MICROFUNGI ON SIGNY ISLAND, SOUTH ORKNEY ISLANDS

By G. J. F. PUGH* *and* D. ALLSOPP*

ABSTRACT. The distribution of cellulolytic, keratinophilic and other microfungi on Signy Island has been studied as a contribution to the investigations into decomposition in the Antarctic. The most frequently isolated fungi were sterile mycelia, *Mortierella* spp. and *Chrysosporium pannorum*. Sterile mycelia were widely distributed; *Mortierella spp.* were more often associated with plants and their remains. *C. pannorum* occurred on cellulosic and keratinaceous substrates and was most frequently isolated from soils with a strong animal influence, and also from sloughed-off seal skin and penguin feather debris.

Microbiological studies in the Antarctic have developed slowly during this century, often because samples collected by expeditions were not examined until many months later. More recently a trend has developed for work to be undertaken *in situ* in the Antarctic. The majority of these studies have been concerned with bacteria, although during the last 20 years or so there has been increased emphasis on investigating the occurrence and activities of fungi. A full account of the microbiological work that has been undertaken has been compiled by D. D. Wynn-Williams (in Block, in press).

The occurrence of members of the Ascomycotina and Basidiomycotina has been reported by Pegler and others (1980), who gave a short bibliography of the work on higher fungi from the Antarctic Peninsula region, maritime Antarctic islands, and South Georgia and listed the fungi recorded throughout this region. R. I. Lewis Smith (personal communication) has recorded many more taxa from this region. Members of the Deuteromycotina have been reported from time to time. Tubaki (1961) and Tubaki and Asano (1965) provided accounts of the species recorded following the Japanese Antarctic Expedition, 1957–9.

Mycological studies on Signy Island (South Orkney Islands) have been related mainly to research on decomposition in progress there. Bailey and Wynn-Williams (in press) mainly studied the bacteria of peat and soils, but also discussed the distribution of microfungi which were isolated from six sites on the island. Yeasts present in peat were studied by Wynn-Williams (1980) who found them abundantly in the early weeks following the thawing of the overwinter snow cover. The presence of *Thyronectria hyperantarctica* (described as *T. antarctica* var. *hyperantarctica*) was reported by Longton (1973). This ascomycete causes radial infections giving rise to concentric rings on mosses; other ascomycetes cause similar infection patterns on moss banks (Fenton, in press).

The present study was undertaken in January–March 1980 as a preliminary examination of the distribution of microfungi on Signy Island, and particularly those which are associated with the decomposition of such recalcitrant organic residues as cellulose and keratin.

Cellulose is a major component of plant remains, so the distribution of the fungi that can decompose it was investigated mainly by using cellulose agar (Eggins and Pugh, 1962) as part of the overall study of decomposition processs. Any fungus which can clear the opaque medium is presumed to possess the potential to decompose cellulose in nature. However, non-cellulolytic fungi can also be isolated on this medium when they grow on the agar but do not clear it.

* Department of Biological Sciences, University of Aston, Birmingham B4 7ET, UK.

Br. Antarct. Surv. Bull. No. 57, 1982, pp. 55–67

The other recalcitrant substrate investigated was keratin, mainly in the form of feathers, seal skin and hair. Many thousands of penguins and other seabirds breed on the island. About 1 000 elephant seals and 3 000 fur seals come ashore. While the penguins are concentrated in their rookeries, and the seals congregate in fairly discrete areas, many of these animals roam inland up to about 700 m from the shore and occasionally to altitudes over 100 m. The total quantity of feathers, skin and hair shed by the penguins and seals represents a considerable but unquantified input of nutrients onto the island. The decomposition of this material is of interest because the keratinophilic fungi are related to the dermatophytes (ringworm fungi) which can cause lesions on man and other animals.

Materials and Methods

Samples were collected from a variety of habitats and substrates on Signy Island (Table I), and experiments were undertaken at the research station there between January and March 1980. Individual samples, obtained in the field using previously sterilized instruments, were placed in sterile polythene bags for transport to the laboratory.

