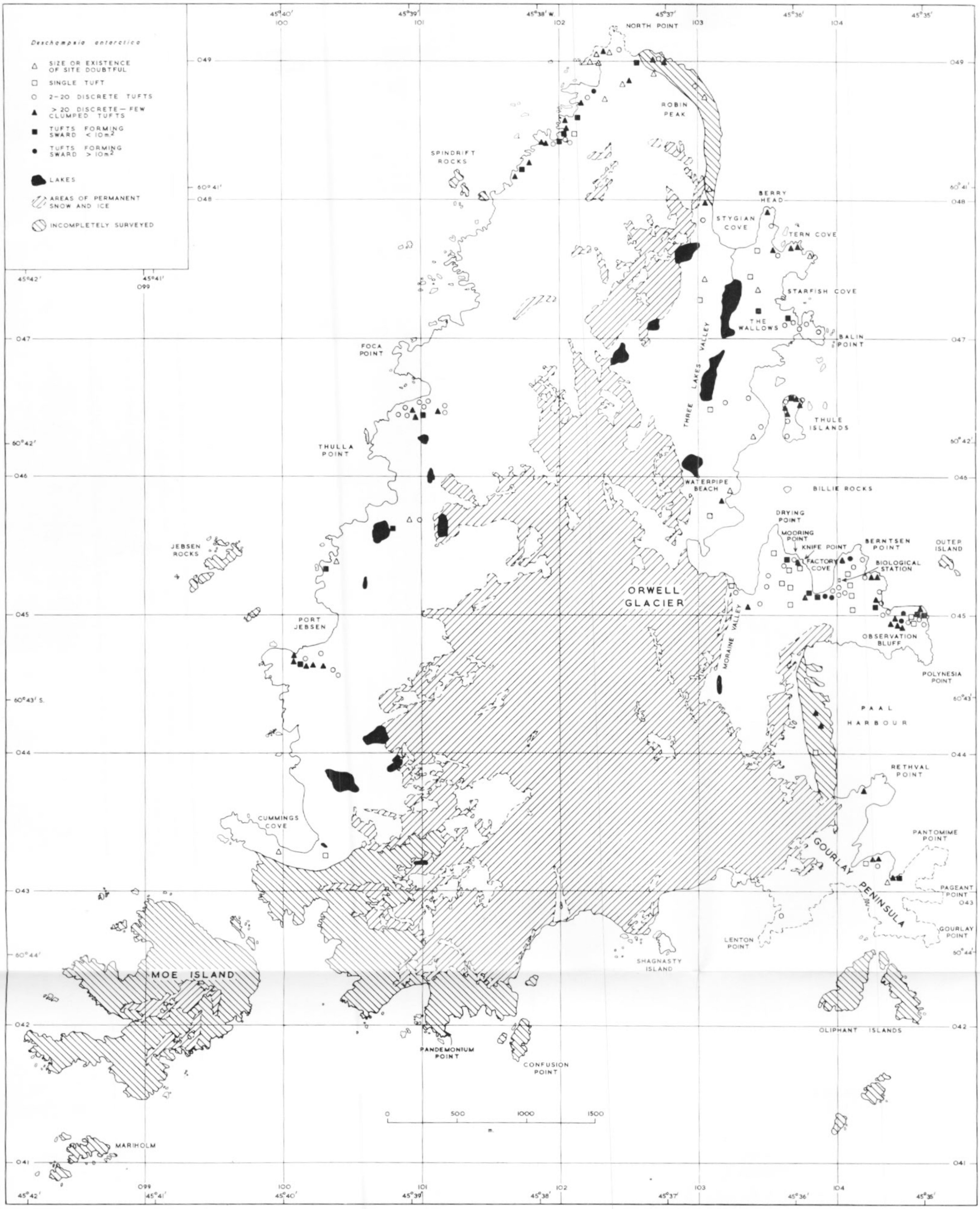

Fig. 1. Distribution and abundance of *Deschampsia antarctica* on Signy Island, March 1970. Origin of grid: lat. 60° 40′ S., long. 45° 40′ W. False coordinates of origin 50,000 N., 100,000 E.

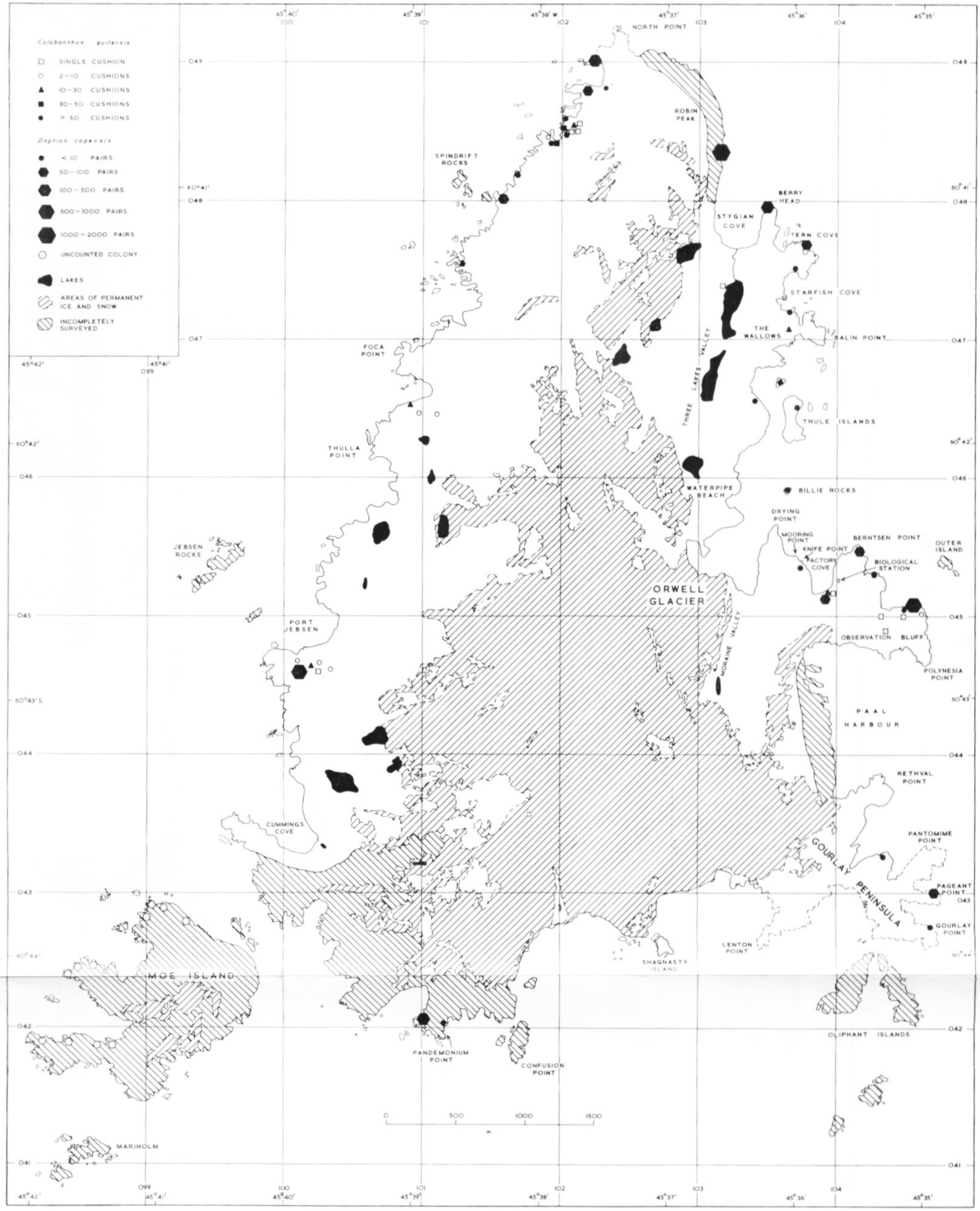

Fig. 2. Distribution and abundance of *Colobanthus quitensis* on Signy Island, March 1970, in relation to the distribution of *Daption capensis* colonies. Data on *D. capensis* colonies from Pinder (1966). Origin of grid: lat. 60° 40′ S., long. 45° 40′ W. False coordinates of origin 50,000 N., 100,000 E.

nitrogen. The grass soils are generally loamy and, although remains of old leaves and inflorescences are frequently found in the surface layers, there is no peat accumulation such as occurs in other soils on Signy Island. Holdgate and others (1967) have commented that "the rapid integration of the organic matter into the soil suggests intense biological activity encouraged by the favourable microclimate, flush conditions and soil oxidation". Fogg (1967) showed that in terrestrial green algae between 1 and 7 per cent of the total photosynthates are released as extracellular products. There is no information on the production of root exudates in Antarctic soils but the release of small amounts of polysaccharides would also increase activity of the soil micro-fauna.

