History, recent variability and restoration of oligotrophic wetlands: editorial

Historie, současná variabilita a obnova oligotrofních mokřadů

Michal H á j e k[1,2] & Petr P y š e k[3,4]

[1]*Department of Botany and Zoology, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno, Czech Republic, e-mail: hajek@sci.muni.cz;* [2]*Department of Vegetation Ecology, Institute of Botany, Academy of Sciences of the Czech Republic, Lidická 25/27, CZ-602 00 Brno, Czech Republic;* [3]*Institute of Botany, Department of Invasion Ecology, Academy of Sciences of the Czech Republic, CZ-252 43 Průhonice, Czech Republic, e-mail: pysek@ibot.cas.cz;* [4]*Department of Ecology, Faculty of Science, Charles University in Prague, Viničná 7, CZ-128 44 Prague, Czech Republic*

Introduction

Mires and oligotrophic lakes are unique ecosystems that have attracted botanists and ecologists since the beginning of the last century or even earlier. Due to clearly developed and distinct ecological gradients (Malmer 1986, Økland et al. 2001), great variation in flora (Chytrý 2012), a high representation of rare, specialized and relict species (Horsák et al. 2012, Jiménez-Alfaro et al. 2012, Kaplan 2012) and the "archive" of biological material stored in the organic deposits (Chambers & Charman 2004) these habitats are an important source of ecological and historical information. Initially, exploration of peat archives by palynological analyses was a separate discipline, but later on palaeoecological research developed into a multi-proxy, interdisciplinary science. By analogy, until quite recently ecology and biogeography did not consider the historical factors that affect present-day species richness and composition. One of the scientists who first started to interconnect palaeoecological knowledge, rigorous ecology and vegetation classification was Kamil Rybníček. He started as an algologist, continued as a vegetation scientist and bryologist, worked on conservation and restoration issues and more recently analysed macrofossils in profiles and interpreted pollen data obtained by his wife, an important Czech palynologist, Eliška Rybníčková (Krahulec 2012), in a broad vegetational and ecological context. In their palaeoecological research they were interested not only in landscape development, but also in local patterns in succession in mires during the Holocene; a topic which is still popular in ecology today (e.g. Hughes & Dumayne-Peaty 2002). Based on his expertise, gained in a wide range of disciplines, Kamil Rybníček integrated the results of ecological and vegetational studies into a coherent palaeoecological interpretation. By analogy, he views the problems of recent vegetation science, ecology and biogeography from a Holocene perspective. Many of the recent papers that account for the current patterns in the distributions of species in central Europe (e.g. Hájek et al. 2011, Horsák et al. 2012) build on fundaments established by Kamil Rybníček. The same is true for the classification of vegetation. As he was familiar with classical Scandinavian ecological classification of mires, he introduced this approach to central Europe (Rybníček 1985). For a long time, a dominance-based approach prevailed in the phytosociological studies of European mires (Dierßen 1982), but some recent papers and surveys are clearly inspired by Rybníček's ecological approach (Dítě et al. 2007, Hájek & Hájková 2011, Sekulová et al. 2011, Moen et al. 2012, Pawlikovski et al. 2013). Last but not least, he triggered and stimulated in other palaeoecologists an interest in plant sociology, a discipline which they previously tended to overlook, but which has important consequences for studies that reconstruct past landscapes.

This special issue, which is dedicated to Kamil Rybníček and Eliška Rybníčková on the occasion of their 80th birthdays, aims to bring about a better integration of palaeoecological, ecological and vegetational information on mires and lakes and increase our understanding of the dynamics of these special habitats and their surrounding landscapes from late-glacial to modern times.

Changes in the ecosystems recorded in late-glacial and Holocene lakes

In their contribution, Birks & Birks (2013) convincingly demonstrate how rapidly the vegetation responded to the climate changes in the late glacial. These authors use previously published data from the well-explored Kråkenes profile in western Norway (e.g. Birks & Birks 2008), which has the added advantage of many radiocarbon dates and multi-proxy biological data, including that on fossil chironomids. They found that vegetation could change very rapidly, within 10 years, even when summer air temperature (inferred from the independent fossil record of chironomids) changed only by about 2°C. Using a multi-proxy approach, they interpret the changes in the sedimentary sequences in terms of ecological processes and succession. Although their study was done in northern Europe, their contribution is also of great relevance to the reconstruction of past landscapes in central Europe.

