DISTRIBUTION OF SOIL NEMATODES IN THE MARITIME ANTARCTIC

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ABSTRACT. Soil and vegetation samples were collected from 15 islands in the maritime Antarctic. Species of *Plectus*, notably *P. antarcticus* de Man, 1904 and *P. parietinus* Bastian, 1865, *Eudorylaimus*, *Aphelenchoides*, *Teratocephalus* and *Clarkus gerlachei* (de Man, 1904) Jairajpuri, 1970 were widely distributed. Other species were restricted to the more northern localities. Differences occurred between the composition and relative abundance of the component nematode genera of similar vegetation communities of different islands, due, it is thought, to both ecological and dispersal factors.

THE maritime Antarctic has been defined (Holdgate, 1964) as the southern polar region where, in summer, the mean air temperature of at least one month is above freezing point and in winter the mean monthly temperature only occasionally falls below −10° C. Precipitation is frequent and in summer it may fall as rain. The vegetation is dominated by lichens and mosses, the latter often forming extensive closed communities. Two flowering plants are locally abundant in sheltered lowland areas and liverworts also occur. The more northerly sub-Antarctic region differs from the maritime Antarctic by its milder climate and much greater biotic diversity (vascular plants dominate the vegetation of lowland areas forming moorland or tussock grass communities), while the southernmost, continental Antarctic region can be distinguished by its much lower temperature regime, arid conditions and vegetation that is limited to lichens and a few mosses (Holdgate, 1964).

The areas included in the maritime Antarctic are the South Sandwich Islands, South Orkney Islands, South Shetland Islands, western coastal fringe of the Antarctic Peninsula south to Marguerite Bay, Bouvetøya and Peter I Øy. The soils of these areas have been briefly described by Allen and Heal (1970), and Gimingham and Smith (1970) have given a detailed account of the vegetation. Tilbrook (1970) has reviewed the invertebrate fauna of the region.

This paper deals briefly with the distribution of the soil nematodes over part of the maritime Antarctic, namely, the South Orkney Islands, South Shetland Islands and islands off the west coast of the Antarctic Peninsula.

METHODS

Soil and vegetation samples were collected from 15 islands within the maritime Antarctic during the austral summers of 1968–69, 1969–70 and 1970–71. The sample sites are listed in the Appendix and the locations of the islands are shown in Fig. 1. Generally, only a single sample was collected from each site and, since it was dug out by hand, its size varied; however, at least 40 g. (wet weight) of the surface few centimetres of soil and vegetation were processed from each habitat. Only at Signy Island and Avian Island were samples taken to a known depth with a soil corer.

All the samples from Signy Island and those collected from the other localities during the 1968–69 summer were processed at Signy Island. Samples collected from the other localities during the 1969–70 and 1970–71 summers were processed at Monks Wood Experimental Station, Huntingdon, England. When there was a delay between the time that the samples were collected and the time that the nematodes could be extracted, the samples were stored at or near 4° C in sealed polythene bags.

The nematodes were extracted using a modified Baermann funnel (Spaull, 1973*a*). They were then identified to genus and a crude estimate made of their relative abundance in the sample. In the samples from Signy Island and Avian Island and in a few other cases, the numbers of the different genera were recorded. Species were identified from specimens that had been heat killed and fixed in TAF or FA 4 : 1 (Hooper, 1970) and mounted in glycerine.

The results for Signy Island, which are based on data given by Spaull (1973*b*), have been grouped according to the type of vegetation sub-formation from which they were derived (Gimingham and Smith, 1970).

Fig. 1.

RESULTS

The distribution and a rough estimate of the relative abundance of the genera in the various habitats are given in Table I. Species of the genus *Plectus* were found at all the localities examined. *P. antarcticus* de Man, 1904 and *P. parietinus* Bastian, 1865 were identified from Alamode, Emperor, Avian, Intercurrence, Elephant and Signy Islands, and they probably occurred at most of the other islands. Other widespread species were those belonging to the genera *Eudorylaimus*, *Aphelenchoides* and *Teratocephalus* together with *Clarkus gerlachei* de Man, 1904. Conversely, *Ditylenchus* sp., *Amphidelus* sp., *Cervidellus* sp., *Caernorhabditis* sp.,

Table I. Rough estimate of the relative abundance of soil nematode genera at 15 islands in the maritime Antarctic