1. Herb samples

Only two species of vascular plants, *Colobanthus quitensis* and *Deschampsia antarctica,* occur on Signy Island. Living leaves, litter and roots of *Colobanthus,* and soil adjacent to its roots, and living leaves and leaf litter of *Deschampsia* were sampled. As a contribution to a detailed survey of decomposition processes on Signy Island, plant fragments were plated on the surface of cellulose agar (CA), which had been prepared at Aston University beforehand using ball-milled chromatographic cellulose powder, as described by Eggins and Pugh (1962). Other fragments were plated on to malt agar (MA) which was used as a general isolation medium. This was prepared on Signy Island using distilled water. Antibiotics were not added to either medium. For both species, portions of the individual living leaves, approximately 2 mm in length, were cut across the mid-region of the leaf, being prepared in sterile Petri dishes. The numbers of plant portions and soil crumb samples plated on each of the two isolation media are given in Table II.

2. Moss samples

Cores 7.5 cm in diameter and 10 cm deep were removed from a pure *Calliergon sarmentosum* carpet. No special precautions were taken to ensure sterile collection in the field, but the cores were opened in a vertical plane using aseptic techniques in the laboratory to obtain sterile subsamples. A smaller core, 2.5 by 5 cm, was also taken from *Polytrichum alpestre* turf and from a *Calliergon sarmentosum* carpet at the two Signy Island reference sites (SIRS 1 and SIRS 2, respectively) where long-term ecosystem studies have been undertaken (Tilbrook, 1973). These two cores were used for a comparative study relating to the SIRS programme. The total number of plates used for each sample is given in Table III.

3. Soil samples

Cores were collected using a trowel. Again, no special precautions were taken to ensure sterile collection in the field, as the cores were subsampled using aseptic techniques in the laboratory. Soil crumb plates, using CA and MA, were made with all soils sampled. The total number of plates used for each sample is given in Tables IV and V.

Table I. Details of substrates, sites and material sampled for isolation of fungi.

Substrate	*Site and grid references**	*Material sampled*	*pH of soil beneath samples†*
Herbs			
Colobanthus quitensis	Factory Bluffs: GR 1039 .0451	Living green leaves	—
		Roots and litter	—
		Rhizosphere soil	6.0
Deschampsia antarctica	Factory Bluffs: GR 1039.0451	Living green leaves	—
		Leaf litter	4.9
Mosses			
Calliergon sarmentosum	Hillier Moss (between SIRS 1 and 2): GR 1037 .0433	Living green leaves	—
		Dead brown leaves (= litter)	—
Calliergon sarmentosum	Hillier Moss (SIRS 2): GR 1036 .0431	Living green leaves	4.7
Polytrichum alpestre	To north of Hillier Moss (SIRS 1): GR 1038 .0434	Living green leaves	4.0
Soils			
With little or no seal influence	Elephant Flats: GR 1030 .0457	Surface soil	—
	Elephant Flats: GR 1029 .0456	Surface soil, associated with marble outcrop	8.0
	South side of Cemetery Bay: GR 1035.0455	Soil beneath green foliose alga *Prasiola crispa*	—
	South side of Cemetery Bay: GR 1033.0452	Mud at high water mark	6.8
With strong seal or penguin influence	Elephant Flats: GR 1031 .0457	Mud in elephant seal wallow	8.2
	South side of Factory Cove: GR 1039 .0452	Mineral soil and excrement in elephant seal wallow	8.2
	South side of Factory Cove: GR 1039 .0452	Moss peat soil adjacent to above seal wallow	4.4
	Gourlay Peninsula: GR 1044 .0431	Guano–feather matrix from mixed Adélie–chinstrap penguin rookery	5.9
	North Point: GR 1023 .0492	Guano–feather matrix from mixed Adélie–chinstrap penguin rookery	—

* Grid reference number refer to D.O.S. 210, edn. 2 map of Signy Island, 1975.
† pH was determined on 1 : 1 mixtures of sample and distilled water, using a glass electrode meter.

