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ECOLOGICAL IMPACT OF PHYTOPATHOGENIC FUNGI IN ANTARCTIC TERRESTRIAL FLORA

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ABSTRACT

Moss vegetation plays an important role as a producer in the early stages of primary succession in Antarctica. Some fungi actively attack mosses growing in Antarctica. We observed the ecological impact of phytopathogenic fungi near Great Wall Station on King George Island. Many fungal infections were seen in moss colonies *(Sanionia uncinata)*, and pathogenic fungi formed moribund leaf patches in the moss carpet. Higher plants, other mosses and algae had invaded those moribund moss patches. These finding suggest that phytopathogenic fungi change the ecological balance in Antarctic terrestrial ecosystems.

KEY WORDS: pathogenic fungi - *Pythium* - moss

INTRODUCTION

Moss vegetation plays an important role in primary succession in polar regions (Miles and Walton, 1993). On the other hand, microorganisms, especially fungi, in polar regions, are well known as decomposers of mosses and higher plants. (Robinson, Wookey, 1997). Fungi have been reported to actively attack mosses growing on islands in Arctic including Jan Mayen in the Greenland Sea (Wilson, 1951), Ellesmere Island in northern Canada (Longton, 1973), Svalbard in Barents (Ridley et al., 1979; Hoshino et al., 1999), and in Antarctica, from Candlemas Island, South Sandwich Islands, in the north to Avian Island, Marguerite Bay, in the south (Longton, 1967) and Cape Bird, Victoria Land (Greenfield, 1983).The most detailed observation was carried out on Signy Island, South Orkney Islands (Fenton, 1983; Longton, 1973).

In Arctic, Wilson (1951) studied infections of *Rhacomitrium* carpet on Jan Mayen Island and reported that the moss disease was caused by an unidentified basidomycete. *Pythium ultimum* var. *ultimum* (Hoshino et al., 1999) and *Pythium* sp. (Tojo et al., unpublished results) cause parasitic disease in *Sanionia uncinata* in Svalbard. On the other hand, *Thyronectria antarctica* var. *hyperantarctica*, an undetermined plectomycete (Hawksworth, 1973; Longton, 1985), *Coleroa turfosorum, Bryosphaeria megaspora, Epibryon chorisodontii* (Fenton, 1983) and *Rhyzopus sp.* (Greenfield, 1983), which may cause parasitic disease in mosses, were isolated from various regions of the Antarctic Zone.

Therefore, fungi also play an important ecological role in polar regions, since some fungi may cause not only disintegration of dead moss leaves but also infection in moss colonies during the decomposition process and pathogenic fungi kill living mosses in polar regions. However, there have been very few ecological studies on moss pathogenic fungi in the Arctic and Antarctic regions.

One of authors was a member of 14th Chinese National Antarctic Expedition (CHINARE 14) and observed moss pathogenic fungi near Great Wall Station (62°13'S, 58°58'W, study shown in Fig. 1), King George Island; Molodezhnaya Station (64°40'S, 45°51'W, a Russian station), Alasheyev Blight, Enderby Land; and Zhongshan Station (69°22S, 76°23'E), Larsemann Hills, Princess Elizabeth Land during 1997-1998 austral summer. In this study, we aimed to elucidate the ecological characteristics of moss pathogenic fungi in Antarctica.

CONCLUSIONS

Fungal infection pattern

The moss carpets of *Sanionia uncinata* (Hedw.) Loeske [= *Drepanocladus uncinata* (Hedw.) Warnst.] were spread over wet or submerged areas near Great Wall Station (Chen et al., 1993). Many moribund moss colonies were found in the moss carpets of *Sanionia uncinata* after the snow bed had melted (Figs. 1, 2). In our observations, many fungal infections in moss were found in moss vegetation near the seashore in the research area. However, we could not find any obvious disease in moss along the coasts of Svalbard (Hoshino et al., 1999). Fungal infections were seen in circular patterns or irregular patches (Fig. 2). *Mycelia* on moss shoots were visible to the naked eye immediately after thawing (Fig. 2 B). Fenton (1983) reported a large number of concentric bands (outer bands indicating fungal infection and inner indicating recovery of moss) in *Chorisodontium aciphyllum* from Signy Island, South Orkney Islands. He reported that there were many concentric fungal rings in Antarctic mosses, one of which reached 5 m in diameter. However, we observed a very large number of small irregular patches and circular patterns of fungal infections of *Sanionia uncinata* on King George Island. Longton (1973) previously reported fungal rings in *S. uncinata* at Factory Cove, Signy Island, and he found occasional pairs of concentric rings in *S. uncinata*. However, we found only a few concentric rings in moss near King Sejong Station (Rep. Korea) in Bartone Peninsula, King George Island.