Locality	Alamode Island				Emperor Island	Guébriant Islands		Avian Island	Pourquoi Pas Island		Cone Island	Limpet Island		Blaiklock Island		Galindez Island					Intercurrence Island	Astrolabe Island	Deception Island		Elephant Island					Signy Island					Coronation Island
Vegetation / Genus	*Drepanocladus* with *Pohlia* and *Cephaloziella*	*Bryum*	*Cephaloziella* with *Pohlia*	*Cladonia* and *Cephaloziella*	*Drepanocladus* with *Bryum*	*Brachythecium* with *Bryum* and *Drepanocladus*	*Drepanocladus*	*Drepanocladus* and *Bryum*	*Deschampsia* with *Pohlia*	*Pohlia*	*Drepanocladus*	*Brachythecium*	*Drepanocladus*	*Polytrichum* with *Pohlia*	*Pohlia* with *Drepanocladus*	*Chorisodontium*	*Polytrichum*	*Drepanocladus* with *Pohlia*	*Brachythecium*	*Deschampsia*	*Brachythecium* with *Bryum* and *Drepanocladus*	Soil below shags' nests	*Drepanocladus*	*Polytrichum*	*Drepanocladus*	*Brachythecium*	*Polytrichum*	*Chorisodontium* and *Polytrichum*	*Deschampsia*	*Drepanocladus/Calliergon/Calliergidium*	*Chorisodontium/Polytrichum*	*Bryum/Grimmia/Tortula/Andreaea*	*Deschampsia*	Soil from penguin rookery and seal wallows	*Deschampsia*
*Plectus**	00	0	0	00	0	00	0	00	×	00	00	0	0	0	×	00	×	00	×	×	00		0	00	0	00	00	00	0	00	0	0	00	×	00
Eudorylaimus	0	0	0	×	×	0	×		×	0		00	00	0	00			×	×	0	×			×	×	×	×	×	×	0	×	0	×		×
Aphelenchoides	0	×	×	0			00	0	×			×	×	00		0	00			0	×			0	×		×	×	×	×	0	×	×		×
*Teratocephalus**	×	00	00	0			0						×			0	×	0	×	×	×			×	×	×	×	×	00	0	00	00	0		×
Clarkus						×		0				0	0					×	00	×	×		×	×	×	×			0	×	×	×	×		0
*Mesodorylaimus**					00						0									0										×		0	0		0
*Rhabdolaimus**	×		×	×																×	×						×		×			×	×		×
*Monhystera**			×				×				×												×	0				×	×	0	×	×	×		×
*Enchodelus**				×										×						×							×	×	×		×	×	×		×
Ditylenchus																×					×			×		×	×		×	×	×	×	×		×
Monhysterid genus "A"																		×		×	×				00	×	×	×	×	×	×	×	×		×
Amphidelus																					×				×		×		×	×		×	×		×
Tylenchus										0						×									×		×	×	×	×	0	×	×		×
Panagrolaimus									00											00	×	00							×				×		×
*Cervidellus**																				×	×							0	×			×	×		
Caenorhabditis																						0												00	
*Prismatolaimus**				×																					×	×	×	×	×	×	×	0	×		×
Antarctenchus																														×	×	×	×		×
Monochid genus "A"																										×									
Unidentified	×	×	×		×		×					×	×																	×	×	×	×	×	×

* Males were rare or absent in species of these genera.
00 Dominant genus; 0 >5 per cent; × <5 per cent.

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Plectus armatus Butschli, 1873 and an unidentified species of *Plectus*, referred to previously as *Plectus* sp. C (Spaull, 1973*b*), were not found south of Galindez Island. *Antarctenchus hooperi* Spaull, 1972 was only found at Signy Island and Coronation Island, and an unidentified rhabditid, genus "A" sp., which was found in the moist organic nest material of a sheathbill (*Chionis alba* (Gmelin)) at Signy Island (Spaull, 1973*b*) was not recorded at any of the other islands.

One species not found during the survey at Signy Island, which was found in samples collected elsewhere in the maritime Antarctic, was an unidentified mononchid, represented by a single male and two juveniles recorded in *Brachythecium* at Elephant Island; also three species of *Eudorylaimus* at Elephant Island, one at Alamode Island and one at Intercurrence Island were not found at Signy Island. Furthermore, since only a few samples were collected at each island and since most of the nematodes have only been identified to the generic level, it is possible that other species are present in the Antarctic Peninsula region that were not found at Signy Island.