In the summer months, several sites near the sea receive considerable amounts of salt spray during gales. In February 1969, when high-water spring tides coincided with north-easterly winds, a small number of grass plants in Factory Cove was submerged several times by large waves, yet they produced inflorescences later in the season. This very high tolerance to salt water was confirmed by an experimental treatment with 100 ml. of undiluted sea-water of small areas of *D. antarctica* in Factory Cove. Each area was watered once, twice, three times up to 14 times over a 14 day period in December 1968, at the end of which, and later in the season, none of the grass showed any signs of damage or discoloration. Although Holdgate (unpublished report) noted that "after heavy summer storms, brownish 'scalding' of the grass patches nearest the sea had been observed", he too concluded that plants of *D. antarctica* appear remarkably tolerant of salt deposition from spray.

Floristic composition

Smith (in press), in his account of the vegetation of Signy Island, has treated the communities formed by *Colobanthus quitensis* and *Deschampsia antarctica* as part of the grass and cushion chamaephyte sub-formation, the latter being the sole representative of the Antarctic herb tundra formation. He found lack of uniformity within the sub-formation, the only constant associates being the moss *Drepanocladus uncinatus* and the liverwort *Cephaloziella varians*, but he recognized two communities within a single *Deschampsia antarctica–Colobanthus quitensis* association, one in which both species are present and the other in which only the grass is found. Within this framework, based on an analysis of 15 sites, Smith was able to arrange the sites in a sequence from lichen- and bryophyte-dominated stands at one extreme to almost pure stands of grass at the other.

Table III presents data for frequency and cover, for each of the 17 sites listed in Table I, obtained from 25, 20 cm. by 20 cm. quadrats placed in a sample plot of 2·4 m. by 2·4 m. by means of random coordinates. The quadrat was subdivided with cotton into 100 small areas of 2 cm. by 2 cm. so that fairly accurate cover values could be obtained. Thus the sampling was more intensive than that used by Smith but the present taxonomic treatment is slightly less detailed.

When the total number of occurrences of the major species in the quadrats are compared with the observed number of joint occurrences with *D. antarctica* and *C. quitensis*, it is possible to test for association between species within the vegetation. Table IV is compiled from the raw data used for Table III and shows the percentage probability of a positive or negative association based on χ^2 values. It must be stressed that quadrat data from several localities have been combined and that care is therefore necessary in interpretation; ideally each site should be analysed separately. However, this treatment of the data suggests that both *D. antarctica* and *C. quitensis* show a positive association with *Brachythecium* sp., *Cephaloziella varians* and *Marchantia berteroana*, and a negative correlation with stony ground. The fact that *C. quitensis* appears to be more common in areas where moss-encrusting lichens are abundant could possibly be a reflection of the species' preference for drier habitats which favour the development of such lichen communities. *D. antarctica*, but not *C. quitensis*, shows positive association with *Drepanocladus uncinatus*, *Polytrichum alpinum*, a species of *Bryum* and *Prasiola crispa*. Smith (in press) noted that *C. quitensis* has not been observed colonizing moss, whereas the grass is apparently successfully doing so, at some localities.

There is some evidence to suggest that *Drepanocladus uncinatus* occasionally increases at the expense of *D. antarctica*, especially in the more exposed localities where single plants of grass

Table IV. Number of joint occurrences and probability of association of various species with *Deschampsia antarctica* and *Colobanthus quitensis* at 17 sites on Signy Island

Species	*Deschampsia antarctica*					*Colobanthus quitensis*				
	Number of occurrences in 350 quadrats	*Number of joint occurrences*		χ^2	*Percentage probability of chance associations*	*Number of occurrences in 175 quadrats*	*Number of joint occurrences*		χ^2	*Percentage probability of chance associations*
		Observed	*Expected*				*Observed*	*Expected*		
Angiosperms										
Deschampsia antarctica	267	—	—	—	—	52	49	39·7	9·7	<1*
Colobanthus quitensis	52	49	39·7	9·7	<1*	70	—	—	—	—
Mosses										
Drepanocladus uncinatus	246	207	187·7	26·8	<0·1*	133	58	53·2	2·4	NS
Brachythecium sp.	158	134	120·5	10·7	<1*	101	53	40·4	14·3	<0·1*
Bryum sp.	111	79	84·7	1·9	NS	54	13	21·6	7·3	<1
Tortula sp.	81	67	61·8	2·0	NS	69	28	27·6	0	NS
Bartramia cf. *patens*	15	13	11·4	0·4	NS	12	8	4·8	2·7	NS
Polytrichum alpinum	93	82	70·9	9·0	<1*	43	19	17·2	0·2	NS
Liverworts										
Cephaloziella varians	115	92	87·7	1·0	NS	87	45	34·8	9·0	<1*
Marchantia berteroana	61	52	46·5	5·4	<5*	61	34	24·4	8·7	<1*
Algae and lichens										
Prasiola crispa	167	137	127·4	5·2	<5*	37	12	14·8	0·8	NS
Moss encrusting lichen	178	138	135·8	0·2	NS	94	50	37·6	13·6	<0·1*
Substrata										
Stone and rock	277	199	211·3	13·3	<0·1	153	56	61·2	4·8	<5
Bare rock	215	166	164·0	0·1	NS	101	42	40·4	0·1	NS

* Indicates positive association.
NS Not significant.

exist with the moss apparently flourishing between dead tillers and leaves. Pieces of grass in exposed situations are not vigorous, often appearing dead or with only a single green leaf at the centre of some of the tillers. However, the more commonly observed situation is that in which one or more small tufts, apparently vigorous and thriving, are growing amongst a *Drepanocladus uncinatus* or *Polytrichum alpinum* community. At several grass sites dead shoots of *Polytrichum alpinum* have been found amongst the soil litter beneath the grass. As long as environmental conditions allow vegetative growth to take place, there seems little chance of grass being overgrown by a bryophyte species and encroachment of the moss between the tillers should not prove deleterious. Such disruption of a pearlwort cushion could be more serious and *C. quitensis* is rarely, if ever, found so intimately associated with bryophytes. Where *C. quitensis* grows in the absence of grass, it is usually colonizing bare stony ground alongside small bryophyte cushions.

