New findings of snow mold fungi from Greenland

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Abstract

Hoshino, Tamotsu, Saito, Izumi, Yumoto, Isao and Tronsmo, Anne Marte 2006. New findings of snow mold fungi from Greenland. – Meddelelser om Grønland, Bioscience 56, Copenhagen, The Commission for Scientific Research in Greenland, p. 89-94.

Three species of snow mold fungi, *Myriosclerotinia borealis* (syn. *Sclerotinia borealis*), *Typhula incarnata* and *T. ishikariensis* (syn. *T. borealis*), were collected from Nuuk, Sisimiut, Ammassalik and Kulusuk in Greenland. *Myriosclerotinia borealis* and *T. incarnata* are new records from Greenland. Some isolates of *T. ishikariensis* were collected from Nuuk and Ammassalik and all isolates from Sisimiut showed irregular growth as hyphal extensions at 10 °C in potato dextrose agar plates. These physiological characteristics of some isolates from Greenland are similar to those of isolates (group III strains) from Finnmark, northernmost Norway and Svalbard.

Keywords: *Myriosclerotinia borealis*, snow mold fungi, *Typhula incarnata*, *Typhula ishikariensis*

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Introduction

Snow mold fungi are psychrophilic and psychrotrophic fungal pathogens of perennial grasses and winter cereals in the Northern Hemisphere (Hsiang *et al.* 1999). The typical snow molds of grass, *Microdochium nivale* (Fr.) Samuels & Hallett (syn. *Fusarium nivale* Fr.), *Myriosclerotinia borealis* (Bub. and Vleugel) Kohn (syn. *Sclerotinia borealis* Bub. and Vleugel), *Typhula incarnata* Lasch ex Fr. and *T. ishikariensis* Imai (syn. *T. borealis* Ekstr.), are important plant pathogenic fungi, and they are distributed in the subarctic area in the Nordic countries such as Finnmark (Årvoll 1975), Lapland (Ekstrand 1955, Jamalainen 1949), Kola Peninsula in Russian Arctic (Petrov 1983) and Iceland (however, *M. borealis* has not been found in Iceland: Kristinsson and Gudleifsson 1976, Hoshino *et al.* 2004b.). However, there are few reports of snow mold fungi in the Arctic, probably because agricultural activities are

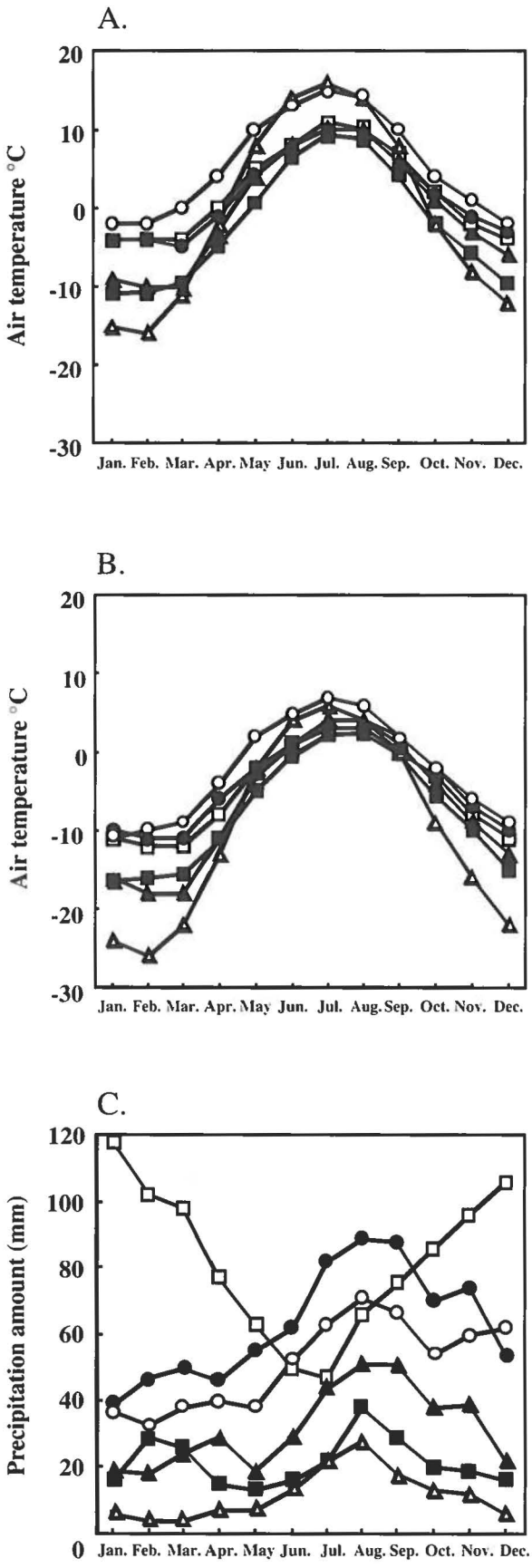

Fig. 1. Temperature and precipitation conditions of our sampling sites. A. highest average of air temperature. B. lowest average of air temperature. C. precipitation. Open circles: Narsarsuaq, closed circles: Nuuk, open triangles: Kangerlussuaq, closed triangles: Sisimiut, open squares: Ammassalik, closed squares: Ittoqqortoormiit.