Moss pathogenic fungi has been isolated from continental Antarctica (Greenfield, 1993). However, we could not find any fungal infections and we were not able to isolate pathogenic fungi from moss colonies near Molodezhnaya Station, Alasheyev Blight, Enderby Land or Zhongshan station, Larsemann Hills, Princess Elizabeth Land.

Mycological characteristics of pathogenic fungi

Figure 3 shows microscopic images of a moribund leaf of *S. uncinata*. *Mycelia* grew well on the moss leaf and were intertwisted at the growth point of the moss (Fig. 3 A, B). We obtained many fungal isolates from moribund moss leaves. However, the morphological characteristics of the mycelia were the same. Hyphae of the isolate did not have clamp connections and produced only hyphal swellings in Difuco Corn meal agar plates (all of them were lacking in oogonia production, in Fig. 3 C). Morphological comparisons between these characteristics and reference data from van der Plaats-Niterink (1981) indicate that the isolate was *Pythium sp.* HS group. Previously, only two species of *Pythium* were isolated in

Antarctica. *P. tenue* Gobi was isolated from McMurdo Oasis on Ross Island and the Victoria Valley in Victoria Land (Knox & Paterson, 1973). *Pythium sp.* has been isolated from moss and plant samples obtained from Laurie Island (South Orkney Islands), King George Island (Harder & Persiel, 1962), Cape Bird (Knox & Paterson, 1973) and the shoreline of the dry valleys of Victoria Land, Antarctic Continent (Vincent, 1988). Fungi previously isolated from moss and plant samples collected near Great Wall Station were reported by Xiao et al. (1994). However, *Pythium* HS group has not been isolated from samples collected on Fildes Peninsula.

Pythium HS group isolated from plants collected in Temperate Zone countries, has been shown to be parasite with strong pathogenic activity in many cultured plants (van der Plaats-Niterink, 1981), but there have been no reports of this fungus having pathogenic activity in mosses. However, those isolates killed *S. uncinata* moss shoot that had been artificially inoculated (Hoshino et al., unpublished results). There has been no farming on King George island, and moss is one of the dominant species of vegetation. Therefore, this Antarctic isolate probably has a wide range of host: to protect itself against the environmental conditions of an Antarctic oasis.

The morphological characteristics of the Antarctic isolate corresponded to those of Temperate isolates. However, the Antarctic isolate showed a different response to temperature (Fig. 4). This isolate grew at 0°C but the Temperate isolates did not grow at 0°C (same conditions as those under a snow cover). On the other hand, the mycelial growth rate of this isolate, compared with that of isolates from the Temperate Zone, was very low at temperatures above 15°C. However, the optimal growth temperature of this isolate did not differ from that of isolates from Temperate Zone countries. These results suggest that the Arctic isolate originally developed from Temperate Zone isolates and adapted to growth under Arctic conditions.

Ecological role of pathogenic fungi

Figure 5 shows our hypothesis concerning the development of moribund moss colonies and the ecological role of phytopathogenic fungi in Antarctica. Pathogenic fungi inverted in a moss carpet and formed patches after several years. Host moss shoots were destroyed in the center part of fungal infections. Higher plants (*Deschampsia antarctica*), other mosses (such as *Polytrichum* and *Bryum*) and microalgae invaded those moribund moss patches. Thus, the invasion of phytopathogenic fungi in a moss carpet of *S. uncinata* is thought to led to the formation of pathogenic patches as "niches." The formation of pathogenic patches lead to changes in the patterns in plant communities in Antarctica.