To a limited extent, the distribution of the genera reflects the type of habitat sampled at each locality. For example, at Signy Island *Caenorhabditis* was only recorded from soils heavily contaminated by vertebrates; Astrolabe Island was the only other island from which such soil was collected and was the only other locality at which *Caenorhabditis* was found. However, *Cervidellus* sp. and *Plectus armatus*, which at Signy Island were restricted to soils associated with vascular plants and cushion-forming mosses growing on base-rich soils, were, at Elephant Island, found in a turf-forming moss community of *Chorisodontium* and *Polytrichum*. Furthermore, some genera are apparently absent from certain islands despite the fact that potentially suitable habitats were examined and that the genera were present on nearby islands; this is exemplified by *Eudorylaimus* which was not recorded at either Avian or Cone Islands but was present at one of the Guébriant Islands, Pourquoi Pas and Limpet Islands (Table I).

Although in part derived from single samples, in the absence of any other quantitative data, the estimated total nematode density per square metre and the relative abundance of the genera in *Drepanocladus*-dominated vegetation at five islands in the Marguerite Bay area are given in Table II; similar data for Signy Island (from Spaull, 1973*b*) are included for comparison. As expected, the diversity of the nematode genera is greater at the more northern locality, Signy Island, but, rather surprisingly, considering that the type of vegetation samples was broadly similar at each island, the composition of the fauna showed large differences between islands. Also, the dominant genus was different at four of the six islands. Even in the same vegetation community from different islands (for example, *Drepanocladus uncinatus* associated with *Bryum algens* from Emperor and Avian Islands) there were differences in the faunal composition and the dominant genus.

Discussion

The diversity of the nematode fauna in the maritime Antarctic decreases with an increase in latitude. Possibly, this is due to progressively lower temperatures; but there is also a marked increase in the amount of "summer" sunshine with an increase in latitude (Table III) and this may have a significant effect on the temperature in moss. Longton (1972) found that during the 1965–66 summer, despite slightly lower air temperatures, the temperature in a moss turf at Galindez Island was consistently higher than at Signy Island. Longton suggested that this difference in moss temperature was due to the greater duration of sunshine at Galindez Island. Also, wind speeds are higher at the more northern islands which will result in increased heat loss from the surface of the vegetation.

Perhaps more important in limiting species diversity at higher latitudes is the reduced duration of the ice- and snow-free period as a result of lower air temperatures. The shorter this summer period, the shorter will be the time available for colonization. As suggested by Yeates (1970), unisexual species have a greater chance of establishing themselves at a new locality than bisexual species. In this context it is worthy of note that at Alamode Island males were rare or absent in approximately 75 per cent of the genera, while the corresponding figure for the Signy Island nematode fauna is less than 50 per cent; however, there is not a simple gradient between these two localities (Table I). A reduction in temperature was found

TABLE II. DISTRIBUTION AND PERCENTAGE ABUNDANCE OF NEMATODE GENERA IN *Drepanocladus*-DOMINATED VEGETATION AT SIX LOCALITIES IN THE MARITIME ANTARCTIC

Genus	Alamode Island. *D. uncinatus* with *Pohlia nutans* and *Cephaloziella* sp. Single sample, approx. 200 cm.², 1·5 cm. deep	Emperor Island. *D. uncinatus* with *Bryum algens*. Single sample, approx. 200 cm.², 1 cm. deep	Guébriant Islands. *D. uncinatus*. Single sample, approx. 50 cm.², 2·5 cm. deep	Avian Island. *D. uncinatus* with *Bryum algens*. Mean of 8, 4·2 cm. diameter cores, 6 cm. deep	Limpet Island. *D. uncinatus*. Mean of two samples, each 250 cm.², 2 cm. deep	Signy Island. *D. uncinatus*. Mean of 4, 4·2 cm. diameter cores, 6 cm. deep
Plectus	66·1	18·0	27·9	72·6	9·5	63·8
Eudorylaimus	15·2	2·9	3·3		84·2	7·9
Teratocephalus	4·9		20·8		0·1	15·6
Aphelenchoides	13·4		45·6	17·7	0·1	
Clarkus				9·7	5·5	2·0
Monhystera			1·1			} 4·5
Prismatolaimus						
Mesodorylaimus		79·0				
Rhabdolaimus	0·1					
Ditylenchus						1·9
Monhysterid genus "A"						1·9
Amphidelus						1·7
Tylenchus						0·6
Unidentified	0·3	0·1	1·3		0·6	0·1
Total numbers/m.² (×10⁶)	0·795	0·281	0·428	1·559	0·190	2·222