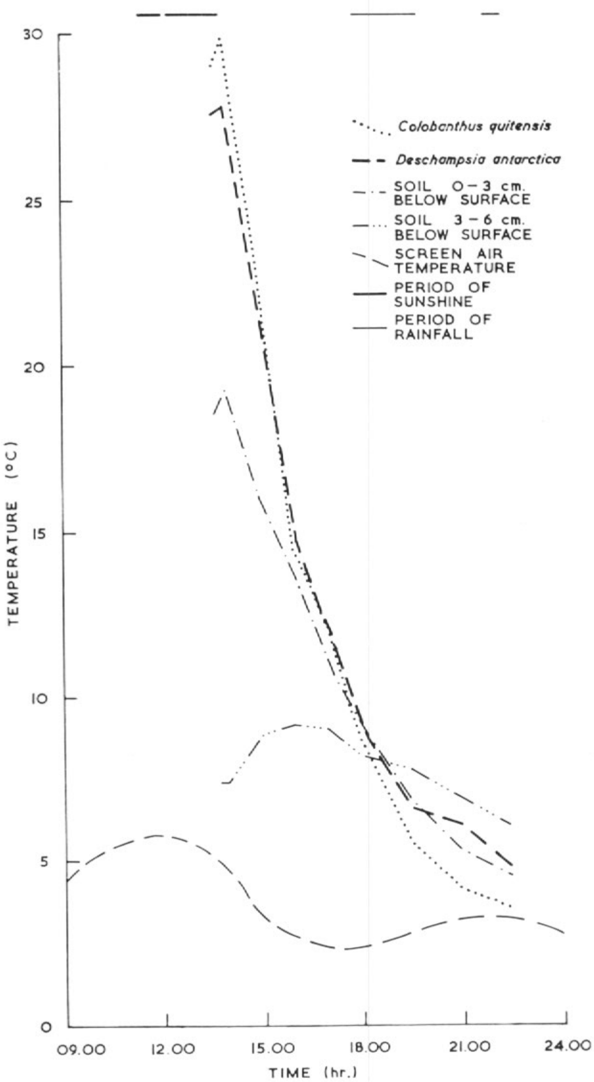

Fig. 3. Temperature fluctuations on a sunny day, 7 January 1968, in colonies of *Deschampsia antarctica* and *Colobanthus quitensis* at Factory Cove, Signy Island.

Temperatures at Plant Level

The studies of Wilson (1957), Matsuda (1964), Rudolf (1966) and Longton and Greene (1967) have shown that absorption of solar radiation by vegetation can raise the temperature of the air around photosynthetically active tissues many degrees above ambient. Colonies of *D. antarctica* and *C. quitensis* each have an open structure capable of enclosing large pockets of still air and so could be expected to be highly successful in absorbing solar radiation. Holdgate (1964) considered the *Polytrichum–Chorisodontium* banks to be the most efficient community type on Signy Island at absorbing solar radiation but thermistor readings taken by the author suggest that temperatures within colonies of *D. antarctica* and *C. quitensis* on sunny days (Fig. 3) rise as high as, possibly higher than, those of the moss banks. Fig. 4 shows that even on an overcast day, so typical of the South Orkney Islands, the temperature within colonies of the grass and the pearlwort can still rise many degrees above air temperature, although at night the ground may cool below ambient. The frequency of occurrence of particular temperatures both around and within individual colonies is considered in the section dealing with variation in vegetative size under cloches.

In winter the primary factor determining the survival of vascular plants is the degree of protection afforded by snow cover. During the autumn of 1969, a total of 55 stakes was erected around the station and snow depths were recorded at these sites approximately twice a week. The stakes were placed in three main groups, 13 in the large *D. antarctica–C. quitensis* sward north of Observation Bluff, 12 in the grass sward in Factory Cove, and the remaining 30 stakes at scattered minor sites where single or small colonies of flowering plants occur. Fig. 5 shows the variation in snow cover throughout the 1969 winter at three stakes, each typical of one of the groups described above.

Although there was great variation in snow cover between and within the grass patches in the vicinity of the station, a continuous insulating layer had developed at all sites by early May and this persisted until the end of August. During this period snow depth was least during the second week in July, when it was particularly noticeable that the larger areas of grass had less snow, 84 per cent of the stakes showing < 20 cm. of snow whereas only 37 per cent of the 30 minor vascular plant sites were so thinly covered. By 23 September, 92 per cent of the 13 sites in the sward at Observation Bluff and 75 per cent of the 12 in Factory Cove were clear of the winter's snow. However, only 7 per cent of the 30 minor sites had emerged from the winter's snowfalls at this date and this figure had risen to only 44 per cent by 26 November.

A series of thermistor readings (Figs. 6 and 7) was taken to study variations in under-snow

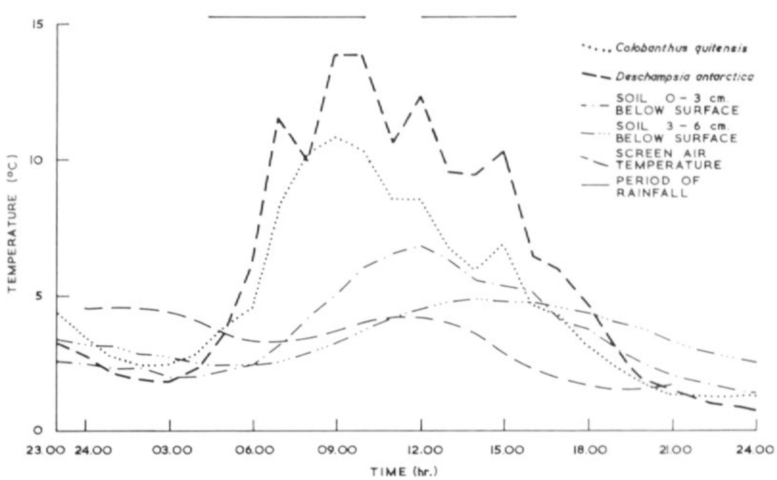

Fig. 4. Temperature fluctuations on an overcast day, 30 December 1967, in colonies of *Deschampsia antarctica* and *Colobanthus quitensis* at Factory Cove, Signy Island.

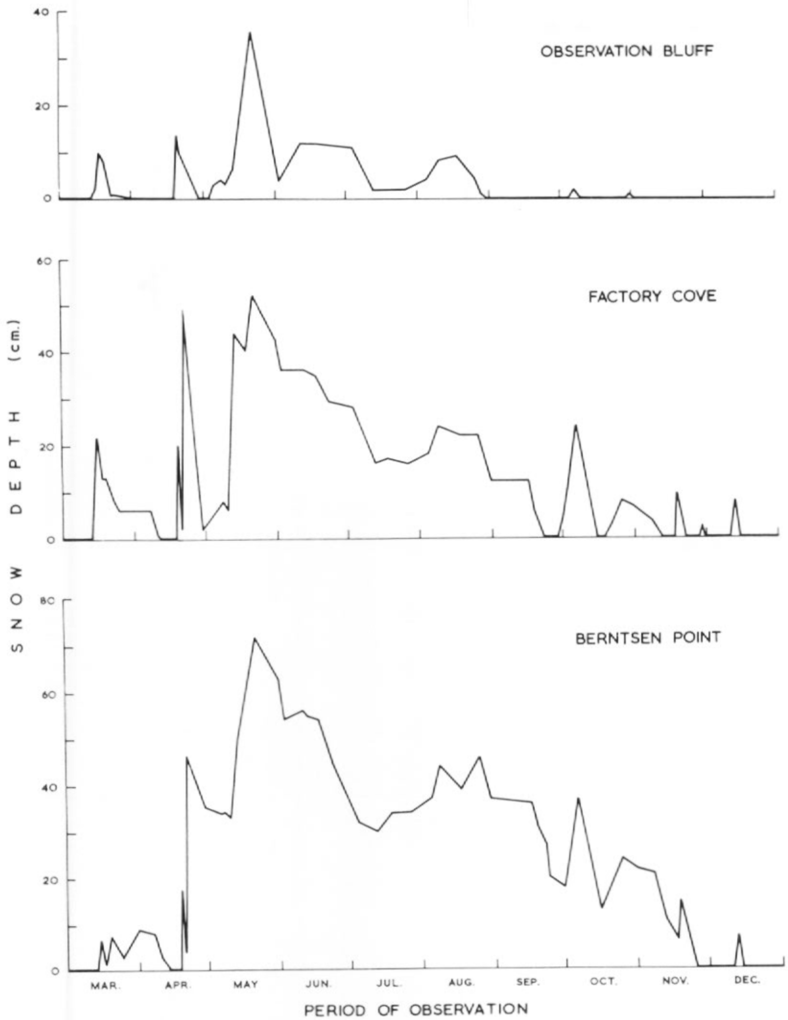

Fig. 5. Snow depths over *Deschampsia antarctica* at three sites on Signy Island during the winter of 1969.