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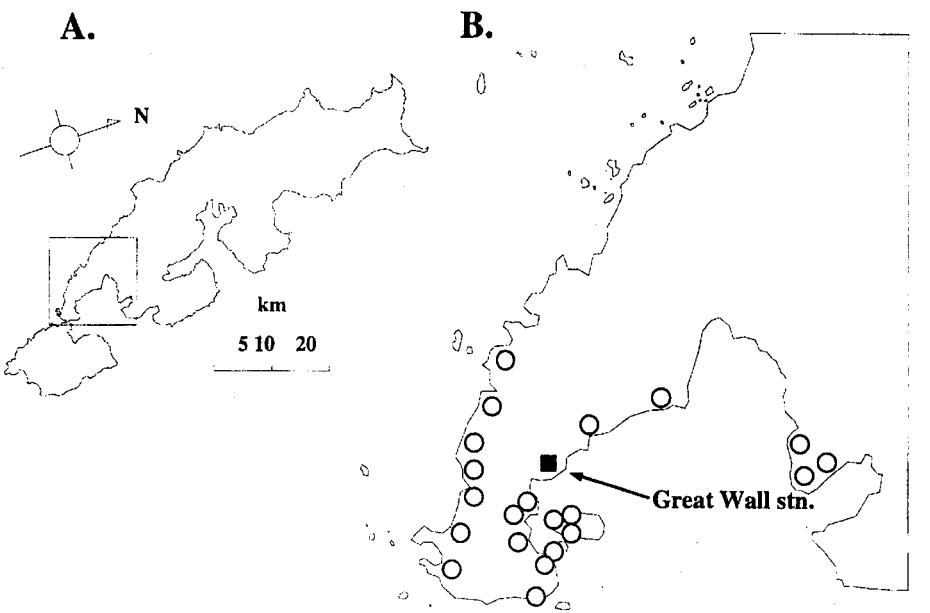

Fig. 1 Distribution of fungal infections on King George Island. A. study area. B. distribution of fungal infections in Fildes Peninsula.

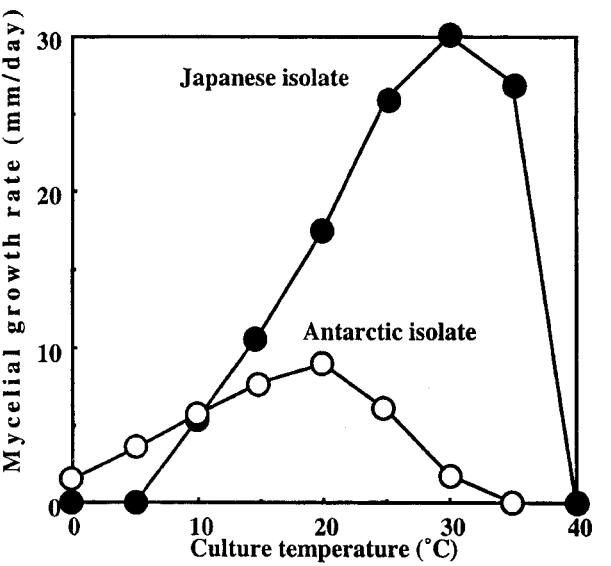

Fig. 4 Effects of culture temperature on mycelial growth of Antarctic and moderate zone isolates, *Pythium* HS group.

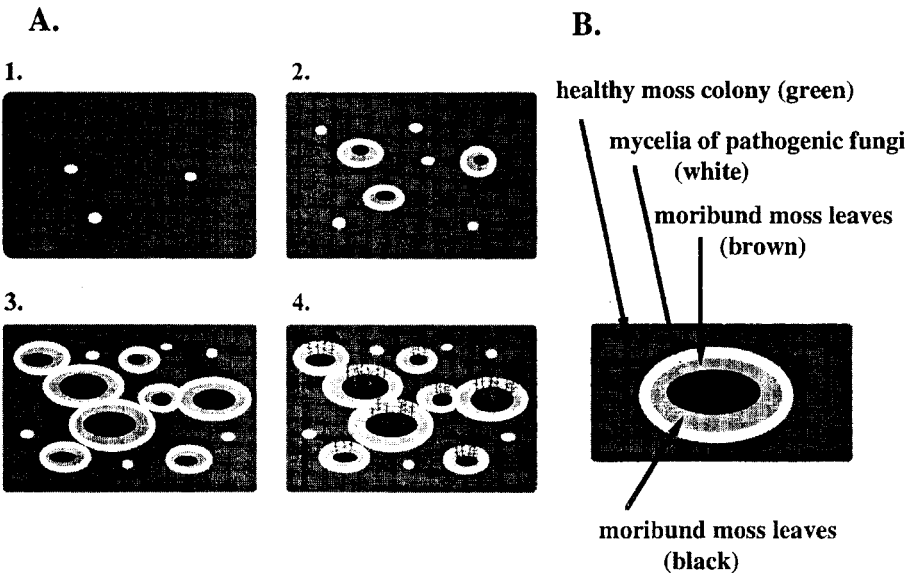

Fig. 5 Development of fungal infections.

