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Abundance and diversity of fungi in relation to chemical changes in arctic moss profiles

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Abstract

Mosses are a dominant component of high-arctic terrestrial ecosystems, yet little is known regarding the abundance and diversity of fungi associated with these abundant plants. We investigated vertical patterns of abundance and diversity of fungi and their relationship with chemical properties within profiles of *Hylocomium splendens* and *Racomitrium lanuginosum* collected in the Oobloyah Bay area on Ellesmere Island, Canada. The moss profiles were divided into 6 (*H. splendens*) and 5 (*R. lanuginosum*) layers according to the color and texture, and hyphal length, fungal assemblages, and contents of organic chemical components (acid-unhydrolyzable residues, total carbohydrates, extractives) and nutrients (N, P, K, Ca, Mg) were measured. Total hyphal length was greatest at the middle layers of *H. splendens* and at the deepest layers of *R. lanuginosum* and was significantly affected by moss species and nutrient contents. A total of 18 and 19 fungal taxa was isolated from the profiles of *H. splendens* and *R. lanuginosum*, respectively, with 11 taxa being common to both moss species. Moss species significantly affected the species distribution of fungi. Individual fungal taxa showed patterns of vertical distribution within the moss profiles. The contents of acid-unhydrolyzable residues and nutrients increased and the content of total carbohydrates decreased down the profile, which was attributable to the ability of fungi to decompose carbohydrates selectively and to immobilize nutrients in decomposed moss residues.

Keywords: High arctic; *Hylocomium splendens*; Hyphal length; Nutrient; *Racomitrium lanuginosum*

1. Introduction

Bryophytes are dominating constituents in high-arctic terrestrial ecosystems (Russell 1990; Bliss and Matveyeva 1992; Tenhunen et al. 1992). Mosses (Bryophyta) as primary producers and their dead tissues, which decompose slowly due to the low contents of nutrients and high contents of phenolics and structural carbohydrates, play important roles in carbon and nutrient budgets in ecosystems (Cornelissen et al., 2007, Lang et al., 2009). The accumulation of live and dead moss tissues is determined by the balance between the primary production by mosses and the decomposition by decomposer organisms in the bryosphere, including fungi (Lindo and Gonzalez, 2010). A diverse suite of fungi interact with mosses as saprobes, parasites, and commensals (Davey and Currah, 2006; Kauserud et al., 2008), but few studies have been performed in high-arctic regions regarding the patterns of abundance

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and diversity of fungi within moss profiles consisting of live, senescent, and dead tissues in different stages of decomposition.

The purpose of the present study was to examine vertical patterns of the abundance and diversity of fungi and their relationship with chemical properties within moss profiles. Colonies of two mosses, *Hylocomium splendens* and *Racomitrium lanuginosum*, were collected in a deglaciated terrain in high-arctic Canada and divided into 6 (*H. splendens*) and 5 (*R. lanuginosum*) layers according to the color and texture. Thus, the changes in organic chemical and nutrient contents in the profiles reflected the pattern of decomposition and accumulation of organic matter. The study of fungal abundance and species composition in the profiles would enable identification of possible factors affecting fungal assemblages and the roles of fungi in the decomposition processes.

2. Methods

2.1. Study site

The study area (80°50−52′N, 82°49−51′W, WGS84) is located within the proglacial field of the southern front of Arklio Glacier in the Kreiger Mountains near Oobloyah Bay, Ellesmere Island, Nunavut, Canada. The details of the study area are described in Mori et al. (2008). In brief, microtopographic glaciation at this site has led to the development of patchwork microhabitats, each with its own water regime and dominant moss species. The geological frame of the study area is mainly built up of Younger Paleozoic and Mesozoic sedimentary rocks, dominated by sandstone, siltstone and shale, of the Sverdrup Basin (Okitsu et al., 2004). Weathering of bedrocks and soil development was generally poor due to low temperature and relatively short periods since the recession of the glacier. The dominant vascular plants included *Salix arctica*, *Dryas integrifolia*, *Cassiope tetragona*, and *Saxifraga oppositifolia* (Mori et al., 2008). *H. splendens* ranged from the edge of the mire (hydric site) to the top of the moraine (xeric site) and dominated the intermediate plain (mesic site) between hydric and xeric sites, and *R. lanuginosum* dominated the vegetation at the top of the moraine (xeric site) (Ueno et al. 2009). Samples were collected on moraines possibly established during the Holocene (3300−2400 years ago) (Moraine B of Mori et al., 2008).

Although no climatic data were available for the study area, data were obtained from the weather station at Eureka (80°00′N, 85°56′W), 130 km south of Oobloyah Bay, and showed an extremely harsh climate. The monthly mean temperatures of the warmest and coldest months (July and February, respectively) were about 3.3 and −38.0 °C, respectively. The annual mean temperature was about −19.7 °C and the annual precipitation was about 64 mm.

2.2. Sampling and field measurements

In July 2003, five blocks of *H. splendens* were collected from a mesic site on a creek bank and five blocks of *R. lanuginosum* from a xeric site on the upper part of a moraine. The distance between the two collection sites was approx. 30 m. Each block measured 10 × 10 cm in area and 12−18 cm (*H. splendens*) or 14−17 cm (*R. lanuginosum*) in depth. The blocks of *H. splendens* were divided into 6 layers (denoted as layers 1−6 from the uppermost layer, each 1−4 cm in thickness) according to color and texture (Fig. 1): layer 1 was green, layer 2 was yellow, layers 3 and 4 were brown, layer 5 had black fragile stems but leaves still attached to stems, and layer 6 had black fragile stems detached from leaves. The blocks of *R. lanuginosum* were divided into 5 layers (denoted as layers 1−5 from the uppermost layer, each 1−4 cm in thickness) according to color and texture (Fig. 1): layer 1 was green, layer 2 was yellow, layers 3 and 4 were brown, and layer 5 had dark brown stems with leaves attached. Each profile was further divided into four subsamples (5 × 5 cm in area), air-dried *in situ* to prevent deterioration during transportation, and stored in paper bags before being transported to the laboratory for analysis. Three of the four subsamples were used for hyphal length estimation, isolation of fungi, and chemical analysis, and the fourth subsample was kept as an extra.

On July 30, 2004, five blocks of *H. splendens* and five blocks of *R. lanuginosum* were collected at the same location and in the same manner as in 2003 to measure moisture content. Blocks of *H. splendens* were divided into three layers (layers 1 + 2, 3 + 4, 5 + 6), and those of *R. lanuginosum* into two layers (layers 1 + 2 + 3, 4 + 5). The fresh samples of layers were weighed, air-dried *in situ*, stored in paper bags, and taken to the laboratory. The samples were dried again at 40 °C for one week to determine oven-dry mass. Moisture content was determined gravimetrically according to the equation: moisture content (%) = amount of water/oven-dry mass × 100. Temperature of moss blocks was measured *in situ* from