to increase the proportion of females in populations of *Aphelenchus avenae* Bastian, 1865 (Dao, 1970). Perhaps such a mechanism is important in the establishment of nematodes in cold regions.

Nematodes may be dispersed by air currents (Krnjaic and Krnjaic, 1970; Orr and Newton, 1971), insects (Lees, 1953) and birds (Epps, 1971). Because the main Antarctic wind belt is circum-polar, the first two modes of dispersal probably have less influence on the introduction of nematodes to the maritime Antarctic than do birds. The sheathbill is the only land bird in the maritime Antarctic. It is also found on the east coast of South America, the Falkland Islands and South Georgia (Jones, 1963). Experiments have shown that this bird is able to fly from the Falkland Islands and South Georgia to Signy Island, and it is supposed that intermittent north–south migrations take place between these islands, the southern part of South America and the northern part of the Antarctic Peninsula (Jones, 1963). Thus the sheathbill is a potential agent for nematode dispersal from the biologically diverse southern temperate region to the maritime Antarctic; the following observation suggests that this potential may be realized:

> Dried mud washed from the feet of four sheathbills, nesting in the vicinity of a penguin rookery at Signy Island, contained several live *Caenorhabditis* sp. as well as a single unidentified rhabditid; this rhabditid was not found in any of the soil samples collected over a 2 year period at Signy Island. Some species of nematode are able to withstand desiccation (Hyman, 1951; Wallace, 1963) and may therefore be successfully transported in dried mud adhering to the feet and plumage of birds; others are susceptible and thus have a limited dispersal potential. However, endotokia matricida, which has frequently been observed in *Caenorhabditis* sp. on Signy Island (unpublished observation of the author) and several other species of nematode (Lees, 1953; Teploukova, 1968; Ellenby,

TABLE III. METEOROLOGICAL DATA FOR FOUR LOCALITIES IN THE MARITIME ANTARCTIC

	*Temperature** (° C)				*Mean total sunshine*† (hr.)		
	Average of the highest monthly mean	*Average of the lowest monthly mean*	*Annual mean*	*Mean annual wind speed** (m./sec.)	"*Summer*" (October–March)	"*Winter*" (April–September)	*Year*
Signy Island 1947–64 (lat. 60° S.)	1·2	−11·7	−3·8	7·4	358·4	199·4	557·8
Deception Island 1947–64 (lat. 62° S.)	1·7	−9·1	−2·9	7·1	473·7	89·7	563·4
Argentine Islands 1947–64 (lat. 65° S.)	0·5	−13·8	−5·2	3·9	588·5	189·3	777·8
Horseshoe Island 1956–59 Adelaide Island 1963–64 (lat. 67° S.)	0·9	−19·0	−6·6	6·0	752·3	157·3	909·6

* From Pepper (1954) for the years 1947–50, from the *Falkland Islands Dependencies annual meteorological tables* for 1951–59 and from the *British Antarctic annual meteorological tables* for 1960–61. The data for the period 1962–64 are from unpublished *British Antarctic annual meteorological tables*.
† From Giles (1971). Includes sunshine data for the period 1945–66.

1969; Sohlenius, 1969), gives some protection to the juveniles against desiccation and therefore aids dispersal (Lees, 1953; Ellenby, 1969).

Judging by the contrasting nematode faunas in the same type of vegetation from different islands (Table II), dispersal barriers are partly responsible for determining the distribution of the nematodes within the maritime Antarctic. However, differences in the dominant genus within the same type of vegetation between islands suggests that local ecological factors are also important.

