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Developmental diversity of peatlands in Bohemian Forest

Diversita vývoje rašelinišť Šumavy

Lenka Soukupová

Botanický ústav AV ČR, CZ–252 43 Průhonice, Czech Republic

Abstract

(1) Peatlands in the Šumava National Park cover 15 % of the area. This rather high proportion contrasts with their location on the southern boundary of bog distribution. (2) Two opposing processes have been active in the development of basic mire types in Bohemian Forest. In lower altitudes, terrestrialization proceeds even since the Late Glacial usually behind the natural leveés and results in the formation of valley raised-bogs, occupied by *Pinus rotundata* forests (in local toponymy often called niva/luh, Au). On mild slopes of concave palaeorelief between 1000 m and 1250 m, paludification proceeds probably since the Atlantic, and results in the origin of sloping mires with *Pinus x pseudopumilio* krummholz (cf. locally designated as slať, Filz.) (3) Complicated microhydrological differentiation of mire surface into hummocks, ridges, hollows, flarks, lawns, pools, kettle-holes and bog-lakes predetermines highly diversified microenvironments occupied by vegetation of various growth strategy. Ultimate raising of mire surface is controlled by interactive effect of biomass production, necromass accumulation and decomposition differing between the bog (nutrient-poorer) and fen (nutrient-richer) components of the mire complex. (4) Adequate actuo-ecological and palaeo-ecological knowledge of peatlands is desired for decision-making in nature conservation and landscape management of the Bohemian Forest landscape.

Key words: valley raised-bogs, sloping mires, microhydrological pattern, vegetation

Introduction

Peatlands (mires), semiterrestrial ecosystems of permanently or periodically wet oligotrophic sites where accumulation of dead organic matter (necromass) from primary biotic production prevails over its decomposition, are spread between 45 and 75° N. In spite of their latitudinal and altitudinal variation over the Holarctic Realm, they include basic structural and functional features comparable over large territories that are studied by actuoecology.

The opportunity to study these ecosystems has been widely exploited in Fennoscandinavia (Cajander 1913, Osvald 1923, du Rietz 1954, Ruuhijärvi 1960, Eurola 1962, Havas 1961, Dierssen & Dierssen 1978, Malmer 1985, Sjörs 1983), Russia (Botch & Masing 1983), North America (Zoltai & Pollett 1983, Foster et al. 1988), Great Britain (Moore & Bellamy 1973), France and the Alps (Gams 1958, Bortenschlager 1984, Ammann & Lotter 1989). As a result of these studies, peatlands were classified according to their (i) shape and surface morphology, (ii) chemistry, and (iii) vegetation (Moore & Bellamy 1973, Gore 1983). Proposed zonations of mire provinces based on surface morphology are usually interpreted as climate-dependent (Frenzel 1983). However, evaluations of decisive effects suggest that not one but several climatic factors are responsible for differentiation of mire structures. For example, zonation of Finnish peatlands by Ruuhijärvi (1960) coincides with the combination of potential evapotranspiration, mean annual temperature and hydrotermic quotient for summer months. Phytosociological classifications are, on the one hand, marked by higher sensitivity to the surrounding environment. On the other hand, they are rather regional, lacking an unifying overview. In Central Europe, described phytosociological units correspond with minerotrophic differentiation of sites, ombrotrophic nutrient-poor bogs are covered by the *Oxycocco-Sphagnetea*, nutrient-richer fens are occupied by the *Caricetea fuscae*.

For the geomorphology of Bohemian Forest, abundant mire complexes are characteristic (SCHREIBER 1924, SOFRON 1980, KUČERA 1989). Within the Šumava National Park, they cover 15 % of the region, i.e., a proportion comparable with that in Sweden where peatlands are rather common (GORE 1983). [SCHREIBER (1924) gives only 1.1 %, but he involves also foothills with sparse peatlands.] From the other Hercynian ranges, abundant bogs are referred from the oceanic Black Forest (HÖLZER 1977, DIERSSEN & DIERSSEN 1984); occurrence of these ecosystems in the remaining Hercynids is lower (RUDOLPH, FIRBAS & SIGMOND 1928, RUDOLPH 1929, KÄSTNER & FLÖSSNER 1933, LANG 1958, JENSEN 1961, VÁŇA 1962, HADAČ & VÁŇA 1967, RYBNÍČKOVÁ 1966, HÜTTEMANN & BORTENSCHLAGER 1987). Number and area mires in Bohemian Forest contrast with their position on the southern boundary of peatlands in the northern hemisphere (GORE 1983). Morever, they are situated on the transition between oceanic and continental climate with ombric continentality of climate between 7 and 9 %, and they are even partly influenced by southern air currents (NEKOVÁŘ 1969). Complicated geomorphology with a variety of suitable landforms and position on the European climatic crossroads predispose the notable diversity of mire complexes in Bohemian Forest.