temperature with time and depth of burial. It appears that the temperature in the top 20 cm. of snow fluctuates widely with changes in air temperature, whilst at lower levels conditions are more uniform with the temperature rarely falling below —10° C. Based on these observations, made during the 1969 winter which was not exceptional in its length or severity, it seems probable that the larger areas of vascular plants experience rigorous winter conditions but have a relatively early start to the growing season, while the more isolated grass patches encounter milder temperatures but at the risk of prolonged snow lie.

VARIATION IN VEGETATIVE SIZE

Various authors have commented on variation in plant size in both *D. antarctica* and *C. quitensis* which they have attributed to habitat factors. Corner (1971), for example, noted that on the Argentine Islands plants of *D. antarctica* from the drier, more exposed habitats possessed "shorter, finer and more wiry leaves" than plants from moister areas. On Signy Island, in 1951, Sladen (unpublished report) had observed that "the grass in the 'lawn' near the station (i.e. on Berntsen Point) although abundant, was small in size and reproductively

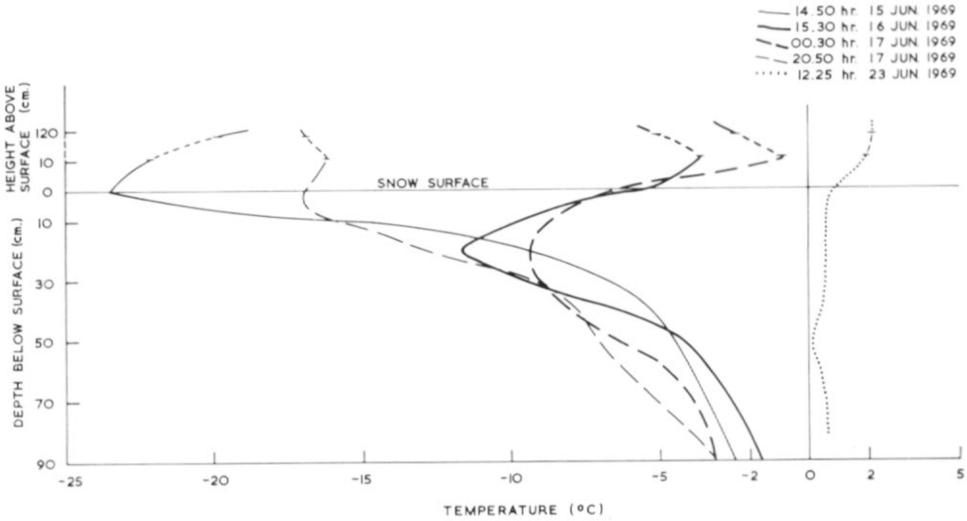

Fig. 6. Variation in snow temperatures with depth at a *Deschampsia antarctica* site in Factory Cove on five occasions in June 1969.

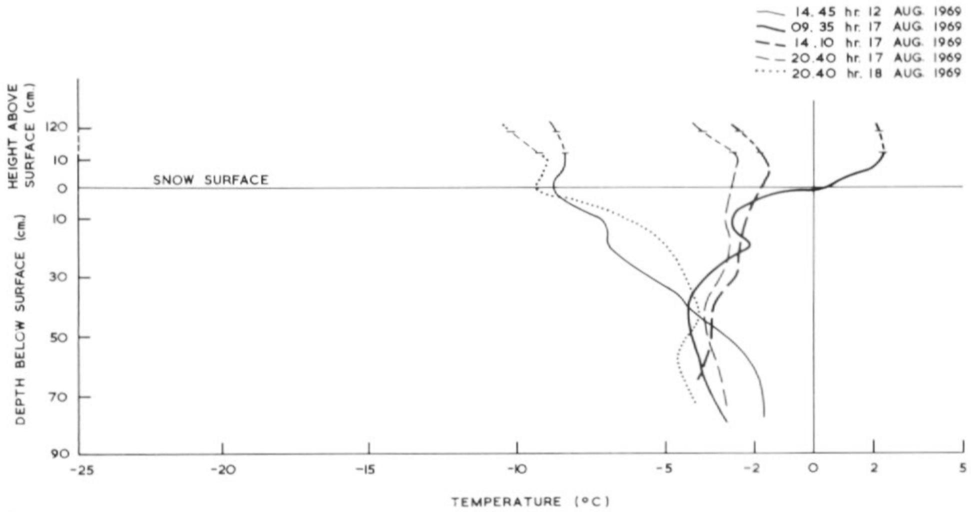

Fig. 7. Variation in snow temperatures with depth at a *Deschampsia antarctica* site in Factory Cove on five occasions in July 1969.

less advanced than at Factory Cove". Smith (in press) has stated that on Signy Island the growth form of *Deschampsia antarctica* varies from small yellowish tufts on dry gravelly soils to tall rich green tufts where the soil is deeper and more permanently wet. From field observations, it is clear that soil enrichment, moisture content and exposure all influence the size of leaves in both species and so the effects of these factors will be considered separately.

On enriched soils

Plants of both *D. antarctica* and *C. quitensis* growing beneath cape pigeon nests are significantly larger and lusher than plants lacking direct influence by birds, as shown by measurements from Port Jebsen (Table V) taken from plants in this position. In both species

TABLE V. VEGETATIVE DIMENSIONS FOR *Deschampsia antarctica* AND *Colobanthus quitensis* FROM SIGNY ISLAND, LYNCH ISLAND AND SOUTH GEORGIA

Species	*Deschampsia antarctica*				*Colobanthus quitensis*	
	Tiller length (mm.)	*Leaf length* (mm.)	*Leaf width* (mm.)	*Ligule length* (mm.)	*Leaf length* (mm.)	*Leaf width* (mm.)
Signy Island						
Berry Head	—	16·2	0·63	2·1	—	—
Factory Cove, east side	—	20·3	0·62	1·9	2·4	1·1
Factory Cove, west side	—	20·5	0·60	2·1	4·3	1·0
Port Jebsen	52·5	26·0	0·56	2·3	5·1	1·2
Berntsen Point	32·5	16·7	0·62	1·6	—	—
Berntsen Point, under cloche	—	23·3	0·56	2·2	—	—
Starfish Cove	34·3	17·1	0·61	1·8	—	—
Starfish Cove, under cloche	46·9	23·5	0·55	2·2	—	—
Observation Bluff, upper slopes	34·3	16·9	0·61	1·7	2·5	1·1
Observation Bluff, lower slopes	32·5	15·8	0·61	1·9	3·4	1·3
Observation Bluff, lower slopes under cloche	37·2	18·3	0·55	1·8	4·7	1·4
Observation Bluff, lower slopes under snow*	33·6	16·9	0·51	1·5	4·9	1·1
Lynch Island	39·6	19·1	0·61	2·3	3·7	1·0
South Georgia						
King Edward Point†	—	46·4	1·5‡	5·5	7·6	1·5
Gull Lake†	—	29·6	1·2‡	3·8	5·1	1·3

* Artificially kept covered from 1 December 1968 to 26 January 1969.
† Unpublished figures from S. W. Greene.
‡ Unrolled diameter.

leaf length was greater than average for Signy Island and the plants appeared particularly luxuriant. The soils at these sites were comparatively rich in calcium (497 mg./100 g. soil) and phosphorus (17 mg./100 g. soil) but did not contain exceptional amounts of total nitrogen (1 per cent extractable cations) or other nutrients.