Five species of nematode have previously been reported from the maritime Antarctic, namely, *Plectus antarcticus*, *P. belgicae* de Man, 1904 (synonymized with *P. parvus* Bastian, 1865 by Maggenti (1961)), *Clarkus gerlachei* and two juveniles of *Dorylaimus* species (de Man, 1904). They were found in fresh-water algae at Beneden Head (formerly "Cape van Beneden", lat. 64°46′S., long. 62°42′W.) on the Antarctic Peninsula. From the results of the present study, it is clear that *P. antarcticus* and *C. gerlachei* are widespread in the maritime Antarctic. *P. antarcticus* also occurs in the continental Antarctic (Timm, 1971). Seven other species have been recorded from the continental Antarctic; five of these are endemic, namely, *P. frigophilus* Kiryanova, 1958, *P. globilabiatus* Kiryanova, 1958, *Eudorylaimus antarcticus* (Steiner, 1916), Yeates, 1970, *Scottnema lindsayi* Timm, 1971 and *Panagrolaimus davidi* Timm, 1971; the remaining two species, *P. parietinus* and *Monhystera villosa* Butschli, 1873 are cosmopolitan. In view of the above distribution pattern, it is rather surprising that *M. villosa* and especially *P. parvus* were not recorded from the localities examined in the present study.

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APPENDIX

List of Nematode Sample Sites in the Maritime Antarctic

(Details of the Signy Island sites are given in Spaull (1973*b*))