The origin of mires in Bohemian Forest

Development of mire ecosystems with characteristic surface pattern and occurrence of specific biota is a complicated process and its knowledge is only partial (KRATZ & DEWITT 1986; PAYETTE 1988). Certain detection of these processes is possible due to macroremains deposited in peat profiles (SVENSSON 1988). Secular changes of the mire and development of surrounding landscape may be further reconstructed from the information on the pollen stored in the peat profile, supplemented by the informations on archeobotany and human settlements. Global problems on the development of palaeo-ecosystems, and the special issue of development in vegetation subsystems, and succession trends in formation of palaeo-vegetation and human influence on the vegetation in the past 15 000 years are studied by palaeoecology (HUNTLEY & BIRKS 1983, BERGLUND 1986, LANG 1994).

Viewing global dynamics of water level in the bogs, two contrasting processes are decisive in their formation – terrestrialization and paludification (MALMER 1975, FRENZEL 1983). The former process is characteristic by long-term filling up of depressions with subsequent decline of wetness, while the latter process is marked by gradual swamping of a terrestrial area. In the temperate zone, as a result of terrestrialization, raised bogs have usually developed with the bottom covered by limnic sediments (RYBNÍČEK 1973, MALMER 1975, GORE 1983). Paludification usually prevails on mild waterlogged slopes where blanket bogs and/or sloping mires arose in temperate to boreal zone. GRANLUND (1932) found that paludification started in periods of increased climatic wetness what corresponds with the fact that, in general, such mires are younger. As the former process is better comprehensible, its knowledge is more detailed. The latter process is more complicated and not fully understandable, and therefore alternative explanations have been suggested as regards their development (KULCZYNSKI 1939/40, HEINSELMAN 1963). In the formation of mires in Bohemian Forest both processes have been active (Fig.1).

Mires in Bohemian Forest are spread within a wide altitudinal range of 700 m, with mean