Table II. Fungi isolated from vascular plants on Signy Island.

	Number of culture plates with fungus												
	Colobanthus quitensis								*Deschampsia antarctica*				
	Leaves		*Litter*		*Roots*		*Soil*	*Total isolates*	*Leaves*		*Litter*		*Total isolates*
Fungal taxa isolated	*CA*	*MA*	*CA*	*MA*	*CA*	*MA*	*MA*		*CA*	*MA*	*CA*	*MA*	
Cephalosporium sp.	—	—	—	2	—	—	—	2	—	—	—	—	0
Chaetomium sp.	—	—	—	—	4	—	—	4	—	—	—	—	0
Chrysosporium pannorum	10	—	10	—	30	—	—	50	—	—	—	4	4
Chrysosporium sp.	—	—	—	—	—	—	—	0	—	1	—	—	1
Cladosporium cladosporioides	—	—	—	5	—	—	—	5	—	6	—	1	7
Mortierella spp.	—	18	—	16	—	30	8	72	—	3	24	15	42
Penicillium spp.	—	—	—	—	—	8	20	28	—	—	—	4	4
Rhizopus sp.	—	—	—	—	—	—	—	0	—	—	—	2	2
Verticillium sp.	—	—	—	—	—	4	—	4	—	—	—	—	0
Pycnidial species	—	—	—	—	—	4	—	4	2	—	21	—	23
Sterile mycelium	20	15	—	16	—	4	4	59	18	35	7	12	72
Total no. of plates with plant fragments/soil crumbs	30	30	30	30	30	30	20	228	40	40	40	40	155

CA, Cellulose agar; MA, malt agar. —, not detected.
All growth on CA was recorded, whether clearing the medium or not.

Table III. Fungi isolated from mosses on Signy Island.

Fungal taxa isolated	*Number of culture plates with fungus*								*Total no. of isolates*
	Polytrichum alpestre (SIRS 1)		*Calliergon sarmentosum (SIRS 2)*		*Calliergon sarmentosum (Between SIRS 1 and 2)*				
	Live green leaves		*Live green leaves*		*Live green leaves*		*Dead brown leaves*		
	CA	*MA*	*CA*	*MA*	*CA*	*MA*	*CA*	*MA*	
Mortierella spp.	5	1	4	3	6	4	—	17	40
Mucor sp.	4	2	—	—	—	—	—	—	6
Penicillium waksmanii	—	—	—	—	—	—	1	3	4
Sterile mycelium	—	3	—	3	—	—	17	—	23
Total no. of plates with plant fragments	5	5	5	5	40	40	40	40	73

CA, cellulose agar; MA, malt agar; —, not detected.
All growth on CA was recorded, whether clearing the medium or not.

As incubator space was limited, samples were normally kept at room temperature (12 ± 3°C), although some samples were incubated at a constant 5, 10 and 45°C. All plates were examined daily to avoid overgrowth of one fungal colony by another. Fungi were subcultured from the isolation plates on to MA in Universal bottles and stored at 5°C at the research station and subsequently at 2°C during the 5-week sea voyage to UK. Unfortunately, a relatively small number of cultures did not survive storage and shipment; many of these were heavily overgrown with bacteria. The surviving cultures have been identified where possible but several taxa have failed to sporulate on selective media after a year and their identification must remain as 'sterile mycelia'.

4. Miscellaneous samples

(a) Seal skin. Portions of skin were collected directly from the backs of moulting elephant seals. Fragments were incubated on MA and in damp chambers for three weeks.

(b) Skua pellets. Ten pellets were collected at random at Elephant Flats, Gourlay Peninsula and North Point. They were teased apart and feather portions cultured on five plates each of CA and MA. The remainder of each pellet was separately incubated in a moist chamber for three weeks.