very low in the Arctic area. However, we found two snow mold fungi, *M. borealis* and *T. ishikariensis*, on *Poa hartzii* Gand in Svalbard (Hoshino *et al.* 2003). Snow mold fungi adapt well to winter environmental conditions in the Arctic region.

A check list of basidiomycetes occurring in Greenland was compiled by Borgen *et al.* (2000). *Typhula borealis* Ekstr. (= *T. ishikariensis*) appears in that article. In addition, related saprotrophic species, *T. lutescens* Boud., *T. sclerotioides* (Pers.) Fr. and *T. setipes* (Grev.) Berthier (syn. *T. candida*), were also found in Greenland. This report suggested a possibility of the presence of snow mold fungi in Greenland. In August 1999, 2000 and 2002, T. Hoshino collected some species of sclerotia-forming snow mold fungi in various areas of Greenland. In this article, we report the biological characteristics of sclerotia-forming snow mold fungi found in Greenland.

Distributions of snow mold fungi in Greenland

T. Hoshino visited Narsarsuaq, Nuuk, Sisimiut, Kangerlussuaq (four cities located in West Greenland), Ammassalik, Kulusuk and Ittoqqortoormiit (three cities in East Greenland) to collect snow mold fungi. Temperatures and precipitation in the sampling sites are shown in Fig 1. Three species of snow mold fungi, *M. borealis* in Ammassalik and Sisimiut, *T. incarnata* in Nuuk, and *T. ishikariensis* in Ammassalik, Kulusuk, Nuuk and Sisimiut, were found. *Myriosclerotinia borealis* and *T. incarnata* are new records for Greenland. No snow mold fungi were found in Narsarsuaq, Kangerlussuaq or Ittoqqortoormiit. Climate conditions of these three sites are different. Narsarsuaq has the warmest climate of all of the sampling sites, whereas Kangerlussuaq and Ittoqqortoormiit have typical continental climates (cold and less precipitation in winter). The flora (the presence of host plants) and soil

freezing conditions appear to be the most important factors of the geographical distribution of snow mold fungi in Greenland.

Snow mold fungi are easily found on cultivated or introduced overwintering grasses such as hay and turf in Japan and other cold regions, and we also collected many sclerotia on introduced grasses in Greenland. However, the sampling site at Narsarsuaq has less human impact than other sampling sites, and native grasses that have resistance against snow mold fungi are the main flora of Narsarsuaq. *Typhula borealis* (= *T. ishikariensis*) was collected in Jameson Land near Ittoqqortoormiit in 1989. However, the number of grasses (fungal hosts) in Ittoqqortoormiit is less than that in other sampling sites. A poor host population in Ittoqqortoormiit limited the presence of snow mold fungi.

In our research of the geographical distribution of snow mold fungi in Siberia, it was very difficult to find snow mold fungi in continental climate areas (less snow cover and deep soil freezing regions) such as Kangerlussuaq. These observations suggested that deep soil freezing has prohibited mycelial growth of snow mold fungi in Siberia and Kangerlussuaq. *Typhula incarnata* did not grow in a culture medium below zero (Tomiyama 1955), and this fungus is distributed only in Southwest Greenland (Nuuk), Faroe Islands (Hoshino *et al.* 2004a) and Denmark (Welling and Jensen 1970). Nissinen (1996) showed a strong positive association between the incidence of *M. borealis* and depth of frozen soil in November in Lapland. By the middle of November, the average depth of frozen soil is 21 cm, and damage due to *M. borealis* is severe. Conversely, when the soil was frozen to a depth of less than 5 cm, *Typhula* spp. caused more damage. *Typhula* spp. predominated in years when soil freezing was delayed by high soil temperature and early establishment of a thick snow cover. Röed (1960) also found a thin snow cover and deep soil frost in winter preceding damage caused by *M. borealis* and suggested that a thick snow cover and unfrozen or slightly frozen soil favor the development of *Typhula* spp. and *M. nivale*. These reports indicate that *M. borealis* adapts well to soil freezing conditions, and this species was found in the highest latitude places (Ammassalik and Sisimiut) of our sampling areas in Greenland. Other snow mold fungi do not adapt so well to soil freezing. *Typhula ishikariensis* is widely distributed in coastal areas with a maritime climate and in regions with less soil freezing.