On moist soils

For a comparison of the effects of soil moisture on *D. antarctica* and *C. quitensis*, reciprocal transplants of each species were made from a wet area of the large grass sward north of Observation Bluff to a drier relatively well-drained part of the same sward. After a year, small samples were taken from the transplants and from the undisturbed wet and dry swards nearby, and various features were measured (Table VI). The leaf measurements for *C. quitensis* were made on one of the second pair of leaves below the apical rosette, while for *D. antarctica* the second leaf below the youngest was taken.

Contrary to expectations, the leaves of *D. antarctica* from the wetter part of the site were shorter (significant at <1 per cent level) than those from the drier area. The transplants from the dry to moist situation also produced shorter leaves in conditions of increased moisture, although there was little change in the length of leaves on plants moved to the drier area. *D. antarctica* leaves appeared narrower and *C. quitensis* leaves shorter in the wetter situation but these differences were not significant. However, due in part to the physical disturbance of the plants and also to the fact that sample size was small, these results are best regarded as indicative of a trend rather than estimates of the amount of difference which could be expected between plants growing in wet and dry situations.

In exposed sites

When the effects of shelter and exposure are considered, it appears that plants of *D. antarctica* are shorter in stature with wider, more robust leaves in the more exposed situations whilst *C. quitensis* cushions are yellower with small leaves. Measurements made in March 1969 at Berry Head, Berntsen Point and the upper slopes of Observation Bluff (Table V) show the reduced stature of both species in more open sites with greater exposure to wind and wind-blown snow.

Under cloches

Plants of *D. antarctica* at Berntsen Point were sheltered for 3 months by covering them with a glass cloche when it was found that leaf and ligule length increased but leaf breadth decreased. Inside the cloche there were fewer dead or yellow leaves and tillers were more delicate in structure than in the surrounding unsheltered grass. Whilst leaves outside the cloche were tightly rolled, those within were fully expanded. Similar changes were observed in plants of *D. antarctica* under cloches at Observation Bluff and Starfish Cove.

Some cloches were removed in the second summer when it was found that plants of *D. antarctica* gradually reverted to the "normal" Signy Island phenotype. In two of the cloches that were left in place for a second summer, several *C. quitensis* plants became withered and brown, while many dead leaves were found amongst *D. antarctica*, although much of the grass remained green and healthy. The cloches lessened the effect of direct rainfall and snow but percolating melt water and run-off were not restricted so that, although the possibility of water deficiency cannot be ruled out, the mortality is thought to be indicative of physiological failure due to the sustained high temperatures. Holtom and Greene (1967), working with material from South Georgia, found that under experimental conditions sustained high temperatures of 18° C or more caused the death of most plants of *D. antarctica* and *C. quitensis* after *c.* 10 months.

To compare the temperature regime inside a cloche near Spindrift Rocks with that in the surrounding natural vegetation, an automatic micro-climate recorder was set up and maintained by E. P. Wright in January 1970. Table VII summarizes the results obtained at the site over a 19 day period.

Temperatures amongst cushions of *C. quitensis* and tufts of *D. antarctica* inside the cloche

TABLE VI. EFFECT OF SOIL MOISTURE ON THE VEGETATIVE SIZE OF *Deschampsia antarctica* AND *Colobanthus quitensis*

Character	*Dimensions in wet area*		*Dimensions in dry area*		*Percentage probability of chance differences between*		
	Undisturbed sward (mm.)	*Transplanted from dry area* (mm.)	*Undisturbed sward* (mm.)	*Transplanted from wet area* (mm.)	*Plants growing in wet and dry areas*	*Phenotypes originating from wet and dry areas*	*Transplants and undisturbed sward*
Deschampsia antarctica							
Tiller length	25·96	22·00	32·36	26·92	<1	<5	<1
Leaf length	14·00	11·90	17·40	13·40	<1	<5	<0·1
Leaf width	0·54	0·58	0·60	0·58	<10	<10	NS
Colobanthus quitensis							
Leaf length	2·66	2·73	3·22	3·06	<10	NS	NS
Leaf width	1·24	1·03	1·05	1·24	NS	NS	NS

NS Not significant.

were above freezing for 84 per cent of the 19 day period, although the outside air temperature was above freezing for only 35 per cent of the time. The plants inside the cloche experienced temperatures between 7·5° and 22·5° C for a greater proportion of the time than did the external vegetation and, along with uncovered vegetation in a dry open position, experienced temperatures of 30° C or more for 1·5 per cent of the time.

Temperatures amongst *D. antarctica* and *C. quitensis* in the moister, more shaded parts of the sward rarely rose above 20° C during the day and at night usually fell to between 0° and —5° C. Temperatures in the soil 3 cm. below the vegetation were of a similar range to those between shaded grass and pearlwort leaves, but temperatures during the night were warmer and never fell below —2·5° C. It is interesting to note that the most equable micro-climate was recorded amongst *D. antarctica* growing in a small water runnel which maintained the vegetation in a permanently saturated state. At this site, 73 per cent of the readings fell within ± 2·5° of 0° C, the temperature never falling below this and only on rare occasions rising above 10° C.

Biotic Influences

Corner (1971) observed an association on the Argentine Islands between the distribution of *D. antarctica* and the presence of soils disturbed by Dominican gulls (*Larus dominicanus*). This is not so apparent on Signy Island where the two flowering plants are more commonly found close to breeding colonies of cape pigeons (*Daption capensis*) (Fig. 2), a species which is only an occasional summer visitor to the Argentine Islands. Cape pigeons can frequently be observed turning over stones and vegetation close to their nests and tossing the pieces behind them. Pieces of grass and pearlwort uprooted by this release activity of the birds can be re-distributed by wind and gravity, and are considered to represent an important method of vegetative propagation for *D. antarctica* on Signy Island. The rapid colonization by *D. antarctica* of the lateral moraine of Orwell Glacier, less than 20 m. from the ice edge is, in all probability, due to the nesting activities of a pair of Dominican gulls. Four tufts, each consisting of only a few tillers, were observed in February 1968 below and around the nest, growing amongst limpet shells and other debris brought to the area by the gulls.

Other species of bird are also known to influence the spread of *D. antarctica*. Howie (unpublished report) observed a shag (*Phalacrocorax atriceps*) flying to the colony at North Point with a piece of grass in its beak, and in December 1969 two nests in this area each had a small piece of *D. antarctica* growing on their outer sides. Dead pieces of grass have been found by the author in the nest of a skua (*Catharacta skua*) near Spindrift Rocks, but this species, burrowing petrels and prions (*Pachyptila desolata*) would appear relatively unimportant as dispersal agents of vascular plants.

In order to test the capabilities of the pearlwort and the grass to withstand periods of time in an uprooted condition, small pieces of *D. antarctica* and *C. quitensis* were kept uprooted in the field under a small cage and re-planted at various intervals. *D. antarctica* was able to overwinter, and continue growth the following season, after remaining uprooted for 40 days before re-planting, but *C. quitensis* only survived in good condition if re-planted within 7 days of uprooting. Thus the possibility of *C. quitensis* increasing its distribution by vegetative means would appear less than for *D. antarctica* either due to its lower tolerance to periods of uprooting or its lower success in re-establishment. This, rather than the lack of suitable habitats, could account for the more limited distribution of this species. A large proportion of *D. antarctica* sites would appear compatible with the requirements of *C. quitensis*, since eight out of ten cushions of this species transplanted to sites where only *D. antarctica* occurred were still apparently healthy after 2½ years.