(c) Birds' nest material. Feathers from the nests of dove prions and sheathbills, and unidentifiable debris (pH 8.3) and seaweed fragments from blue-eyed shag nests were each cultured on five plates of MA.

(d) Seaweeds. The cosmopolitan littoral fungus *Dendryphiella salina* has been reported from several east Antarctic localities (Tubaki and Asano, 1965). In an attempt to isolate this and other species from western Antarctica, six unidentified species of marine algae were collected on the shore of Factory Cove and several other seaweed taxa were collected at King Edward Cove, South Georgia. Five replicate fragments of each were incubated on plates of CA. Portions of *Macrocystis pyrifera* were also collected on the shore at Port Stanley, Falkland Islands and ten fragments were incubated.

Table IV. Fungi isolated from soils with little or no biotic influence.

	Number of culture plates with fungus				
	Elephant Flats		*Cemetery Bay*		
Fungal taxa isolated	*Non-seal area*	*Associated with marble outcrop*	*Beneath Prasiola crispa*	*High-water mark mud*	*Total no. of isolates*
Chrysosporium pannorum	—	2	—	4	6
Cladosporium cladosporioides	—	—	4	—	4
Gliocladium roseum	5	2	—	—	7
Mortierella spp.	—	3	—	—	3
Pycnidial species	—	1	—	—	1
Sterile mycelium	10	5	5	3	23
Total no. of plates with soil crumbs	5 CA + 5 MA	5 CA	5 MA	5 MA	44

—, not detected.

Table V. Fungi isolated from soils with strong biotic influence.

	Number of culture plates with fungus					
	Elephant-seal wallow mud		*Peaty soil near seal wallow*	*Penguin guano–feather matrix*		
Fungal taxa isolated	*Elephant Flats*	*Factory Cove*	*Factory Cove*	*Gourlay Peninsula*	*North Point*	*Total no. of isolates*
Chrysosporium pannorum	20	2	5	—	2	29
Mortierella spp.	—	—	4	—	—	4
Mucor sp.	—	—	—	3	—	3
Penicillium sp.	—	—	—	—	5	5
Phoma sp.	3	—	—	—	—	3
Trichophyton terrestre	—	5	3	—	—	8
Wardomyces sp.	—	4	—	—	—	4
Sterile mycelium	8	2	—	5	—	15
Total no. of plates with soil crumbs	10 CA + 10 MA	5 CA + 5 MA	5 CA + 5 MA	5 CA + 5 MA	5 CA + 5 MA	71

—, not detected.

5. Keratinaceous samples

Clean feathers removed from newly dead Adélie penguin chicks, blue-eyed shags, pintado petrels, dove prions and sheathbills were used as baits, and placed on soils which were known to contain keratinophilic fungi. This was to obtain an indication of differential colonization which might suggest a possible inhibitory or stimulatory effect of the feather surface fats and oils (preening gland oils) on the fungi. Feathers from the same bird species were also inoculated with the keratinophilic fungus *Chrysosporium pannorum*. Penguin feathers, which were found in wind-blown aggregations, were incubated in moist chambers.

6. Air spora

Plates of MA were exposed to the atmosphere for 5 h during one day in January on the jetty in Factory Cove. Two plates were also exposed in the lounge and two in the microbiology laboratory in the research station, also for 5 h during the day.

Results

There were no differences in the fungal taxa isolated at each of the lower temperatures between 5 and 12°C, and the results obtained have been amalgamated. However, the fungi did appear and grow somewhat more quickly in the room temperature (12°C) incubations. No fungi were obtained after incubation at 45°C suggesting an absence of thermophilic taxa, although bacteria were abundant on plates which had been inoculated with samples collected from penguin rookeries and shag nests.

