Oecologia Montana 2011,
20, 33 - 35

Variation in the species composition of bryophytes as influenced by chemical composition of rocky substratum, The Western Carpathians

R. ŠOLTÉS[1] and S. PAVLARČÍK[2]

[1]*Institute of High Mountain Biology, Univerzity of Žilina, Tatranská Javorina 7, 05956-SK, Slovak Republic, e.mail: rudolf.soltes@uniza.sk;* [2]*Research Station of the Tatra National Park, State Forests, SK-05960 Tatranská Lomnica, Slovakia; e-mail: pavlarcik@centrum.sk*

Abstract. Bryophytes are widely used for monitoring of heavy metal deposition. Nevertheless, the data on bryophyte occurence related to rock chemistry are rare. Well documented is e. g. the group of copper-loving bryophytes. The goal of this paper is to relate the occurence of bryophytes to rock chemistry. The investigation was focused to 11 predominantly mountainy, less rural sites throughout the West Carpathians, Slovakia. All the relevés were collected using the Tansley's sampling scale. The data were plotted onto CCA ordination diagram, for statistical analysis was used CANOCO 4.5 package for Windows. *Brachythecium velutinum* showed significant correlation with copper, the others correlations are insignificant.

Key words: heavy metals, The Western Carpathians, rocks, ordination analysis

Introduction

Bryophytes are an important component of biodiversity. They respond more quickly to environmental change like atmosphere and metal contamination than vascular plants, because of great exchange capacity, absence of a cuticle and simple tissue organisation. Bryophytes are widely used to measure heavy metal air pollution.

Rocks being weathered, elements free themselves from relatively insoluble minerals (Bates, 1978). In order to relate bryophyte species-richness and composition to climate and stand structure, Humphrey *et al.* (2002) compared bryophyte communities of spruce and pine plantations in different parts of Britain. The main substrata assessed were rocks, cliffs (where occurred) and mature trees. The rocks were found unimportant and were excluded from data analysis. Nevertheless, rocks are an important habitat for bryophytes because in exposed places competition from vascular plants is reduced by the exposure to winter winds and cold temperatures and overheating in the summer (Hallingbäck *et al.* 1995).

Data on interrelationship between bedrock chemistry and bryophytes are very rare. Xiang *et al.* (2010) studied the content characteristics of Ca, Mg and Zn in bryophytes from different geological settings in Chine, Hubei province. They found that the enrichment degree of metal element in bryophytes depends on geological background and on the species. Weibull & Rydin (2005) studied bryophytes growing on siliceous boulders (diameter 50–200 cm, 145 boulders) in two forests in east-central Sweden. The authors found that litter seepage and exposure had significant effect. Kataeva *et al.* (2004) investigated the concentration of some oxides (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, Cr, Ni) in tundra soils and plants of ultramafic and acid rocks in the Polar Urals. The close dependence of soils chemical composition with that of the underlying bedrock was shown.

The aim of this work is to relate the floristic data to bedrock characteristics and to identify a bioindicative value based on statistical analysis of floristic and bedrock chemistry data.

Material and Methods

The survey is based on the analysis of 11 bryophytes records taken in the Western Carpathians sites in Slovakia (The Tatra Mts, Volovské vrchy Hills, Ľubovnianska vrchovina). This is predominant a mountainy, less rural site. All the relevés were taken using the 3-degree Tansley's sampling scale. Eleven records were made in eleven study sites (Table 1).

CANOCO 4.5 for Windows package was used for statistical analysis. Since the length of the first gradient in the log report was > 4, we used the unimodal method - CCA (Ter Braak & Šmilauer 2002). The statistical significance of the explanatory (environmental) variables in canonical methods were determined by Monte Carlo permutation tests. Explanatory variables were tested separately (partial tests).

Nomenclature of the bryophytes follows Kubinská & Janovicová (1998), metals presence in the bedrock follows Grecula *et al.* (1995).

For ecological interpretation of the ordination axes, types of bedrock were plotted onto CCA ordination diagram as categorical supplementary environmental variables.

Sampled sites characteristics

1. The High Tatra Mts., Svišťová dolinka Valley, area 2 x 2 m^2, substratum hematite, trace metal Fe, altitude 1440 m a.s.l., August 26, 1998.