Locality	*Sample habitat*	*Date collected*	*Date processed*	*Collected by*
Alamode Island lat. 68°43′S., long. 67°32′W.	*Drepanocladus uncinatus* (Hedw.) Warnst. with *Pohlia nutans* (Hedw.) Lindb. and *Cephaloziella* sp. growing on near bare granite; water by seepage from snow field, *c.* 10 m. a.s.l., west facing slope	14.2.69	13.5.69	D. G. Bone
	Bryum algens Card. growing as above	14.2.69	14.5.69	D. G. Bone
	Cephaloziella sp. with *P. nutans* growing as above	14.2.69	15.5.69	D. G. Bone
	Cladonia metacorallifera Asah. and *Cephaloziella* sp. growing as above	14.2.69	13.6.69	D. G. Bone
Emperor Island lat. 67°52′S., long. 68°43′W.	*D. uncinatus* with *B. algens* growing on exposed fairly moist rock ledge, *c.* 30 m. a.s.l.	24.2.69	4.5.69	D. W. Brown
One of the Guébriant Islands lat. 67°48′S., long. 68°24′W.	*Brachythecium austro-salebrosum* (C. Muell.) Par. with *B. algens* and *D. uncinatus* growing in a basin-like area on a north-facing slope, *c.* 40 m. a.s.l.	18.2.69	25.5.69	D. W. Brown
	D. uncinatus growing in a channel on north-facing slope *c.* 7 m. a.s.l.	18.2.69	25.5.69	D. W. Brown
Avian Island lat. 67°46′S., long. 68°54′W.	*D. uncinatus* and *B. algens* growing on a well-drained north-east-facing slope, *c.* 20 m. a.s.l.	7.2.69	27.4.69	W. Taylor
Pourquoi Pas Island lat. 67°41′S., long. 67°30′W.	Soil below *Deschampsia antarctica* Desv. with *P. nutans* growing on a rocky north-west-facing slope.	21.2.70	17.6.70	S. P. Finigan
	P. nutans growing on north-west-facing slope, *c.* 7 m. a.s.l.	21.2.70	12.11.70	S. P. Finigan
Cone Island lat. 67°41′S., long. 69°10′W.	*D. uncinatus* growing on a south-west-facing slope, *c.* 20 m. a.s.l.	22.2.70	12.11.70	S. P. Finigan
Limpet Island lat. 67°38′S., long. 68°19′W.	*B. austro-salebrosum* growing on a well-drained south-east-facing rock terrace, *c.* 20 m. a.s.l.	18.2.69	29.4.69	D. W. Brown
	D. uncinatus growing as above	18.2.69	29.4.69	D. W. Brown
Blaiklock Island lat. 67°33′S., long. 67°00′W.	*Polytrichum alpinum* L. Ex. Hedw. with *P. nutans* and *Cephaloziella* sp. growing near a melt stream, *c.* 5 m. a.s.l.	20.2.69	30.6.69	D. W. Brown
	P. nutans with *D. uncinatus* growing on well-drained area *c.* 5 m. a.s.l.	20.2.69	30.6.69	D. W. Brown
Galindez Island lat. 65°15′S., long. 64°15′W.	*Chorisodontium aciphyllum* (Hook. f. et Wils.) Broth. growing on a well-drained, exposed, north-facing slope, *c.* 15 m. a.s.l.	10.3.69	27.5.69	D. W. Brown
	Polytrichum alpestre Hoppe, growing as above	10.3.69	1.6.69	D. W. Brown
	D. uncinatus with *P. nutans* growing in a slight hollow on a north-facing slope, *c.* 40 m. a.s.l.	10.3.69	13.6.69	D. W. Brown
	Brachythecium sp. growing in a wet hollow, *c.* 25 m. a.s.l.	21.1.70	23.6.70	S. P. Finigan
	Soil below *D. antarctica* growing on a dry rocky cliff top, *c.* 17 m. a.s.l. frequented by Dominican gulls (*Larus dominicanus* Lichstenstein) and skuas (*Catharacta skua lonnbergi* (Mathews))	21.1.70	22.6.70	S. P. Finigan
Intercurrence Island lat. 63°55′S., long. 61°24′W.	*B. austro-salebrosum* with *B. algens* and *D. uncinatus* from rocky north-facing slope, *c.* 7 m. a.s.l.	30.1.69	23.6.69	D. W. Brown
Astrolabe Island lat. 63°19′S., long. 58°42′W.	Ornithogenic soil, *c.* 20 m. below blue-eyed shags' (*Phalacrocorax atriceps* King) nests	Dec. 68	28.1.69	P. J. Rowe
Deception Island lat. 62°57′S., long. 60°38′W.	*D. uncinatus* growing on coarse volcanic ash at Collins Point	Dec. 68	28.1.69	N. J. Collins
	Polytrichum sp. growing as above	Dec. 68	28.9.69	N. J .Collins
Elephant Island lat. 61°10′S., long. 55°14′W.	*D. uncinatus* growing on a north-west-facing slope, *c.* 130 m. a.s.l. near Cape Belsham	4.3.71	7.6.71	E. C. Walshaw
	D. uncinatus, *c.* 130 m. a.s.l. near Walker Point	25.2.71	22.6.71	E. C. Walshaw
	Brachythecium sp., *c.* 130 m. a.s.l. near Walker Point	25.2.71	15.6.71	E. C. Walshaw
	Brachythecium sp. growing on east-facing slope, *c.* 10 m. a.s.l. near cape pigeon's (*Daption capensis* Linn.) nest, south of Endurance Glacier	13.3.71	13.7.71	E. C. Walshaw
	Polytrichum sp. growing on west-facing slope, *c.* 280 m. a.s.l. south of Endurance Glacier	23.3.71	3.6.71	E. C. Walshaw
	Polytrichum sp. growing on level ground, *c.* 260 m. a.s.l., south of Endurance Glacier	23.3.71	14.7.71	E. C. Walshaw
	C. aciphyllum and *Polytrichum* sp. growing on east-facing slope, *c.* 90 m. a.s.l. on southern wall of glacier, east-south-east of Mount Elder	18.3.71	12.7.71	E. C. Walshaw
	Soil below *D. antarctica* growing on north-facing slope, *c.* 40 m. a.s.l. on southern moraine of Endurance Glacier	13.3.71	8.6.71	E. C. Walshaw
	Soil below *D. antarctica* growing on east-facing slope, *c.* 100 m. a.s.l. on southern wall of glacier, east-south-east of Mount Elder	18.3.71	14.6.71	E. C. Walshaw
	Soil below *D. antarctica* from level ground, *c.* 130 m. a.s.l. on southern wall of glacier, east-south-east of Mount Elder	18.3.71	10.6.71	E. C. Walshaw
	Soil below *D. antarctica* from level ground, *c.* 80 m. a.s.l. at Stinker Point	21.3.71	2.6.71	E. C. Walshaw
Signy Island lat. 60°43′S., long. 45°38′W.	The sample sites have been briefly described by Spaull (1973*b*). The samples were collected by the author between February 1968 and February 1970. They were all processed within 48 hr.			
Coronation Island lat. 60°38′S., long. 45°35′W.	Soil below *D. antarctica* from west side of Cape Hansen	26.9.69	26.9.69	J. A. Edwards

Brackets group those sample sites for which the results have been combined in Table I.