Herb, moss and soil samples

The fungi that were associated with the leaves and litter of *Deschampsia,* and the leaves, litter, roots and rhizosphere soil of *Colobanthus* are given in Table II. The most frequently isolated fungi were sterile mycelia, with *Mortierella* spp. the next in abundance. Pycnidial fungi were quite common in *Deschampsia* litter and probably represented several species, but they did not develop to a recognizable state. There were 228 isolates from 200 *Colobanthus* portions, and 155 isolates from 160 *Deschampsia* portions.

The green leaves, brown litter from 1 to 2 cm deep, and cores taken from moss samples in the SIRS (Table III) yielded fewer fungi than were found associated with the higher plants, with 73 isolates from 180 portions. *Mortierella* spp. and sterile mycelia were predominant.

Fungi isolated from the mainly mineral soils away from the animal colonies are listed in Table IV. Again sterile mycelia were most often encountered. The influence of seals and penguins on the soil fungi can be seen in Table V, where *Chrysosporium pannorum,* a keratinophilic fungus, was the most frequently isolated species, being particularly associated with the elephant seal wallows and their other resting areas. *Trichophyton terrestre,* which is another keratinophilic species, was also found in the two sampling areas near the Station. Since the number of isolations on CA and MA were frequently low and showed no significant difference between media, data for both CA and MA have been combined in Tables IV and V.

Miscellaneous samples

(a) Seal skin. Material incubated on MA yielded *Chrysosporium pannorum* and sterile mycelia. After three weeks' incubation of the skin samples in damp chambers, *C. pannorum* was abundant and there was a single occurrence of *Trichophyton* sp. (with macrocondia measuring 45 by 6 μm).

(b) Skua pellets. Three isolates each of *C. pannorum* and *Mortierella* spp. and four of sterile mycelia were cultured from the total of ten Petri dishes used. Material cultured in damp chambers yielded no fungi.

(c) Birds' nest material. The fungi isolated are listed in Table VI, with a subjective indication of their abundance.

(d) Seaweeds. After incubation on CA, only one alga, a dulse-like red species, yielded *C. pannorum.* All ten portions of *Macrocystis pyrifera* from the Falkland Islands yielded *Dendryphiella salina,* although it was not isolated from any of the algae sampled at South Georgia or at Signy Island.

Keratinaceous samples

Trichophyton terrestre grew on all feathers from pintado petrels, dove prions and blue-eyed shags, on 75% of the penguin chick down, and on 50% of the sheathbill feathers. *Chrysosporium pannorum* growth was recorded on all feather samples inoculated with that species. *C. pannorum* was frequently present, and *Chrysosporium* sp. (*C.* cf. *asperatum*) was occasionally present on penguin feathers incubated in moist chambers.

Air spora

Very few fungi were obtained by exposing plates of MA to the atmosphere outside the research station, the only records being four colonies of *Alternaria alternata,* one of *Phoma* sp. and one sterile mycelium. The four plates of MA exposed in the station yielded one colony of *Aspergillus niger,* six of *Penicillium* sp. and one sterile mycelium.

Discussion

The isolation of microfungi in the major collections in January–March 1980, listed in Tables II–V, showed the frequent detection of only a few fungal categories. These are summarized in Table VII, which indicates that sterile mycelia were the most commonly isolated group. These isolates were not uniform, and they probably contained representatives of several species. This heterogeneous group of isolates was abundant in all habitats, but represented a smaller proportion of the total isolations in soils with an animal influence than in the other areas.

Mortierella spp. were next in order of abundance and comprised at least two, possibly three species. The common isolate from the more acidic higher plant and

Table VI. Fungi isolated from material in birds' nests.

Fungal taxa isolated	*Dove prion*	*Sheathbill*	*Blue-eyed shag*	
	Feathers	*Feathers*	*Unidentified debris*	*Seaweed fragments*
Chrysosporium pannorum	—	Abundant	—	—
Chrysosporium sp.	Abundant	—	—	Occasional
Mortierella sp.	Frequent	Frequent	—	—
Penicillium spp.	—	—	Occasional	Frequent
Rhizopus sp.	—	Frequent	—	—
Sterile mycelium	—	—	Occasional	—

Inoculations of each category were made on five plates of MA.
—, not detected.

