FUNGAL ECOLOGY 14 (2015) 8–23

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/funeco

Climatic gradients within temperate Europe and small-scale species composition of lichen-rich dry acidophilous Scots pine forests

Alica KOŠUTHOVÁ[a,b,*], *Ivana SVITKOVÁ*[a], *Ivan PIŠÚT*[a], *Dušan SENKO*[a], *Milan VALACHOVIČ*[a], *Piotr Tomasz ZANIEWSKI*[c], *Michal HÁJEK*[b,d]

[a]*Department of Cryptogams and Department of Geobotany, Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 9, Bratislava 84523, Slovakia*
[b]*Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, Brno 61137, Czech Republic*
[c]*Department of Forest Botany, Faculty of Forestry, Warsaw University of Life Sciences – SGGW, Poland*
[d]*Department of Vegetation Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Lidická 25/27, CZ-602 00 Brno, Czech Republic*

ARTICLE INFO

Article history:
Received 24 January 2014
Revision received 2 October 2014
Accepted 21 October 2014
Available online
Corresponding editor:
Darwyn Coxson

Keywords:
Baltic sea
Biodiversity
Cladonio-Pinetum
Continentality
Europe
Lichenized fungi

ABSTRACT

We investigated patterns in community composition in Central-European lichen-rich pine forests along a macroclimatic gradient, using two plot sizes. Diversity of lichens, especially the number of boreal and subatlantic taxa per plot increased from southern Slovakia to northern Poland (Baltic Sea). The ecological indicator value for continentality was highest in two inland regions which were characterised by low winter temperatures. Principal coordinates analysis sorted the regions along two major compositional gradients of similar importance, one mirroring the south-to-north gradient and correlating with the Gorczyński index of thermal continentality, and a second correlating with lowest winter temperature. Regional differences driven by macroclimate were the most important determinant of species composition even in small plots. Continentality was of primary importance in assembling terrestrial lichen communities, but its particular components acted differently. Lowest winter temperature appeared to be well connected with ecological meaning of continentality, which is expressed among others in ecological indicator values.

Introduction

Knowing patterns in species composition is very important for understanding processes in communities. Therefore, it is important to perform research on causal relationships between local species assemblages and multiple ecological gradients. While the effects of local environmental factors have been well studied, less is known about causal climatic effects, because large-scale climatic gradients often co-vary with biogegraphical gradients structured by dispersal

* *Corresponding author*. Current address: Department of Cryptogams, Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 9, Bratislava 84523, Slovakia.
E-mail address: kosuthova.alica@gmail.com (A. Košuthová).
http://dx.doi.org/10.1016/j.funeco.2014.10.005
1754-5048/

constraints (Hájek et al., 2011). Current metacommunity studies suggest that species composition of communities of spore-dispersing organisms is little affected by pure biogeographical effects, being structured predominantly by edaphic and/or climatic filters (Hájek et al., 2011; Jones et al., 2014). This property makes spore-dispersing organisms such as cryptogams, suitable model organisms to test climatic factors affecting community assembly, but this advantage has been utilised only rarely.

The responses of particular cryptogam species to climatic factors have mostly been tested in the context of ongoing climate change, especially in boreal and arctic regions (Werth et al., 2005; Wagner et al., 2014) or across contrasting climatic zones (e.g., from hyperhumid to arid regions in Australia; Rogers, 2006). Generally, lichens have been reported to be one of the most sensitive groups with respect to climatic factors (Cornelissen et al., 2001; van Herk et al., 2002; van Wijk et al., 2003; Ellis et al., 2007; Lang et al., 2012). They dominate terrestrial vegetation types whenever other groups of organisms are stressed by either cold climate or nutrient insufficiency or both (Cornelissen et al., 2001; Rustad et al., 2001; Chytrý et al., 2008; Sparrius et al., 2013). Climate and nutrient availability interact – nutrient enrichment may occur due to humus mineralisation. In northern and boreal temperate zones, where climate is generally more suitable for vascular plant productivity as compared to arctic-subarctic zones, lichen-rich assemblages are restricted to edaphically specific, nutrient-poor habitats such as those in sandy regions. Hence, climate may act less clearly and species composition of lichen communities may be affected strongly by habitat quality (Moning et al., 2009; Lisewski and Ellis, 2011; Košuthová et al., 2013a,b).