Lake sediments are used for the reconstruction of late-glacial and Holocene landscapes in central Europe in other papers in this special issue, Jankovská & Pokorný (2013) for north-western Bohemia and Petr et al. (2013) for south-western Slovakia. Both studies use not only records of pollen but also algae (coccal green algae and diatoms, respectively) to reconstruct the trophic conditions in former lakes and describe in detail the gradual eutrophication of the lake from the late glacial to middle Holocene. Jankovská & Pokorný (2013) focus on multiple sites within a lake and analyse four different profiles, while Petr et al. (2013) focus on a multi-proxy approach, which includes analyses of diatoms and macrofossils, geochemistry and geomorphology, in order to determine the development of the lake in a broad geological and biological context. These studies thus extend our palaeolimnological knowledge to include that for low altitudes in the Czech Republic and Slovakia, which previously was rather scarce and only available for a few specific sites (e.g. Vracov lake in southern Moravia; Rybníček 1983), and make a substantial contribution to tracing the spread of temperate trees after the onset of the Holocene. Together with an analogous study of the warm-spring deposits in southern Slovakia (Hájková et al. 2013) this research confirms the early spread of warm-demanding temperate trees (Pokorný 2011), with sites in Slovakia located at the Pannonian-Carpathian interface probably already colonized during the late glacial from the glacial refugia located somewhere in the Pannonian basin or their moister hilly margins (Petr et al. 2013, Hájková et al. 2013). The hunt for the location of these refugia continues, accelerated by the surprising information recorded in the Bulhary profile at the Pannonian-Carpathian boundary in southern Moravia (Rybníčková & Rybníček 1991).

Interaction between lakes and mires is studied by Ammann et al. (2013). By analysing data from a patterned mire high in the mountains, where small bog lakes (pools) alternate with bog hummocks, they explore the patterns in and causes of transformations between lakes and mires. Two principal results emerge from their research. First, chronological unconformities often occur at the contact zone between lake sediments and peat, which are best explained by deepening of pools by the decomposition of underlying peat. Second, the formation of recent pools was triggered by transhumation during the Bronze Age, which lowered the timberline and thus reduced the evapotranspiration in the catchment area. Overall, agricultural activities during the Bronze Age had a well documented marked effect on central-European mountain landscapes. In this special issue, Jankovská & Pokorný (2013) and Hájková et al. (2013) demonstrate that human settlement did not alter significantly the pollen record before the Bronze Age. Ammann et al.'s paper, however, shows how agriculture, as early as in the Bronze Age, affected even subalpine and alpine zones (Amman et al. 2013).

Persistence of open fens and steppes during the Holocene

The profile from the Vracov lake, analysed by Rybníčková & Rybníček (1972), is among the first rigorously dated Holocene profiles from lowland steppe regions in the former Czechoslovakia. At that time the possibility of natural steppe habitats occurring in central Europe during the forest optimum of the Holocene was discussed. If steppes survived the forest optimum then most of the species confined to dry steppes in this region, including those with a disjunct occurrence, are Pleistocene relicts. For central Europe, there is increasing evidence supporting this assumption (Magyari et al. 2010, Pokorný 2011, Chytrý 2012). Some studies even suggest the same scenario for disjunctly occurring species of semi-dry and mesic grasslands in the Bílé Karpaty Mts, where repeated prehistoric settlement helped these species to survive periods of forest spread (Hájková et al. 2011).

Two papers in this special issue present detailed evidence of this phenomenon for two distant and biogeographically different regions, north-western Bohemia in the rain shadow of the Krušné hory Mts (Jankovská & Pokorný 2013) and the Upper Nitra basin, located at the northern margin of the Pannonian Lowland in the foothills of the Inner-Carpathian mountains in Slovakia (Hájková et al. 2013). Both studies report that open habitats persisted, at least locally, from late glacial throughout the entire Holocene. In pre-Neolithic times these species could have survived because Mesolithic hunter-gatherers used fire to open up forests (as hypothesized by Jankovská & Pokorný 2013 and partially supported by the high amount of microcharcoals recorded by Hájková et al. 2013) or by the browsing of wild large herbivores, as suggested by the findings of *Sporormiella* spores in warm-spring deposits of that period (Hájková et al. 2013). Early-Neolithic colonization of both regions coincides with the creation of a "habitat bottleneck" for non-forest species. In the Western Carpathians, the second bottleneck for light-demanding species occurred during the expansion of *Fagus* and *Carpinus*, but human activities during the Bronze Age enabled light-demanding species to survive (Hájková et al. 2013, Petr et al. 2013).