Table VII. Summary of frequency of occurrence of microfungi isolated from different habitats on Signy Island.

Fungal taxa isolated	*Herbs*				*Mosses*		*Soils*				*Total no. of isolates*	
	Colobanthus quitensis		*Deschampsia antarctica*				*With little or no biotic influence*		*With strong biotic influence*			
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Chrysosporium pannorum	50	22	4	3	0	0	6	14	31	43	91	16
Mortierella spp.*	72	32	42	27	40	55	3	7	4	6	161	28
Penicillium spp.*	28	12	4	3	4	5	0	0	5	7	41	7
Pycnidial species	4	2	23	15	0	0	1	2	3	4	31	5
Sterile mycelium	59	26	72	46	23	32	23	52	15	21	192	34
Other fungi	15	6	10	6	6	8	11	25	14	19	56	10
Total no. of isolates	228		115		73		44		72		572	

* Two to three species.

moss sites resembled *M. bainieri* in having cymosely branched sporangiophores, and oval spores 10×5 μm in size. The isolate from the marble outcrops at Mirounga Flats was in the Isabellina Section and resembled *M. turficola*. It had cymosely branched sporangiophores and small globose spores, about 2 μm in diameter. *M. turficola*, in the same Section, has previously been isolated from alkaline soils in the same area (Bailey and Wynn-Williams, in press). *Mortierella* spp. were least frequently isolated from soils, but formed much larger proportions of the total isolates from plant material, and particularly from moss leaves and litter.

Chrysosporium pannorum, which accounted for 16% of the total number of fungal isolates, was the most abundant species identified. In northern polar regions it has been recorded in the Canadian Arctic by Ivarson (1973) and in Alaska by Flanagan and Scarborough (1974). In the Antarctic it was collected at McMurdo Station and Cape Evans by the Japanese Antarctic Expedition, 1955–7 (see Carmichael, 1962, p. 1164; Tubaki and Asano, 1965), and has not infrequently been reported by other microbiologists under one of its many synonyms. Thus it has been recorded, for example, as *Geomyces pannorus* by Kerry (1979), and as *G. cretaceus* and *G. vulgare* by Bailey and Wynn-Williams (in press). This species grows well at low temperatures, and has been found on meat in cold storage at −6°C, as well as on frozen foods (see Carmichael, 1962). In temperate climates Kuthubutheen and Pugh (1979) isolated it from soil and litter most frequently in the winter months. The optimal temperature for radial growth was 18°C. They reported it as having moderate cellulolytic activity over a range of temperatures from 5 to 28°C. This was in general agreement with Flanagan and Scarborough (1974) who found that it was able to decompose cellulose at temperatures between 2 and 5°C as well as at room temperature. In the present study, it was more frequently isolated on CA than on MA and its cellulolytic ability was evident by the clear zone underneath each colony.

In addition to being able to grow on cellulose, *Chrysosporium pannorum* has also been found on keratinous substrates such as feathers (Pugh, 1965). Its distribution in the Antarctic habitats studied (Table VII) shows that it was most frequently obtained from soils with a strong animal influence, where it represented about 40% of the total isolates. In soils without a marked animal influence it represented only 14% of the total. On the higher plants it was most often isolated from the roots of *Colobanthus*, and it also occurred on the litter of both *Colobanthus* and *Deschampsia*. as well as on the green leaves of the former species. It was not isolated from the leaves, litter or core material of the mosses which were studied. Previously it has been isolated from litter (Ivarson, 1973) and green grass leaves (Kuthubutheen and Pugh, 1979).