Although there are a lot of data on the response of terrestrial lichen assemblages to climatic and edaphic factors from arctic regions, there are less data from temperate Europe. Most studies from temperate Europe have dealt with particular lichen species, not communities, including experiments focused on physiological differences between species due to various climatic conditions (Grube and Spribille, 2012; Vondrák and Kubásek, 2012). Experiments included both mycobiont and photobiont partners (Bačkor et al., 2010; Škaloud and Peksa, 2008), which help to explain the preference of a symbiotic partner for particular environmental conditions (Muggia et al., 2013; Peksa and Škaloud, 2011). Large-scale analyses of terrestrial lichen assemblages within continental temperate Europe are rare although they would represent a prerequisite for future application of climatic models on Central-European terrestrial lichens and would shed more light into climatic drivers controlling assembly of communities of terrestrial lichens. The relationships between climatic factors and lichen distributions within Central Europe are more often theoretically expected than really tested.

Lichen-rich dry acidophilous Scots pine (*Pinus sylvestris*) forests are a suitable model habitat to test macroclimatic effects on local community assembly. Lichen-moss mats are of principal functional importance in these forests (Brodo, 1961; Crittenden, 1991, 2000), but determinants of their species composition were never explored at a larger scale. Although specific edaphic factors such as low nutrient availability or drought determine the occurrence of this habitat, climatic factors may shape community structure. In Central Europe, the species pool of these forests includes different biogeographical elements (oceanic, boreal, continental). The distribution ranges of these elements overlap and span the entire distribution of the studied habitat. Even though Central-European phytosociologists and habitat conservationists are aware of inter-regional differences in species composition (Heinken and Zippel, 1999; Danielewicz and Pawlaczyk, 2004), no large-scale study has tested whether species composition of local communities significantly differs between Central-European regions, whether observed floristic differences coincide with macroclimatic factors and whether assembly of local plant communities (*Cladonio-Pinetum*) is affected by different climatic niches of species forming the habitat species pool. To fill this gap, this study aimed to: (1) describe the variability in species richness and composition (alpha and beta diversity) of lichen-rich Scots pine forests along the macroclimatic gradient within inland temperate Europe, from the Baltic Sea in Poland to southwest Slovakia, with the main attention focused on terricolous lichens; and (2) find out how the main compositional gradients coincide with macroclimate and local environmental factors, with a special emphasis on the gradient of continentality.

Materials and methods

Study area

The research was conducted between 2006 and 2011 in four selected regions differing in climate, distributed from subcontinental Slovakia through inland Poland up to the suboceanic Baltic Sea region.

These four regions were selected to cover the continentality gradient in Central-Northern Europe stretching from (**1S**) the Central European subcontinental region (Borská nížina lowland, south-western Slovakia, at the margin of the Pannonian lowland, Futák, 1980) via (**2**) the Central-Northern European subcontinental region (Masovian Landscape Park, central Poland, close to Warsaw), (**3**) the Central-Northern European suboceanic region (Bory Tucholskie National Park, northern Poland) to (**4N**) the Baltic Sea coast suboceanic region (Słowiński National Park, northern Poland, on the coast of the Baltic Sea) (Fig 1).

Study habitat

The study habitat represents dry acidophilous Scots pine forests (the *Cladonio-Pinetum* association), which are distributed in acidic, nutrient poor sandy areas throughout temperate Central Europe. These forests are naturally rich in terricolous lichens, especially the genus *Cladonia*. The distribution area of this vegetation type lies in the boreal and northern temperate zones (Ermakov and Morozova, 2011); with a tendency to occur rather close to sea coasts in temperate part of Europe. It occurs in Poland (Matuszkiewicz and Matuszkiewicz, 1973, 1996; Sokołowski, 1965), Germany (Heinken and Zippel, 1999; Heinken, 2007), the Netherlands (Emmer and Sevink, 1994), and partly in Norway, Finland, Latvia, Lithuania (Solon, 2003), Sweden (Olsson, 1974) and Estonia (Zobel et al., 1993). Its southern distribution margin