THE MYCORRHIZAL STATUS OF THE DOMINANT VEGETATION ALONG A PEATLAND GRADIENT IN SOUTHERN BOREAL ALBERTA, CANADA

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Abstract: We investigated the mycorrhizal status of the dominant vascular plant species occurring in ten peatlands along a bog—fen—marsh gradient in southern boreal Alberta in 1997. All members of the Ericaceae were ericoid mycorrhizal, and members of the Salicaceae and Pinaceae were ectomycorrhizal. Also, some members of the Salicaceae and Betulaceae were simultaneously ecto- and vesicular-arbuscular mycorrhizal (VAM). Fruiting bodies of the known ectomycorrhizal fungal genera Cortinarius, Lactarius, and Russula were collected in late fall. Furthermore, the cosmopolitan ectomycorrhizal taxon Cenococcum geophilum was associated with trees and shrubs in all fens and bogs. VA-mycorrhizal fungi were not found in any of the dominant herbaceous plant species in these peatlands; however, vesicles suggesting the presence of VAM fungi were found in Calamagrostis canadensis in the riverine marsh and Rubus chamaemorus in the bog. Neither Carex species in fens and marshes, nor Typha latifolia in the lacustrine marsh were mycorrhizal; however, microsclerotia, sclerotial plaques, septate, aseptate, and clamped hyphae were observed to grow on and within cortical cells of their roots. Many of these hyphae were dematiaceous and may belong to the Mycelium radicis atrovirens complex (MRA), partially consisting of the endophytic fungal genera Phialocephala and Leptodontidium. Hyphae resembling Rhizoctonia were also observed, although definitive identifications were not attempted. The ecological significance of MRA genera remains largely unknown. Thus, the dominant vegetation in southern boreal bogs and fens is mycorrhizal, possibly enabling these plant species to proliferate in these nutrient-poor ecosystems by accessing otherwise unavailable nutrient pools. In contrast, marsh vegetation is generally non-mycorrhizal, possibly due to higher surface-water nutrient concentrations and fluctuating water levels.

Key Words: bog, fen, marsh, Mycelium radicis atrovirens complex, VA-mycorrhizas, ectomycorrhizas, ericoid mycorrhizas

INTRODUCTION

Peatlands have been defined as ecosystems where organic material accumulates to a depth greater than 40 cm and the water table is at or near the soil surface (Gorham 1991). Peatlands cover approximately 20% of Canada's (National Wetlands Working Group 1988) and 18% of Alberta's land surface (Vitt et al. 1996). In Alberta, fens and bogs cover approximately 11.4% and 4.9% of the land surface, respectively, while marshes are less common, covering only 1.5% of the land surface (Vitt et al. 1996). Bogs are ombrotrophic peatlands that receive nutrients only from precipitation and, in Alberta, are dominated by Sphagnum species, Picea mariana, and members of the Ericaceae. Conversely, fens are minerotrophic ecosystems that receive nutrients from ground- and surface-water flow as well as from precipitation. Fens can be subdivided into poor, moderate-rich, and extreme-rich fens, a classification based on water chemistry and characterized by the number of indicator moss species (Du Rietz 1949), whereby poor fens have few and extreme-rich fens have many moss species indicative of alkaline conditions. In Alberta, peatlands are dominated by Sphagnum species at the poor end and by "brown" mosses, such as Drepanocladus aduncus (Hedw.) Warnst., Scorpidium scorpoides (Hedw.) Limpr., and Aulacomnium palustre (Hedw.) Schwein., at the rich end of the gradient. Additionally, many shrub and herb species are found in fens. Marshes are minerotrophic ecosystems dominated by sedges, grasses, and reeds, generally have higher surface-water nutrients than fens, and are often associated with open bodies of water. Mosses, shrubs, and trees are generally absent due to high and fluctuating water levels. Marshes in southern boreal Alberta have peat substrates (Thormann and Bayley 1997) and were classified as peatlands in this study.

Mycorrhizas are mostly mutualistic associations between fungi and the roots of higher plants, in which the fungi form consistently recognizable and physical-
ly distinct associations without causing any perceivable negative effect (Fernando 1995). There are five common types of mycorrhizas: ectomycorrhizas, vesicular-arbuscular mycorrhizas (VAM), arbutoid mycorrhizas (ectomycorrhizas), ericoid mycorrhizas, and orchid mycorrhizas. Read (1991) and Smith and Read (1997) provide detailed information on these different types of mycorrhizas.