The question of Pleistocene relicts is commonly discussed in the context of rare fen species with scattered distributions in central Europe (Rybníček 1966, Sádlo 2000, Pokorný et al. 2010, Hájek et al. 2011). In this issue, the study of Hájková et al. (2013) provides evidence of local survival of a rare fen species, *Cladium mariscus,* during the

Holocene and Dítě et al. (2013) focus on *Trichophorum pumilum*, which is considered to be an extremely rare Pleistocene relict in Europe. The latter study summarizes data on its distribution, phytosociology and macrofossil record in Europe and presents the story of its Quaternary history on this continent.

Recent ecology and biogeography of fens

The study of Dítě et al. (2013) is the only one in this special issue in which both recent and historical data are used to explain the current diversity of vegetation. Based on a direct comparison of records of vegetation-plots and a literature review these authors suggest that recent *Trichophorum pumilum* fens in the Western Carpathians have survived locally since the full- and throughout the late glacial and entire Holocene in an ecologically specific habitat, travertine fens. As a consequence, their species composition is analogous to strongly continental halophytic fen grasslands in the Russian Altai Mts, the landscape of which is considered to be similar to that present in full-glacial Europe.

Other studies in this special issue focus on the recent ecology of fens and bogs. Pawlikovski et al. (2013) study the ecological determinants and diversity of vegetation in lowland calcium-rich fens in north-eastern Poland. They record two major types of fen, which differ in the representation of calcareous-fen specialists, which are generally not included in most of recent surveys of vegetation (but see Rybníček et al. 1984). Importantly, they demonstrate that nutrient limitation is the crucial ecological factor delimiting these fens, with those rich in specialist species, many of which are endangered, being phosphorus-limited. Their results reveal the importance of a gradient in phospohorus-limitation within fens, in a single ecologically and biogeographically rather uniform region (Pawlikowski et al. 2013). Analogous results on the distribution of endangered species along a phospohorus-limitation gradient are reported also by Hettenbergerová et al. (2013), but in this case this factor co-varied with moisture.

Other contributions also point to the importance of previously neglected ecological factors. Hettenbergerová et al. (2013) disentangle factors that causally affect species richness, composition and conservation value of extremely small spring fens scattered within the Western-Carpathian grassland mosaic, which were recently the objective of two large cross-taxon projects lead by K. Rybníček (Poulíčková et al. 2005). The study of Hettenbergerová et al. (2013) focuses on the effect of small-scale variations in moisture, possible role of edge effects and a cross-taxon comparison. As to other approaches presented in this special issue, Patberg et al. (2013) draw attention to the role of dissolved carbon dioxide in determining the abundance of submerged sphagna and Aggenbach et al. (2013) to the effects of the oversupply of iron on the occurrence of fen species.

Restoration of mires

The two latter papers (Aggenbach et al. 2013, Patberg et al. 2013) address the question of whether some previously neglected stressful ecological factors may hamper the restoration of bogs and fens. Both studies compare the restoration success of fens with different water- and soil chemistry. Aggenbach et al. (2013) demonstrate that oxidized iron, which accumulates in the topsoil of temporarily drained fens, hampers the establishment of fen specialists after the restoration of the initial water regime. Patberg et al. (2013) indicate that a high availability of carbon dioxide in groundwater is a prerequisite for the successful reestablishment of *Sphagnum* mosses in bog restoration projects. These results indicate that restoration of such a fragile ecosystem as calcareous fen or ombrotrophic bogs can be constrained by unknown factors, which account for poor restoration prospects recorded in many cases. In addition, Holocene peat archives once lost cannot be restored. All these facts are strong arguments for the conservation of the last remnants of mires and immediate intervention to save damaged fens. The conservation of pristine mires based on the principle of preliminary caution in landscape planning seems to be a better way to protect mires than relying on ecological restoration.

To conclude, we believe that this special issue represents a substantial contribution to the ecology and palaeoecology of mires and the papers included will be of special interest to those researchers interested in explaining recent species distributions and patterns of species richness in central Europe.

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