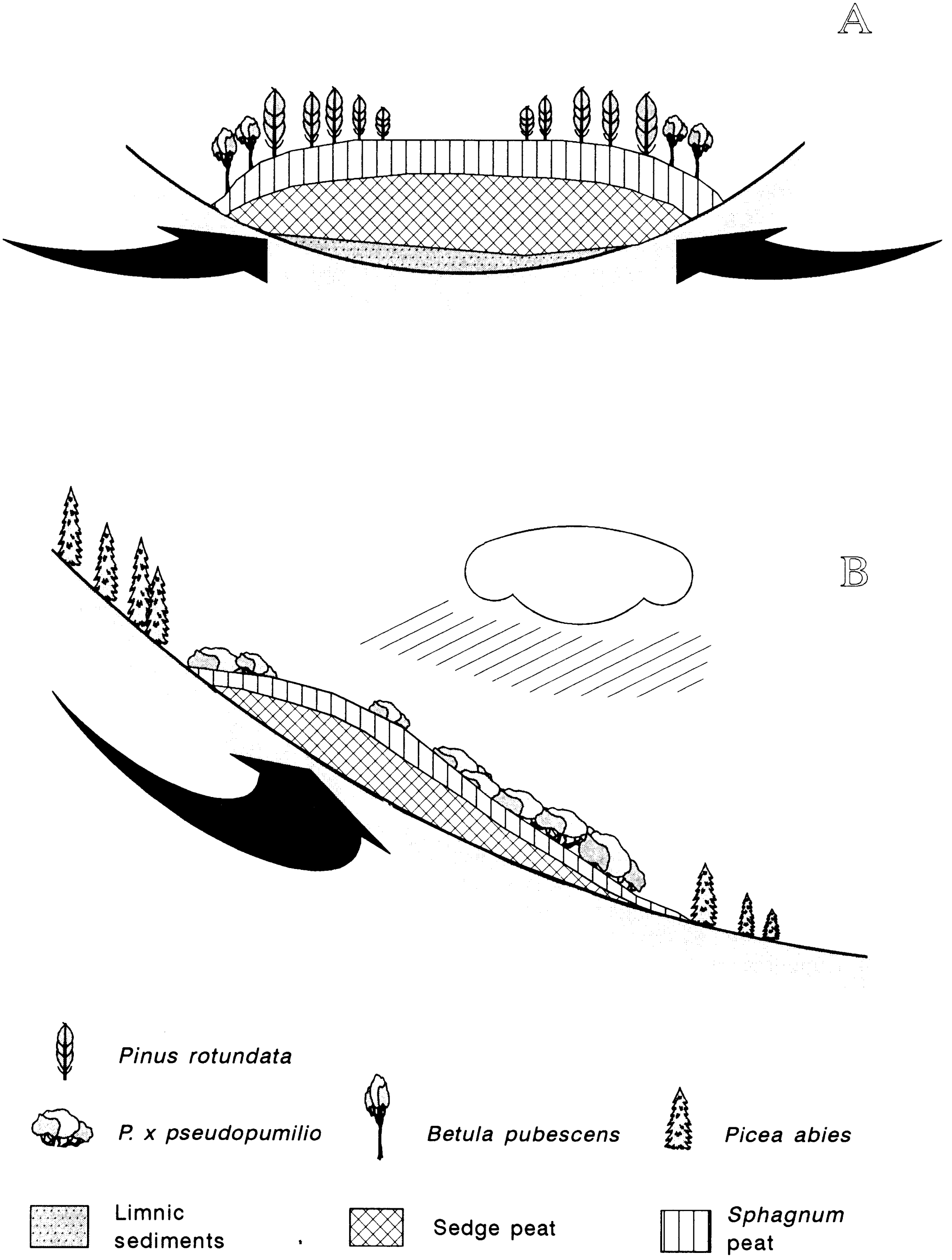

Fig. 1. – Alternative development in peatlands of the Bohemian Forest: (A) valley raised-bogs have been formed by terrestrialization, usually behind natural leveés under the influence of high water table, (B) sloping mires have been formed by paludification, in the surroundings of springs on mild slopes of concave palaeorelief exposed to high precipitation. Black arrows indicate the direction of main water income.

annual precipitation reaching from 729 to 1552 mm. Different geology, landforms, and mesoclimate predetermine basic hydrological and hydrochemical factors of the peatbogs, and predispose remarkable richness of their surface pattern. This variability is even reflected by local toponymy: for the designation of valley-raised bogs the cognomen „luh, niva (Au)“ is often used, sloping mires are mostly, but not consequently, called „slať (Filz)“.

In lower altitudes where material from retrograde erosion was deposited (Šebesta 1996), terrestrialization was active in the development of valley-raised bogs behind natural leveès, e.g., Mrtvý Luh (735 m), Malá Niva (755 m), Chalupská slať (915 m), Hůrecká slať (870 m). As it is documented by pollen analyses, formation of these bogs might started already in the Late Glacial (Hůrecká slať : Svobodová 1995). Peat depth attains up to 7.2 m (Mrtvý Luh: Rybníček 1989). At present, valley-raised bogs are partly or completely forested by the *Pino rotundatae-Sphagnetum*. Open central parts lack bog-lakes and are occupied by the *Sphagnetum fusci*. This type is marked by prominent laggs with communities of the alliances *Sphagno recurvi-Caricion canescentis, Betulion pubescentis* and *Calthion*.