Several instances of mechanical disturbance to *D. antarctica* swards are evident in the large gully near Polynesia Point, where divots of this species are to be found lying on the surface of the scree. A number of these appears too heavy to have been distributed by birds and they are more likely to have been torn out from the sides of the gully by falling rocks, dislodged by freeze-thaw weathering or human passage.

The presence of human habitation on the island may also be of some consequence, as it is difficult to see what means other than disturbance by man could account for the distribution of some small grass tufts behind the station. There are four of these occurring along a line

Table VII. Percentage frequency of hourly temperatures recorded at a grass site north of Spindrift Rocks, arranged in 2·5° C increments

Position of thermistor	*Percentage frequency of recordings in each increment*																		
	<−5·1	−5·0 to −2·6	−2·5 to −0·1	0 to 2·4	2·5 to 4·9	5·0 to 7·4	7·5 to 9·9	10·0 to 12·4	12·5 to 14·9	15·0 to 17·4	17·5 to 19·9	20·0 to 22·4	22·5 to 24·9	25·0 to 27·4	27·5 to 29·9	30·0 to 32·4	32·5 to 34·9	35·0 to 37·4	37·5 to 39·9
In air and soil																			
13 cm. above ground level	1·3	13·2	50·3	18·2	9·2	4·6	2·6	0·2	0·2	—	—	—	—	—	—	—	—	—	—
3 cm. below ground level	—	—	24·0	36·9	12·7	8·6	5·7	4·8	1·5	2·2	1·5	0·9	1·1	—	—	—	—	—	—
In Deschampsia antarctica																			
Waterlogged tuft	—	—	40·3	32·4	13·4	6·9	3·0	1·6	0·2	1·2	0·9	—	—	—	—	—	—	—	—
Moist shaded tuft	—	9·1	38·6	24·6	9·8	6·0	3·2	3·2	1·8	1·4	1·4	0·7	0·4	—	—	—	—	—	—
Dry exposed tuft	—	5·7	32·5	23·1	10·3	5·7	5·1	5·1	2·9	2·9	1·3	1·3	0·7	0·9	1·1	1·1	0·2	—	0·2
Tuft under cloche	—	—	15·9	26·5	16·5	7·6	6·5	7·1	8·8	4·1	1·8	1·8	—	1·8	—	—	0·6	—	0·6
In Colobanthus quitensis																			
Moist shaded cushion	—	4·4	39·8	23·1	10·3	5·9	5·[illegible]	4·4	2·0	0·9	0·9	1·8	0·9	0·4	0·2	—	—	—	—
Dry exposed cushion	—	5·7	45·7	15·2	7·5	5·1	5·1	3·7	3·1	2·2	1·3	1·3	0·7	1·3	0·7	1·3	—	0·2	—

Recordings made between 8 and 27 January 1970 inclusive.

[*face page 22*

40–70 m. in length on the more stable parts of a stone stripe which has for some time been the main footpath used by people leaving the station area for Observation Bluff. The only large area of *D. antarctica* nearby is that in Factory Cove, *c.* 300 m. distant.

C. quitensis is extremely intolerant of disturbance by seals and penguins whilst *D. antarctica* is only slightly less so, transplants of both species at Drying Point being completely obliterated by seals within 6 months. However, a small area of grass persists to the north of a marble outcrop at The Wallows, although surrounded by large pods of elephant seals for most of the summer and frequently showing signs of having been wallowed upon. *D. antarctica* is also found in the less frequented parts of the penguin colonies at North Point and Gourlay Peninsula, and several of the low-lying grass patches are favoured sites for moulting penguins. It appears, therefore, that this species can survive a certain amount of biological disturbance.

Glacial Influences

It is doubtful whether the overall distribution of vascular species on Signy Island can be attributed solely to the influence of birds or other animals which may be important agents for local dispersal. Taylor (1955), when considering the origin of the Macquarie Island flora, concluded that most insular species are likely to be recent immigrants and, if this is true of Signy Island, it may be expected that the present distribution of both *D. antarctica* and *C. quitensis* will have been affected by the recent glacial history of the island.

Matthews and Maling (1967) considered that many features on Signy Island indicate a "comparatively recent glacial retreat after the deglaciation of most of the present ice-free areas" and that during a time of greater glaciation Orwell Glacier extended north into Shallow Bay. The fact that the east face of Robin Peak shows ice scarring up to 30 m. above sea-level and that the lakes in Three Lakes Valley are glacial remnants, not separated by bands of harder rock, indicate that there was once a much larger glacier covering Borge Bay with its snout in Stygian Cove. It seems reasonable that the peninsula on which Observation Bluff is situated and possibly the ridges on the west coast of Signy Island were either less affected by the general flow of ice from the west or else became ice-free at an earlier date than the main valleys. Such a sequence of glacial retreat would be consistent with the relative abundance of vascular plants around the island. At the north end of Moraine Valley, most of the grass is found widely scattered as single tufts and there is negligible sward development which is reconcilable with the recent rapid retreat of Orwell Glacier. Plants in Three Lakes Valley and the north-eastern parts of the island would be earlier post-glacial invaders and would be expected to show more development. Indeed *D. antarctica* frequently occurs in small, fairly isolated patches and there are few sites where *C. quitensis* also occurs. The largest concentration of *D. antarctica* and *C. quitensis* sites is on the north side of the peninsula on which Observation Bluff is situated and around Factory Cove where there are few single plants but a high density of small swards.

On the west coast of the island, the movement of ice has eroded the landscape into a series of east–west ridges. The ground in the amphitheatres between the ridges is still very unstable with large areas of patterned ground. This is unsuitable for vascular plant colonization, although a few small tufts of grass have been seen between soil polygons at Knife Point and Cummings Cove. It is on the more stable ground on the north-facing crags and ledges that vascular plants usually occur.

Summary and Conclusions

The distribution of *Deschampsia antarctica* and *Colobanthus quitensis* on Signy Island is now known in considerable detail. Both species are found on well-drained north-facing slopes in the coastal zone and the sites are usually flushed by melt water. *C. quitensis* is less common than *D. antarctica*, occurring at lower altitudes and on steeper slopes, frequently on a largely mineral soil with a high clay content. *D. antarctica* occupies a wider range of habitats and can tolerate wetter sites and a higher degree of animal and bird contamination. It is usually found growing on acid or neutral organic soils which, because of their composition and structure, have been likened by Holdgate and others (1967) to the brown earths of temperate climates. There appears to be no mineral shortage, with the possible exception of available nitrogen, the input of nutrients coming from three sources: percolating melt water, sea spray and the run-off from bird colonies, particularly ledge-nesting petrels. *D. antarctica* is extremely tolerant of high salinity and several sites exist only a few metres from the sea; the pearlwort does not grow in such exposed situations.

Drepanocladus uncinatus and *Cephaloziella varians* are the two cryptogamic species most constantly associated with the two angiosperms, *D. antarctica* showing a positive association with these and with *Polytrichum alpinum*. In several situations *D. antarctica* appears to be invading the bryophyte communities but in others both grass and pearlwort seem in the process of being overcome by mosses. *C. quitensis* is not tolerant of competition, being more often found on bare ground and at sites where moss-encrusting lichens are abundant possibly because the vigour of the bryophytes is less in such situations.