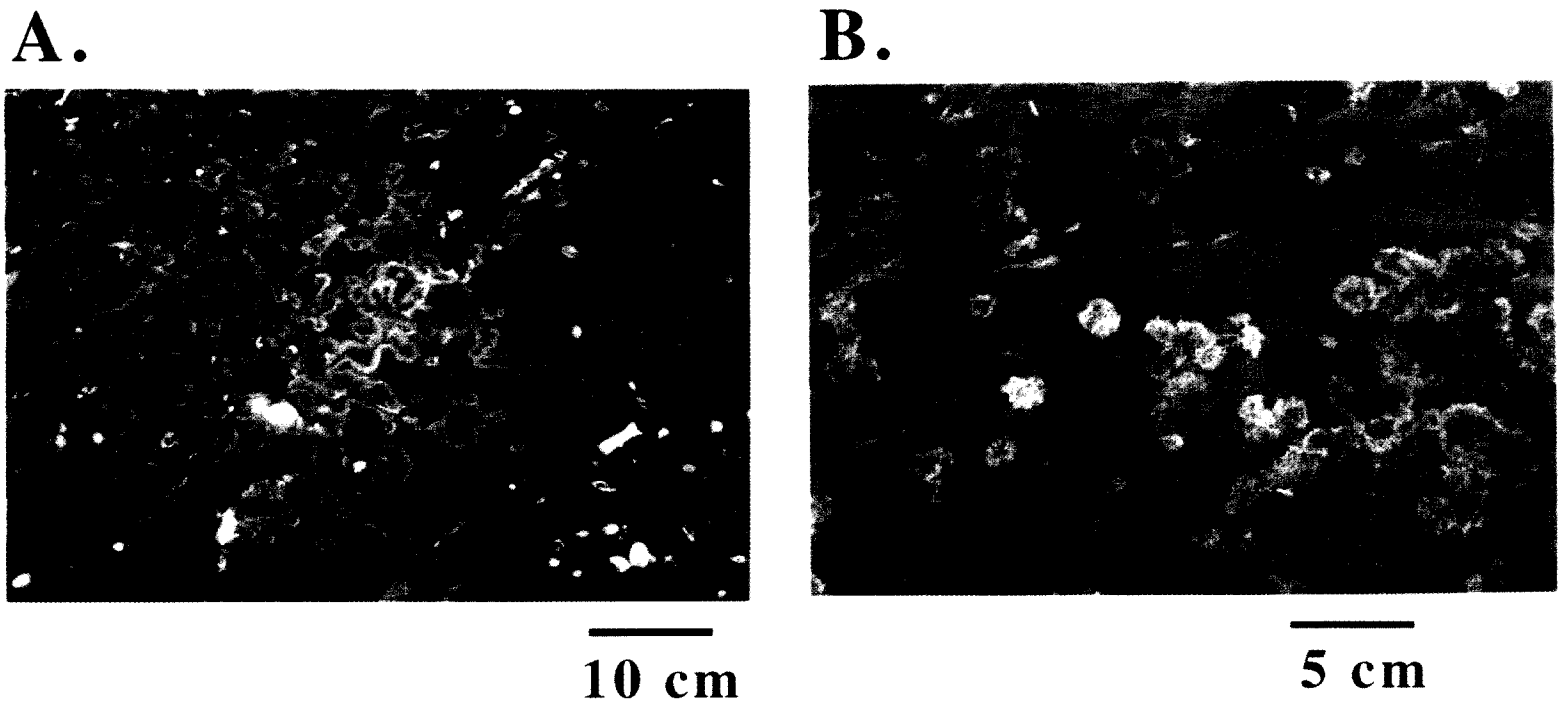

Fig. 2 Fungual infections in *Sanionia uncinata* in Fildes Peninsula, King George Island.
A. fungual infections in Half Three Point. **B.** fungual infections on Ardley Island.