The results which were obtained from miscellaneous collections confirm the relative abundance and prevalence of the three main fungal groups. The versatile *C. pannorum* grew on keratinaceous substrates, and was particularly common in elephant seal wallow mud, and on both moulted skin and skin picked off the backs of the seals prior to its being shed. Feathers which had accumulated in hollows on the ground were colonized by *Chrysosporium* spp. which were also present on feather debris and on seaweed fragments in birds' nests. Other keratinophilic fungi included *Chrysosporium* sp. (cf. *C. asperatum*), *Trichophyton terrestre* and an unidentified species of *Trichophyton*. Although these species were usually associated with elephant seals, they also occurred on feathers. However, they were rarely isolated from the soil in the penguin rookeries on Gourlay Peninsula and at North Point. These soils were essentially trampled guano and feathers, and yielded abundant bacteria, but few fungi.

As it was shown by Pugh and Evans (1970) that bird preening oils can adversely affect the growth of several keratinophilic fungi, freshly collected feathers from five

bird species were used as baits. There were some differences in the degree of colonization by *T. terreste,* which may indicate some inhibitory effect by sheathbill feathers. Feathers from the same birds were inoculated with *C. pannorum,* which was able to grow on all the feathers tested. These two fungal species, therefore, are not markedly inhibited by the preening oils present on the feathers. Interestingly, *Chrysosporium* sp. and *T. terrestre* were the least affected fungi used by Pugh and Evans (1970). Their non-isolation from the rookery soils may be caused by the guano or by competition from bacteria or by other environmental factors. This aspect needs further study.

Dendryphiella salina was isolated from the seaweed *Macrocystis pyrifera* collected in the Falkland Islands. It has previously been reported from several localities in the Antarctic by Tubaki and Asano (1965) who obtained it from soil samples collected at Syowa Station, soil and algae from East and West Ongul Island, algae at Cape Evans and soil and moss near McMurdo Station. It was not isolated during the present study from the small number of shore-line collections of other seaweed taxa which were made on Signy Island and on South Georgia.

In a consideration of the life strategies of fungi, Pugh (1980) distinguished betwe four categories of behaviour, based on the presence or absence of stress and of disturbance (Grime, 1979); in low stress–high disturbance situations, ruderal organisms predominate with essentially an r-strategy (i.e. a short life cycle and heavy sporulation). Organisms in this category include the 'sugar fungi' (Burges, 1939) such as members of the Mucorales and yeasts (very active in freeze–thaw cycled peat at Signy; Wynn-Williams, 1982), which are able to exploit rapidly any available simple soluble carbohydrates. In the high stress–high disturbance situations, Grime (1979) found no higher plants. Pugh (1980), however, placed two groups of fungi in this category, the *Survivors* which were characterized by *Chrysosporium pannorum* and sterile mycelia, and *Escapers* such as *Dendryphiella salina.*

The presence of *C. pannorum* and sterile mycelia as predominant fungi in the Antarctic might have been predicted from Pugh's analysis of fungal strategies. The prolific occurrence of *Mortierella* spp. and yeasts (Wynn-Williams 1980), however, would not have been predicted, as these are typical members of the ruderal group, in which there is a fast growth rate and high sporulation. It is postulated that the species of *Mortierella* are able to flourish in these inhospitable regions because of the nutrients which are made available by the breakdown of plant cells during freeze–thaw cycles, and possibly during normal plant exudation. This would be consistent with their greater abundance in association with plants than elsewhere. Wynn–Williams (1980, 1982) has suggested that the yeasts flourish soon after the thaw f similar reasons. The nutrition and biology of the yeasts and of *Mortierella* sp certainly warrant further study, as their presence seems anomalous.

Acknowledgements

We thank the Director, British Antarctic Survey, for allowing us the opportunity to visit and work on Signy Island: Drs R. I. Lewis Smith, D. W. H. Walton and D. D. Wynn-Williams for their help at Cambridge, and to Mr D. Rootes and Station personnel for their many kindnesses on Signy Island. We gratefully acknowledge financial assistance from the Royal Society, the Trans-Antarctic Association, and the University of Aston in Birmingham.