Suitable gentle slopes of extensive plain palaeorelief in the central Šumava between 1000 and 1200 m are covered by sloping mires. High precipitation (annual mean between 1000 to 1500 mm), and relatively low temperature with annual mean between 3 and 4 °C (Nekovář 1969) predisposed paludification process (e.g., in Rokytecká slať , Blatenská slať , Rybárenská slať , Tetřevská slať). Pollen-derived dating of their profiles (Klečka 1928) suggests their origin in the Atlantic. The mires mostly include several smaller bog centres with bog-lakes; peat depth reaches up to 5.5–6.5 m (Pohořal 1964). They are marked by occurrence of *P. x pseudopumilio* (*Pinus mugo x P.rotundata*) krummholz, belonging usually to the association *Sphagno magellanici-Pinetum mughi*. Open central parts are mostly covered by the alliance *Oxycocco-Empetrion hermaphroditi* (namely by the *Sphagno magellanici-Trichophoretum caespitosae*). Numerous depressions (see below) are occupied by several communities of the *Leuko-Scheuchzerion*. (Sofron & Šandová 1972, Sofron 1980, pers.observ.).

Microtopographic differentiation

Undulating surface pattern of peatlands is related mutually with microhydrological pattern of surface. Dried parts, usually hummocks or ridges covered by xeromorphic vegetation, alternate with shallow waterlogged depressions, like hollows, flarks or lawns occupied by emergent macrophytes and floating moss-mats, and occassionally deep waterbodies appear, such as little bog-lakes or pools with open water. Each of the mentioned structures represents an unique microhabitat with vegetation of different growth ecology (Clymo 1992). Blue-green algae (Granhall & Selander 1973, Lederer 1996), lichens, mosses (Lindholm 1990, Rochefort et al. 1990, Rydin 1993), graminoids (Clymo 1970), forbs and ericoid shrubs (Wallén 1986), and woody species (Krisai 1973) play their special role in the building of bog surface and superficial water flows on the mire. A growing mire performs an intermittently changing environment passing up and down the hydrological limit. To highlight organization within mire ecosystems with special regard to interactions between dominant life forms and to assess the balance between production and decomposition processes on different sites of the microtopography, in relation to physical parameters (microclimate, pedology, hydrochemistry, microhydrology) is the main goal of actuo-ecological research.

Depressions noted by enormous variety of shapes and types (Masing 1982), are of special importance also in the succession of bogs in Bohemian Forest. In mud-bottom and tussock-bordered hollows, decomposition prevails above accumulation and the countour is often maintained by resistant *Eriophorum vaginatum* (Hosiaisluoma 1975, Jeník & Soukupová 1992). For occasionally and/or permanently inundated lawns, with green carpets of *Sphag-*

num dusenii, S. cuspidatum, Drepanocladus fluitans, Carex limosa, Scheuzeria palustris, and *Rhynchospora alba* (on southern foothills) small-scale terrestrialization is expected (KRISAI 1971, KUČERA 1995). However, JOHNSON, DAMMAN & MALMER (1991) found that decomposition rate of dead mosses in lawns was higher than in the surface-raising wet hummocks, on Šumava occupied by *Sphagnum magellanicum, S. fuscum, S. balticum, S. rubellum, Polytrichum strictum, Eriophorum vaginatum, Carex pauciflora, Oxycoccus palustris, Andromeda polifolia*. In contrary, dry hummocks covered by lichens, *Calluna vulgaris, Empetrum hermaphroditum, Vaccinium uliginosum, Betula nana,* and dwarfed *Pinus x pseudopumilio*, represent stagnation and/or decaying phases of mires. Thus both processes of decomposition and accumulation operate hand in hand (SJÖRS 1990, MALMER 1992), and result in a complicated pattern of different micro-forms covered by a varying mixture of well-adapted vegetation that is difficult to deal with (AARTOLAHTI 1965, VERRY 1984, SJÖRS 1990, BACKÉUS 1991). This problem in Šumava mires, namely in the Luzenská slať, was already touched by KUČERA (1995: p. 97) who was quite indecisive about the fate of different depressions in the development on mire surface.