Material of *D. antarctica* and *C. quitensis* from Signy Island has comparable vegetative dimensions to plants from elsewhere in the South Orkney Islands and is very similar, although slightly smaller, to the high-altitude phenotypes of both species on South Georgia. However, stature and the amount of standing dead material varies with habitat on Signy Island. Both species are extremely lush and of large dimensions in enriched areas below petrel nests. Where the soil is very moist, both species are again deep green in colour with few yellow or dead leaves, but the leaves in *D. antarctica* at least appear to be shorter than those from drier areas. In exposed situations the proportion of dead material in the sward or cushion increases and both species are more yellow-green in colour, having shorter, more wiry leaves than plants from moderately sheltered areas.

Because of the ameliorating effect of solar radiation on temperatures at ground level, both species experience a more favourable micro-climate during the summer months than might be expected. On sunny days amongst vegetation in dry areas, temperatures can rise above 30° C for short periods but in the moister parts of swards it is rarely higher than 20° C. The increase in temperature amongst plants in very wet situations is slight but temperatures at night are invariably milder than amongst dry vegetation. A similar equable temperature regime exists around the roots of the vascular plants.

Both species are absent from some apparently suitable sites, both inland and coastal, and the survival of artificial transplants of *D. antarctica* and *C. quitensis* in such areas has shown that a future increase in their distribution can be expected. Seedlings of *C. quitensis* are produced infrequently on Signy Island; R. I. L. Smith (personal communication) observed several near Observation Bluff early in 1967, while the author saw them at this site and near North Point in 1970. The establishment of *D. antarctica* seedlings has only once been observed on Signy Island, i.e. during the 1969–70 season. As mature seed and seedlings so rarely occur, both species are largely dependent on vegetative means of dispersal, relying on birds, frost heave and, more recently, human passaging to transport vegetative propagules from place to place. The fact that *C. quitensis* is less resistant to uprooting and/or is less able than *D. antarctica* to re-establish itself, rather than a lack of suitable habitats, may well account for its more restricted distribution relative to *D. antarctica*.

The present-day patterns of distribution and abundance agree well with the sequence of glacial retreat postulated by Matthews and Maling (1967), for isolated tufts of grass are commonest in those areas which have been most recently deglaciated, while large and small swards have only developed in areas which have been bare for longer periods.

Observations so far indicate that the larger grass swards are insulated during winter by a covering of snow which is shallower than that overlying most of the isolated grass patches, and therefore they become free of snow earlier in the season. Whether this increased length of growing season alone can account for variation in the size and density of swards is questionable, particularly as clearance of snow will leave the plants vulnerable to cold periods during spring and autumn. In addition, the shallow snow cover during winter exposes them to lower and more fluctuating temperatures than plants covered by deeper layers of snow. On a micro-scale this would appear to be a major factor controlling the distribution and amount of dead material in a sward, although the abundance of areas of grass is related most closely to the length of time the ground has been available for colonization.

At present, subjective observations suggest that both species are increasing in abundance and extending their range on Signy Island. Although it is impossible at present to give any conclusive evidence to support this thesis, it seems likely that both species are colonizing ground as it becomes deglaciated but that swards are only established slowly, both because of the rarity of successful establishment from seedlings and because of low growth rates.

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APPENDIX

DETAILS OF SPECIMENS AND FIELD RECORDS OF *Deschampsia antarctica* AND *Colobanthus quitensis* FROM SIGNY AND CORONATION ISLANDS

The specimens cited are preserved in the herbarium of the British Antarctic Survey (BIRM*) at present housed in the Department of Botany, University of Birmingham, or in the British Museum (Nat. Hist.) (BM).

The field records, with numbers indicating their file order in the data bank associated with the Survey's herbarium, relate to sites for which no permanent specimens exist and have been derived from the following unpublished sources:

Signy Island, base biological register (1947–48, 1950–51). Base register H92/1, H111/1, H617/1.
M. W. Holdgate (1961–62) Botanical field note books and manuscripts. Field records 2262, 2265, 2267, 2279, 2287, 2461, 2495.
C. A. Howie (1964–65) Botanical field note book. Field records 2252–89 inclusive.
R. I. L. Smith (1964–67) Botanical field note book. Field records 2290–372 inclusive.
J. A. Edwards (1967–70) Botanical field note books. Field records 2259, 2373–460 inclusive.

All specimens and field records from Signy Island are arranged according to the 1 km. squares of the South Orkney Islands grid. The specimens and field records for Coronation Island are additional to those given by Holtom and Greene (1971).

Signy Island

Deschampsia antarctica

099 043	0999 0432	Field record 2466.
100 043	1002 0432	Field record 2394.
100 044	1000 0446	Field record 2279.
	1000 0447	East of large scree, Holdgate 516 (BIRM*), Field records 2335, 2425.
	1001 0446	Above giant petrel colony, Field records 2280, 2336, 2426; at foot of large cliff face, Field records 2282, 2428. Unspecified habitat, Field record 2287.
	1002 0446	Field records 2337, 2338.
	1002 0447	On fine scree, Field records 2281, 2427.
	1003 0445	Below narrow arête, Field records 2339, 2429.
100 045	1002 0453	Field records 2312, 2402.
	1003 0453	Field record 2470.
	1008 0456	On ledge 17 m. above and to the east of small lake, Field records 2313, 2403, 2471.
	1009 0456	On ledge just above lake surface, Field record 2264; near giant petrel colony, Field record 2404.
100 046	1008 0464	Below Dominican gull nests, Field record 2454; diffuse area of grass on consolidated scree, Field record 2455.
	1009 0464	Field record 2265; in wet runnels, Holdgate 511 (BIRM*), Field record 2367; above marble promontory, Field records 2366, 2453, 2493.
	1009 0465	Howie 12 (BIRM*).
101 046	1010 0464	Near the sea, Howie 15 (BIRM*); with *Brachythecium*, Robin H76/1 (BM), Field records 2368, 2494.
	1010 0465	Field record 2262.
	1011 0464	Longton 1148 (BIRM*); below rock outcrop south of hut at Foca Point, Field records 2369, 2456.
	1011 0465	Field record 2267.
101 048	1016 0481	Field records 2351, 2442, 2485, 2490.
	1017 0482	Below cape pigeon nests, Field records 2348, 2439, 2487; south of cape pigeon nests, Field records 2346, 2437, 2488.
	1018 0484	Holdgate 509 (BIRM*).
	1019 0484	Above headland, Field records 2344, 2435; at foot of headland, Field record 2432; at either side of stone chute, Field records 2343, 2433, 2434.
102 048	1020 0483	Field record 2441.
	1020 0484	On small promontory, Field records 2347, 2438, 2486; in wet area amongst *Drepanocladus*, Field record 2434; on plateau above cliffs, Field record 2441.
	1020 0485	Field record 2489; above small promontory, Field record 2441.
	1021 0485	Howie 13 (BIRM*); Field records 2349, 2350, 2440.
	1021 0486	Field record 2259.
	1021 0487	Field record 2490.
	1022 0487	Field records 2285, 2345, 2436, 2484.
	1022 0489	Steep slope to sea, Field record 2252; below giant petrel colony, Field record 2269.
	1023 0487	Howie 4 (BIRM*).
	1024 0488	Field records 2273, 2321.
	1025 0488	Field records 2274, 2322.
	1025 0489	Base register H617/1, Field records 2318, 2410, 2474.
	1026 0489	Field records 2275, 2324, 2478.
	1027 0489	Field records 2323, 2413.
	1029 0488	Field record 2341.
102 049	1022 0490	Field records 2270, 2320, 2476.
	1023 0490	Dry cliff, Field record 2272; coastal scree, Field records 2268, 2319, 2411, 2475.
	1024 0490	Field records 2271, 2412.
	1026 0490	Howie 3 (BIRM*).
	1027 0490	Field record 2477.
103 042	1036 0428	Field records 2315, 2406.
103 044	1038 0440	Field record 2331.
	1038 0442	Field record 2330.