Descriptions of collected fungi

Myriosclerotinia borealis (Bub. & Vleugel) Kohn
Syn.: *Sclerotinia borealis* Bub. & Vleugel, *S. graminearum* Elen.
New to Greenland.
Fungal sclerotia were widely spread in thickets in the central areas of Ammassalik and Sisimiut (Fig. 2). The specimens were collected in August 2000 and 2002 by T. Hoshino, and they are kept in AIST Hokkaido (Japan), Botanical Museum, University of Oulu (Finland) and The Herbarium of Fungi, Botanical Garden & Museum, University of Copenhagen (Denmark). However, sclerotia of this fungus were not found in Narsarsuaq, Nuuk, Kangerlussuaq, Kulusuk and Ittoqqortoormiit. The sclerotia were dull black, variably shaped and formed on leaves and in leaf sheaths of *Phleum pratense* L. (in the city center) and *Poa* spp. (mainly *P. alpina* L.). Diameters of the sclerotia were 2-8 mm. Mycelial growth of isolates from Ammassalik and Sisimiut occurred at –5 and 15°C on potato dextrose agar plates (PDA), with optimum growth temperature of 5°C, and hyphae did not grow at 20°C in PDA. These physiological characteristics of isolates from Sisimiut are similar to those of known isolates from Nordic countries, Canada and Japan (Smith 1986).

Distribution in Nordic countries: Finland (Jamalainen 1949), Norway (Årvoll 1975), Svalbard (Hoshino *et al.* 2001) and Sweden (Ekstrand 1955).

Typhula incarnata Lasch ex Fr.
Syn.: *T. graminum* auctt. non Karsten, *T. itoana* Imai
New to Greenland.
Fungal sclerotia were found in a thicket near the center of Nuuk (Fig. 3). Sclerotia were not found in Narsarsuaq, Kangerlussuaq, Sisimiut, Ammassalik, Kulusuk and Ittoqqortoormiit. The specimens were collected in August 1999 by T. Hoshino, and they are kept in AIST Hokkaido (Japan) and The Herbarium of Fungi, Botanical Garden & Museum, University of Copenhagen (Denmark). The sclerotia were orange-brown and oval-shaped, and they formed on and in leaves on *Phleum pratense*. Diameters of sclerotia were 2.0-5.0

Fig. 2. *Myriosclerotinia borealis* in Sisimiut. A. disease of *M. borealis* in *Phleum pratense*. B. sclerotia in natural conditions.

Fig. 3. *Typhula incarnata* in Nuuk.