Briefly, ectomycorrhizal fungi are characterized by root-tip hypertrophy (excessive growth), the formation of a Hartig net (intercellular mycelium enveloping the cells of the cortex and epidermis of the plant root), and a mantle (a compact layer of mycelium enveloping the root tips of the host plant). These fungi synthesize a wide range of enzymes, such as cellulases (Linkins and Antibus 1982), phosphatases (Alexander and Hardy 1981), and polyphenol-oxidases (Giltrap 1982), that enable them to degrade litter. The ability of ectomycorrhizal fungi to mobilize nitrogen from proteins (Abuzinadah and Read 1986) may be their most important role. Many of these nutrients, as well as water, are translocated through the mycelium of the ectomycorrhizal fungus to the host plant in exchange for photosynthates (Smith and Read 1997).

Vesicular-arbuscular mycorrhizal fungi manifest themselves as highly branched arbuscules and swollen vesicles (structures involved in the exchange and storage of nutrients) in root cortical cells. VA-mycorrhizal fungi have a more restricted range of abilities to access and mobilize nutrients (Read 1991). However, increased access to phosphates via the proliferation of their mycelia throughout the soil horizons (Sanders and Tinker 1971) and the synthesis of alkaline phosphatases (Gianinazzi-Pearson and Gianinazzi 1983), which solubilize bound phosphates (Owusu-Bennoah and Wild 1980), provide host plants with additional P for growth.

Arbutoid mycorrhizal fungi are characterized by the formation of a mantle, a Hartig net, and intracellular proliferations within cortical cells of their host plants, primarily achlorophyllous Monotropaceae (Smith and Read 1997). Translocation of nitrogen (N), phosphorus (P), and carbon (C) by arbutoid mycorrhizal fungi from woody plant species to the members of the Monotropaceae has been shown in field studies, a process termed ‘myco-heterotrophy’ by Leake (1994).

Ericoid mycorrhizas are characterized by septate hyphae forming successive coils within root cortical and/or epidermal cells (Stoyke and Currah 1991). It is thought that the primary advantage to ericaceous host plants is access to otherwise unavailable nitrogen pools (Read 1991). Ericoid mycorrhizal fungi can access ammonium ions and use amino acids from organic soil horizons via the action of enzymes, such as proteases and acid phosphatases (Pearson and Read 1975). In addition, although the mycelium of ericoid mycorrhizal fungi does not extend far beyond the cortical cells of the host plants into the surrounding soil, it has the ability to degrade a number of complex organic substances (tannins, lignin, chitin) (Leake 1987, Leake and Read 1989, Haselwandter et al. 1990) and thereby mobilize some of the generally limiting nutrients.

Orchid mycorrhizas form pelotons (coiled, anastomosed hyphae) within orchid roots (Zelmer et al. 1996), and experimental evidence suggests that these endophytes are involved in the uptake of nutrients from the soil solution, including C and P (Alexander et al. 1984). It has been shown that germinating orchid seeds in situ require the presence of the mycorrhizal fungus to survive, although the seeds of many orchid species can also be grown to maturity in vitro without a mycorrhizal fungus (Smith and Read 1997).

Mycorrhizas are common in many habitats, and their presence suggests that they play ecologically significant roles (Wetzel and van der Valk 1996, Näsholm et al. 1998, van der Heijden et al. 1998), such as the acquisition, storage, and translocation of nutrients. The significance of mycorrhizas has been shown in many studies, particularly in stressed ecosystems, including high altitude (Haselwandter and Read 1982), high latitude (Kohn and Stasovski 1990), and nutrient-limited ecosystems (Haselwandter 1987). Host plants frequently have elevated tissue concentrations of N and P, show reduced wilting due to water stress (Harley and Smith 1983) or high salinity (Rozema et al. 1986), and have higher water-uptake rates than non-infected plants (Harley and Smith 1983). Most of the hypothesized functions of mycorrhizal fungi have resulted from in vitro studies; however, recent in situ studies indicate that mycorrhizal fungi indeed are able to access otherwise unavailable nutrient pools and translocate these nutrients to host plants (Näsholm et al. 1998).

Information on mycorrhizas in peatlands is limited and often contradictory (Wetzel and van der Valk 1996). The absence of VAM in aquatic macrophytes of the Cyperaceae and Juncaceae has been reported by many researchers (Harley and Smith 1983, Anderson et al. 1984, Allen 1991) and is possibly due to fine roots that enable these plants to efficiently absorb nutrients from the rhizosphere (Powell 1975). Conversely, Reid et al. (1976) and Wetzel and van der Valk (1996) reported the presence of VAM in temperate and prairie pothole ecosystem vegetation (members of the Cyperaceae and Juncaceae), respectively. Similar reports were made for halophytic wetland species (Ho 1987) and aquatic plants, such as species in the genera Littorella, Lobelia, and Isoetes (Søndergaard and Laegaard 1977). Generally, mycorrhizas were noted in