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Ciliates as restoration indicators in peatbogs — 10 years of study

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Abstract

There is almost no information on how restoration of *Sphagnum*-dominated peatbogs, and in particular removal of reeds, affects the functioning of ciliate communities. Changes in vegetation patterns caused by restoration procedures may take years to be observed, while microbial processes already display effects after short-term exposure to changes in environmental conditions due to restoration. Based on the results of a long-term study, we assumed that mowing down of reeds causes changes in the physicochemical properties of peatbog water and sought to answer the question of how ciliate communities react to these changes and whether these microorganisms can play a significant role as bioindicators in evaluating the restoration process. Removal of reeds clearly modified the taxonomic composition and abundance of ciliates. This was reflected in an increase in the abundance and diversity of these protozoa and in a significant increase in the proportion of sphagnophilous species. Our results suggest an indicator species approach based on functional groups may be appropriate for biomonitoring peatbog restoration. A better understanding of what regulates microbial populations and activity in peatbogs and unravelling of these fundamental mechanisms are particularly critical in order to more accurately predict how peatbogs will respond to anthropogenic disturbances.

Keywords: Ciliates; Ecological indicators; Protozoa; Peatbogs restoration

Introduction

Peatbogs are wetland ecosystems which cover nearly 5 million km^2 and store a third of terrestrial carbon globally (Bragazza et al. 2006). Furthermore, they belong to the fastest disappearing and most endangered ecosystems in Europe, which is especially disquieting in light of progressive climate warming (Robson et al. 2005). Many peatlands have been drained for agriculture or mined for peat, which has greatly altered their plant communities (McCornac and Schneider 1994). Other human actions affecting peatbogs include afforestation, acid rain, agricultural pollution, and use as landfill sites (Headley et al. 1992). The drainage and harvesting of peatbogs alter nutrient dynamics and affect microbial communities in peat (Andersen et al. 2013). The removal of vegetation cover and lowering of the water table expose the humic substrate and poor-quality organic matter to aerobic conditions, thus hindering microbial activity (C-limitation), as much of the C is refractory (Bayley et al. 2005). Methods aimed at restoration of peatbogs have been developed and tested for over decade, and recent studies have shown that typical bog vegetation can quickly become dominant following restoration (Poulin et al. 2012). The gradual drainage of *Sphagnum* peatbogs results in their increased fertility and in changes in the proportions of individual

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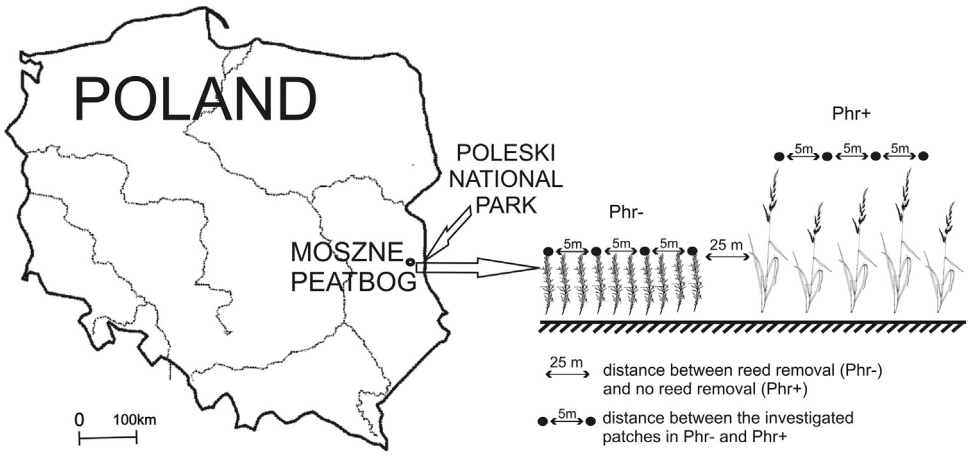

Fig. 1. Location of the investigated peatbog and study site.

plant species. *Sphagnum* peatbogs are especially often overgrown by *Phragmites australis*. One method of inhibiting succession in this type of peatbog is to cut down reeds and remove them from the peatbog. However, peat formation and carbon sequestration also depend on belowground processes that regulate organic matter turnover and affect vegetation responses. Therefore, in order to assess the long-term success of peatbog restoration we must determine whether the nutrient pool changes over time and whether microbial communities develop towards natural conditions under the growing vegetation. Thus for the fast majority of studies evaluating the effects of restoration have mainly concerned the effect of modification of hydrological conditions on vegetation (Andersen et al. 2013; Poulin et al. 2012). Information is lacking on how modification of the vegetation structure, including mowing of reeds, may affect the occurrence of microbial communities (Andersen et al. 2013; Elliott et al. 2015; Marcisz et al. 2014). However, the microbial community may be more sensitive or respond more readily to changes in hydrological conditions and trophic status than plants (Mieczan and Tarkowska-Kukuryk 2017). Thus, microbial processes and patterns may be used as sensitive indicators of changes in environmental conditions in peatbogs (Jassey et al. 2010; Mieczan et al. 2015a; Wright et al. 2009). No studies have previously been conducted on the effect of reed removal on ciliate communities. Protozoa (including ciliates) are the most common microbial communities in peatbogs. Due to the clear predominance of ciliates in peatbog ecosystems, they are recognized as having the most important role in matter and energy flow (Mitchell et al. 2003; Nguyen-Viet et al. 2007). Those microorganisms are significant consumers of bacteria, flagellates, and algae, and participate in mineralization of organic matter and circulation of biogenic compounds (Gilbert et al., 1998a, b; Mieczan et al. 2012; Wilkinson and Mitchell 2010). Studies suggest that the most important factors limiting the occurrence of microorganisms in peatbog ecosystems are physical and chemical habitat properties — primarily water table depth and pH (Mitchell et al. 2003; Mieczan et al. 2012; Nguyen-Viet et al. 2007). Little is known of how long-term variability of environmental conditions may influence the composition of microbial communities in peatbogs. The lack of sufficient information in the literature prompted us to initiate research on that specific group of organisms in peatbogs. Hence the primary objective of the present study was to determine the dynamics of ciliates in a restored peatbog. Based on the results of a long-term study (10 years), we assumed that removal of *Phragmites australis* (Car.) causes changes in the physicochemical properties of peatbog water and sought to answer the question of how ciliate communities react to these changes. In addition, we attempted to establish whether ciliates can play a significant role as bioindicators in evaluating the restoration process of these ecosystems.

The objectives of this study were: to determine the long-term dynamics of ciliates before and after restoration of a *Sphagnum*-dominated peatbog; to assess the effect of physical and chemical factors on microbial community structure before and after restoration of the peatbog; to attempt to determine whether ciliates can be used as bioindicators of changes in environmental conditions in *Sphagnum* peatbogs.

Material and Methods

Study site

A study on the effect of restoration processes, mainly involving removal of common reed, on the functioning of ciliate communities was carried out in the *Sphagnum*-dominated peatbog Moszne (Poleski National Park, eastern Poland, 51° N, 23° E) (Fig. 1). In the 1960s and 1970s this area underwent intensive drainage procedures, which led to a reduction in the groundwater and surface water levels and to peat mineralization processes. This was reflected in degradation of the vegetation — mainly the appearance of vegetation characteristic of eutrophic habitats, such as *Phragmites australis* (Car.). Starting in the late 1990s intensive restoration measures were undertaken in Poleski National Park, aimed at