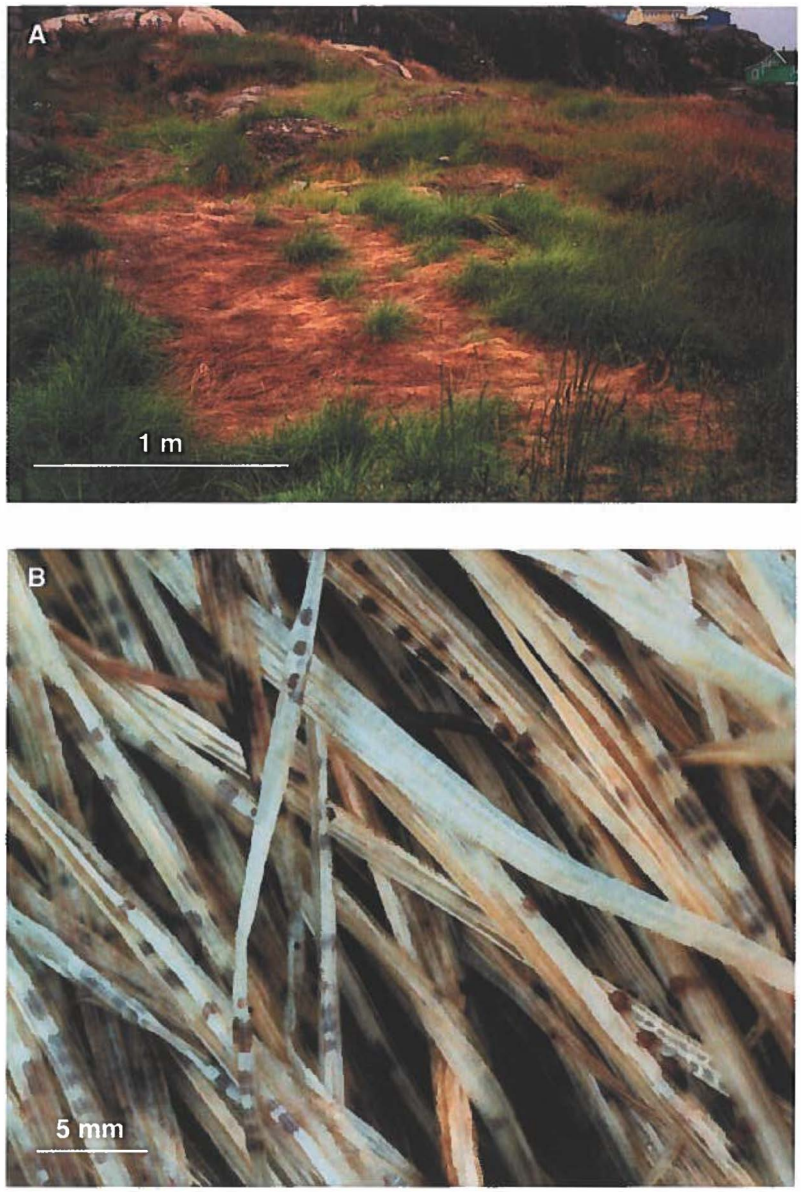

Fig. 4. *Typhula ishikariensis* in Sisimiut. A. patch of *T. ishikariensis* in *Phleum pratense*. B. sclerotia in natural conditions.

mm. Mycelial growth of isolates from Nuuk occurred at –5 and 20 °C in PDA, with optimum growth temperature of 5-10 °C (Hoshino *et al.* 2004a). These physiological characteristics of isolates from Nuuk are similar to those of known isolates from Nordic countries (Hoshino *et al.* 2004a), Canada and Japan (Smith 1986).

Distribution in the Nordic countries: Denmark (Welling and Jensen 1970), Faroe Islands (Hoshino *et al.* 2004a), Finland (Jamalainen 1957), Iceland (Kristinsson and Gudleifsson 1976), Norway (Årvoll 1975) and Sweden (Ekstrand 1955).

Typhula ishikariensis Imai

Syn: *T. borealis* Ekstr., *T. graminearum* Gul., *T. hyperborea* Ekstr. ?, *T. humulina* A. Kuzn., *T. idahoensis* Remsberg

Previous record in Greenland: *Typhula borealis* from Jameson Land in 1989 (No.: HK, SAE, JHP-549, 2643 in The Herbarium of Fungi, Botanical Garden & Museum, University of Copenhagen, Denmark).

Fungal sclerotia were widely spread in thickets in the central areas of Nuuk, Sisimiut, Ammassalik and Kulusuk. *Typhula ishikariensis* formed large patches (ca. 2-6 m) on *Phleum pratense* in Sisimiut (Fig. 4). The specimens were collected in August 1999 (Nuuk),

2000 (Sisimiut) and 2002 (Ammassalik and Kulusuk) by T. Hoshino, and they are kept in AIST Hokkaido (Japan) and The Herbarium of Fungi, Botanical Garden & Museum, University of Copenhagen (Denmark). The sclerotia were dark brown to black and globose or ovoid in shape, and they formed on and in leaves and were not firmly attached to plant tissue. Diameters of sclerotia were 0.6-1.2 mm. Mycelial growth of isolates from Greenland occurred at -5 and 15°C in PDA, with optimum growth temperature of 5-10°C.

The mycelial growth of some isolates from Nuuk and Ammassalik and all isolates from Sisimiut was arrested at 10 and 15°C on PDA, and the hyphae did not grow at 20°C. Similar results have been obtained for *T. ishikariensis* group III isolates from Finnmark (Matsumoto *et al.* 1995, 1996, Hoshino *et al.* 1997) and Svalbard (Hoshino *et al.* 2003). *Typhula ishikariensis* in Norway has been classified into three groups (groups I, II and III) by Matsumoto and Tronsmo (1995) according to genetic relationships and cultural characteristics. These three groups also have different distribution patterns: groups I and II are predominant in the southern and middle parts of Norway, while group III prevale in the north (Matsumoto *et al.* 1996).

Distribution of *T. ishikariensis* in the Nordic countries: Finland (Jamalainen 1957), Iceland (Kristinsson and Gudleifsson 1976, Hoshino *et al.* 2004b), Norway (Årvoll 1975), Svalbard (Hoshino *et al.* 2003) and Sweden (Ekstrand 1955).

Acknowledgements

We thank The Research Council of Norway and Agency of Industrial Science and Technology (AIST) for the financial support of our research project.

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