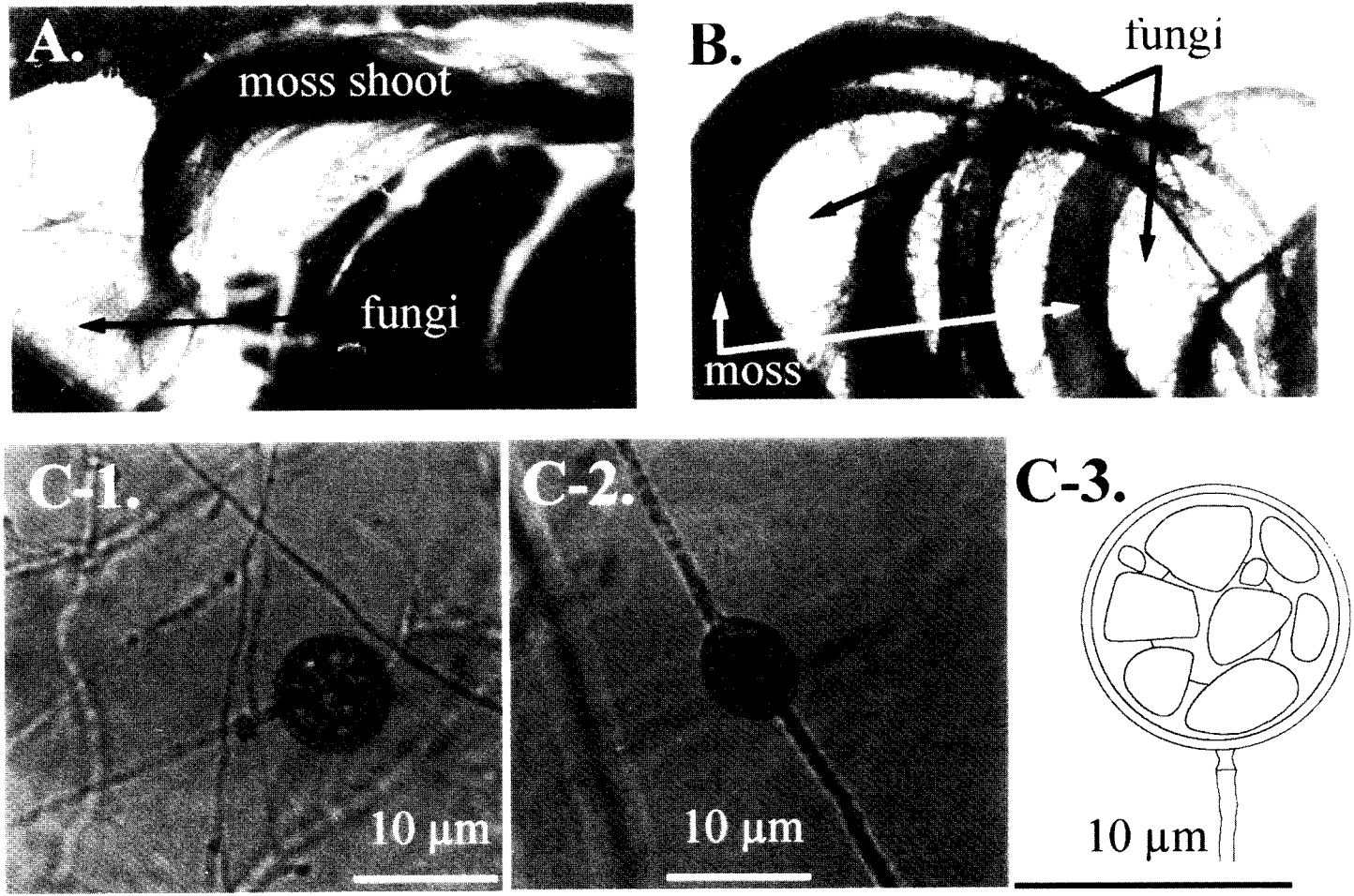

Fig. 3 Microscopic observations of moss pathogenic fungi.
A., **B.** part of a fungus-infected moss shoot. **C-1.** terminal hyphal swelling. **C-2.** intercalary hyphal swelling. **C-3.** illustration of hyphal swelling.