MS received 26 April 1982; accepted in revised form 21 June 1982

References

Bailey, A. D. *and* Wynn-Williams, D. D. In press. Soil microbiological studies at Signey Island, South Orkney Islands. *British Antarctic Survey Bulletin,* No. 51.

Block, W. In press. Terrestrial microbiology, invertebrates and ecosystems. (*In* Laws, R. M., *ed. Ecology of the Antarctic, 1.* London, Academic Press.)

Burges, A. 1939. Soil fungi and root infection. *Broteria,* **8,** 64–81.

Carmichael, J. W. 1962. *Chrysosporium* and some other aleuriosporic hyphomycetes. *Canadian Journal of Botany,* **40,** 1137–73.

Eggins, H. O. W. *and* Pugh, G. J. F. 1962. Isolation of cellulose-decomposing fungi from the soil. *Nature, London,* **193,** No. 4810, 94–5.

Fenton, J. H. C. In press. Fungal infection patterns in Antarctic moss communities. *Transactions of the British Mycological Society.*

Flanagan, P. W. *and* Scarborough, A. M. 1974. Physiological groups of decomposer fungi on tundra plant remains. (*In* Holding, A. J., Heal, O. W., Maclean, S. F. *and* Flanagan, P. W., *eds. Soil organisms and decomposition in Tundra.* Stockholm, Tundra Biome Steering Committee, 125–50).

Grime, J. P. 1979. *Plant strategies and vegetation processes.* Chichester, J. Wiley.

Ivarson, K. C. 1973. Fungal flora and rate of decomposition of leaf litter at low temperatures. *Canadian Journal of Soil Science,* **53,** 79–84.

Kerry, E. 1979. Microbiological studies of soils from Sabrina Island, Antarctic. (*In* Lewis, D. *Voyage to the ice.* The *Antarctic expedition of Solo.* London, Wm. Collins, 112–14.)

Kuthubutheen, A. J. *and* Pugh, G. J. F. 1979. Effects of temperature and fungicides on *Chrysosporium pannorum* (Link) Hughes. *Antonie van Leeuwenhoek,* **45,** 65–79.

Longton, R. E. 1973. The occurrence of radial infection patterns in colonies of polar bryophytes. *British Antarctic Survey Bulletin,* No. 32, 41–9.

Pegler, D. N., Spooner, B. M. *and* Smith, R. I. Lewis. 1980. Higher fungi of Antarctica, the sub-Antarctic Zone and Falkland Islands. *Kew Bulletin,* **35,** 499–562.

Pugh, G. J. F. 1965. Cellulolytic and keratinophilic fungi recorded on birds. *Sabouraudia,* **4,** No. 2, 85–91.

Pugh, G. J. F. 1980. Strategies in fungal ecology. *Transactions of the British Mycological Society,* **75,** No. 1, 1–14.

Pugh, G. J. F. *and* Evans, M. D. 1970. Keratinophilic fungi associated with birds. II. Physiological studies. *Transactions of the British Mycological Society,* **54,** No. 2, 241–50.

Tilbrook, P. J. 1973. The Signy Island terrestrial reference sites: An introduction. *British Antarctic Survey Bulletin,* Nos 33 and 34, 65–76.

Tubaki, K. 1961. On some fungi isolated from the Antarctic materials. *Publication of the Seto Marine Biology Laboratory,* **14,** 3–9.

Tubaki, K. *and* Asano, 1965. Additional species of fungi isolated from the Antarctic materials. JARE 1956–62. *Scientific Report,* Ser. E, **27,** 16 pp.

Wynn-Williams, D. D. 1980. Seasonal fluctuations in microbial activity in Antarctic moss peat. *Biological Journal of the Linnean Society,* **14,** 11–28.

Wynn-Williams, D. D. 1982. Simulation of seasonal fluctuations in microbial activity of Antarctic moss peat. *Soil Biology and Biochemistry,* **14,** 1–12.