103 045	1030 0457	Field records 2372, 2458.
	1031 0458	Field records 2371, 2457.
	1032 0451	Field records 2329, 2421.
	1032 0452	Field record 2421.
	1032 0458	Field record 2495.
	1033 0450	Field records 2409, 2473.
	1034 0450	Field records 2306, 2396, 2467
	1034 0452	Field record 2396.
	1035 0452	Field record 2396.
	1035 0454	Field record 2395.
	1036 0450	Field record 2459.
	1036 0452	Field record 2314; overlooking Moraine Valley, Field records 2307, 2397.
	1036 0453	Holdgate 507 (BIRM*), Howie 16 (BIRM*), Howie 17 (BIRM*), Field records 2317, 2408; in rocky gully, Field records 2266, 2316, 2472; moist area to east, Field record 2407.
	1037 0451	Holdgate 510 (BIRM*), Field records 2263, 2309, 2399.
	1037 0453	Amongst patterned ground, Field record 2405; near whaler's mooring chains, Field record 2407.
	1038 0451	Field record 2399.
	1039 0451	Disc. Invest. St. 1962 (BM), Holdgate 519 (BIRM*), Holdgate 521 (BIRM*), Howie 14 (BIRM*), Howie 23 (BIRM*), Longton M583 (BIRM*), Sladen H630/1 (BIRM*, BM), Sladen H631/1 (BM), Taylor 405 (BIRM*), Field records 2308, 2398.
103 046	1030 0464	Field records 2360, 2448.
	1031 0465	Field records 2361, 2449.
	1033 0462	Field record 2365.
	1033 0465	Howie 10 (BIRM*), Field record 2452.
	1034 0463	Field record 2365.
	1036 0462	Field record 2363.
	1036 0463	Field records 2362, 2450.
	1036 0464	Field record 2450.
	1036 0465	Field records 2364, 2451, 2492.
	1037 0465	Field records 2451, 2492.
103 047	1030 0472	Field record 2358.
	1030 0474	Field record 2358.
	1030 0478	Field records 2342, 2431.
	1030 0479	Field records 2342, 2431.
	1033 0474	Field record 2359.
	1034 0471	Howie 11 (BIRM*), Field record 2447.
	1034 0473	Field record 2357.
	1034 0476	Field record 2354.
	1035 0476	Field records 2288, 2355, 2445, 2491.
	1035 0478	Field records 2305, 2393.
	1035 0479	Field record 2393.
	1036 0471	Several patches near sea, Base register H92/1, Robin H93/1 (BM), Field records 2352, 2444, 2461.
	1036 0476	Holdgate 506 (BIRM*), Field records 2356, 2446.
	1037 0470	Field record 2443.
	1037 0471	Field record 2460.
	1037 0476	Field record 2356.
	1038 0470	Field records 2302, 2389.
	1038 0475	Howie 1 (BIRM*).
103 048	1030 0480	Field record 2276.
	1030 0487	Field record 2283.
104 043	1041 0431	Field records 2310, 2400.
	1041 0437	Field records 2340, 2430, 2483.
	1042 0431	Field record 2468.
	1042 0432	Field record 2400.
	1043 0430	Field records 2311, 2401, 2469.
	1044 0430	Field record 2401.
104 044	1043 0449	Field record 2416.
	1044 0449	Above large peat bank, Holdgate 517 (BIRM*), Howie 7 (BIRM*), Field record 2414.
	1045 0449	At foot of large gully, Howie 27 (BIRM*), Field record 2419; higher, in gully on western side, Howie 25 (BIRM*), Field records 2420, 2482.
	1046 0449	Holdgate 500 (BIRM*), Field records 2278, 2334, 2424.
104 045	1040 0451	Field record 2460.
	1040 0452	Field record 2460.
	1040 0453	Holdgate 512 (BIRM*), Holdgate 520 (BIRM*), Holdgate 522 (BIRM*), Robin H50/1020 (BM), Sladen H629/1 (BM), Sladen H633/1 (BIRM*, BM), Base register H111/1, Field records 2303, 2390.
	1041 0450	Field record 2460.

	1041 0452	Field records 2260, 2391.
	1041 0453	Below anemometer tower, Taylor 346 (BIRM*), Field record 2392; ground behind fuel tank, Field record 2460.
	1042 0450	Two swards on scree above large cliffs, Field records 2328, 2418, 2481.
	1042 0451	Field record 2418.
	1042 0452	Field records 2261, 2304, 2391, 2465.
	1043 0450	Below large east-facing cliffs, Field records 2327, 2417; below inland rock outcrops, Field records 2326, 2415, 2479.
	1043 0451	Field record 2480.
	1044 0450	Bailey 1–20 (BIRM*, 20 specimens), Holdgate 505 (BIRM*), Holdgate 513 (BIRM*,) Holdgate 514 (BIRM*), Holdgate 515 (BIRM*), Howie 2 (BIRM*), Howie 6 (BIRM*), Howie 26 (BIRM*), Howie 29 (BIRM*), Field records 2325, 2414.
	1045 0450	Holdgate 501 (BIRM*), Howie 5 (BIRM*), Field record 2333.
	1046 0450	Near edge of cliff, Holdgate 503 (BIRM*), Field records 2277, 2332, 2422; below cape pigeon nests, Field record 2423.

Colobanthus quitensis

100 044	1000 0446	Field records 2293, 2377.
	1001 0446	Field record 2377.
	1002 0445	Field record 2378.
	1002 0446	Field record 2377.
	1003 0446	Filed record 2294.
100 046	1009 0464	Longton 1149 (BIRM*).
	1009 0465	Field records 2258, 2300, 2387, 2464.
101 046	1010 0464	Field records 2301, 2388.
101 048	1019 0484	At foot of cliff, Field record 2379; above large cliff, Holdgate 508 (BIRM*), Field records 2253, 2295, 2380.
102 048	1020 0484	Field record 2385.
	1020 0485	On two small points north of rocky headland, Field records 2255, 2382; on north side of a point, opposite small sea stack, Field records 2256, 2257, 2297, 2383, 2463; point to south of sea stack, Field record 2383.
	1021 0484	Field record 2386.
	1021 0485	Field record 2384.
	1023 0488	Field records 2254, 2296, 2381, 2463.
103 045	1039 0451	Large grass sward, Disc. Invest. St. 1962 (BM), Sladen H627/3b (BM), Field records 2290, 2373, 2462; smaller grass sward to east, Field record 2373.
103 047	1031 0473	Field record 2299.
	1036 0470	Field record 2298.
104 044	1043 0448	Field record 2376.
	1044 0449	Field record 2374.
104 045	1043 0450	Field record 2375.
	1044 0450	Bailey 21–39 (BIRM*, 19 specimens), Holdgate 504 (BIRM*), Holdgate 518 (BIRM*), Howie 20 (BIRM*), Howie 21 (BIRM*), Howie 22 (BIRM*), Howie 28 (BIRM*), Field records 2291, 2374.
	1046 0450	Field record 2292.

Coronation Island

Deschampsia antarctica

Marshall Bay, Lynch Island, Edwards BAS Misc. 23 (BIRM*).
Cape Hansen, west side, Edwards BAS Misc. 20 (BIRM*).
Cape Hansen, east side, Edwards BAS Misc. 22 (BIRM*).
Shingle Cove, Edwards BAS Misc. 25 (BIRM*), Edwards BAS Misc. 27 (BIRM*).

Colobanthus quitensis

Marshall Bay, Lynch Island, Edwards BAS Misc. 24 (BIRM*).
Cape Hansen, west side, Edwards BAS Misc. 21 (BIRM*).
Shingle Cove, Edwards BAS Misc. 26 (BIRM*).