Differing ability of plant populations as regards water level is challenging for derivation of successional hydroseres that coincide with small-scale terrestrialization (e.g., SOFRON & ŠANDOVÁ 1972, RYBNÍČEK & RYBNÍČKOVÁ 1974). Such series are useful in the interpretation of relationships among the mire communities. In the last 2000 years, however, PAYETTE (1988) reconstructed cyclic successions. In this respect, prevailence of one-way successional trends in the abovementioned proposed hydroseres is astonishing, and the opposite process should be reconsidered. Moreover, microhydrology is not the only decisive factor in this development. MALMER (1992) brought attention to different humification in relation to availability of minerals in different parts of mires: about a fifth of annual litter production is accreted into bog-peat (cf. wet hummocks), and three–times less into fen-peat (depressions, laggs). Also this setup between nutrient-poorer and nutrient-richer microhabitats implicates how fragile the balance among the processes controlling the development of peatlands is. Adequate actuo-ecological research of these components will advance understanding of biodiversity in these ecosystems in Bohemian Forest range.

Conclusions

Peatlands, as ecosystemic islands of specific structure and development, are decisive for developmental analysis of biodiversity and ecological classification mountain region of Bohemian Forest. In the Hercynian mountains, and in Bohemian Forest particularly, they provide a key for understanding of biotic development in Europe since the Late Glacial. Extensive bogs and fens in Bohemian Forest range, with their extraordinary variability of surface structures and multiple environmental diversification, have been providing a framework for long-term survival and mixing of relic elements and species immigrating from warmer habitats and from the Alps (SPITZER 1981, MIKKOLA & SPITZER 1983, HADAČ & VÁŇA 1967, LEDERER 1996). Recent overloading by eutrophication and drainage makes these ecosystems highly threathened (TWENHÖVEN 1992) and further research is urgently needed. In particular, viewing the dramatic dynamics in polluted mountain regions of Czech Republic, this knowledge is needed as a basic decision-making criterion for the predictions of management in nature reserves and landscape, and in Šumava Biosphere Reserve, particularly.

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Souhrn

(1) V Biosférické rezervaci Šumava rašeliniště zaujímají zhruba 15 % rozlohy, což je podíl charakteristický pro území častého výskytu rašelinišť (např. Švédsko), zatímco pro oblast na jižní hranici rozšíření rašelinišť je tato hojnost neobvyklá.

(2) Šumavská rašeliniště se vyskytují v přibližně 700-metrovém výškovém rozmezí, v jeho rámci se na tvorbě těchto ekosystémů podílely rozdílné geologické, geomorfologické, klimatologické i biotické faktory. Z hlediska určujícího vodního režimu se pak při jejich formování účastnily dva alternativní procesy – terestrializace (zazemňování) a paludifikace (zvodnění). Za agradačními valy toků se v nižších nadmořských výškách při genezi *údolních vrchovišť* (lokálně zvaných niva/luh, Au) uplatňovala terestrializace, a to mnohdy již od pozdního glaciálu. *Svahová rašeliniště* na mísovitých svazích paleoreliéfu mezi 1000 a 1250 m n.m. s výstupy pramenů formovala od atlantiku paludifikace (typ obvykle, ale ne soustavně nazývaný slať, Filz). Dominantní dřevinou na údolních vrchovištích je stromovitá borovice blatka (*Pinus rotundata*), na svahových rašeliništích pak klečovitý kříženec borovic blatky a kleče, tzv. borovice bažinná (*P. x pseudopumilio*).

(3) Komplikovaná mikrohydrologická diferenciace rašeliništního povrchu s kopečky (bulty), pásy, sníženinami (šlenky), prohlubněmi, třasovisky, járky, nádržkami, kolky a rašeliništními jezírky předurčuje vysokou rozrůzněnost mikrobiotopů, obsazených vegetací odlišné růstové dynamiky. Samotné narůstání ložiska pak je výsledkem interaktivně působících procesů produkce biomasy, akumulace a dekompozice nekromasy, které se odlišují mezi oligo- (rašeliništními) a minerotrofnějšími (slatinnými) komponentami rašeliništních komplexů.

(4) Šumavská rašeliniště jako ostrovní ekosystémy se specifickou strukturou a vývojem představují jednu ze základních složek šumavské biodiversity. Je proto třeba definovat jejich hodnotu vyváženě s ohledem na aktuoekologické a paleoekologické poznání a využít těchto znalostí při rozhodování o způsobu hospodaření na území Biosférické rezervace Šumava.

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