Results and Discussion

Record No	1	2	3	4	5	6	7	8	9	10	11
Ptychodium plicatum	1	0	0	0	0	0	0	0	0	0	0
Schistidium boreale	1	0	0	0	0	0	0	0	0	0	0
Schistidium atrofuscum	1	0	0	0	0	0	0	0	0	0	0
Plagiomnium rostratum	1	0	0	0	0	0	0	0	0	0	0
Brachythecium velutinum	1	0	0	2	2	2	0	1	1	1	2
Homalothecium philippeanum	2	0	0	0	0	0	0	0	0	2	0
Sanionia uncinata	1	0	0	0	0	0	0	0	0	0	0
Tortella tortuosa	1	0	0	0	0	0	0	0	0	2	0
Bryum elegans	1	0	0	0	0	0	0	0	0	0	0
Gymnostomum aeruginosum	1	0	0	0	0	0	0	0	0	0	0
Callicladium haldanianum	1	0	0	0	0	0	0	0	0	0	0
Orthothecium intricatum	1	0	0	0	0	0	0	0	0	0	1
Dicranella heteromalla	0	1	1	1	0	0	0	0	0	0	0
Pleurozium schreberi	0	2	0	0	0	0	0	0	0	0	0
Hypnum cupressiforme	0	2	0	1	0	0	0	0	0	0	0
Polytrichum piliferum	0	0	1	0	0	0	0	0	0	0	0
Kiaeria blyttii	0	0	1	0	0	0	0	0	0	0	0
Gymnomitrion coralloides	0	0	1	0	0	0	0	0	0	0	0
Polytrichum alpinum	0	0	2	0	0	0	0	0	0	0	0
Andreaea rupestris	0	0	1	0	0	0	0	0	0	0	0
Arctoa fulvella	0	0	1	0	0	0	0	0	0	0	0
Taxiphyllum wissgrillii	0	0	0	1	0	0	0	0	0	0	0
Pohlia nutans	0	0	0	2	0	0	0	0	0	0	0
Polytrichum formosum	0	0	0	0	0	0	2	0	0	0	0
Rhytidiadelphus squarrosus	0	0	0	0	0	0	2	0	0	0	0
Plagiomnium affine	0	0	0	0	0	0	2	0	0	0	0
Homalothecium sericeum	0	0	0	0	0	0	0	2	0	0	0
Ceratodon purpureus.	0	0	0	0	0	0	0	0	2	0	0
Neckera crispa	0	0	0	0	0	0	0	0	0	2	0
Ctenidium molluscum	0	0	0	0	0	0	0	0	0	2	0
Distichium capillaceum	0	0	0	0	0	0	0	0	0	0	2
Oreoweisia serrulata	0	0	0	0	0	0	0	0	0	0	1

Table 1. Sampled sites, bryophytes records

2. Volovské vrchy Hills, slag heap near Bindt, area 2 x 1 m^2, trace metal Fe, altitude 610 m a.s.l., June 3, 1998.
3. The High Tatra Mts., Kriváň Mt. substratum mylonite, hydrothermal silicic veins with patches of antimonite, 2 x 1 m^2, trace metals Sb, Fe, Au, altitude 2120 m a.s.l., September 5, 1998.
4. Volovské vrchy Hills, Tichovodská dolina Valley, substratum siderite (dom.), pyrite, chalkopyrite, 2 x 2 m^2, trace metals Cu, Fe, altitude 863 m a.s.l., June 3, 1998.
5. Volovské vrchy Hills, Banský vrch Hill, Brickwork of the smelter, area 1 m^2, trace metal Cu, altitude 720 m a.s.l., October 10, 1998.
6. Volovské vrchy Hills, near Slovinky, substratum siderite, area 1 m^2, trace metals Cu, Fe, altitude 760 m a.s.l., October 10, 1998.
7. Volovské vrchy Hills, near Henclová, substratum limonite, area 2 x 1 m^2, trace metal Fe, altitude 760 m a.s.l., June 3, 1998.
8. Volovské vrchy Hills, near Poráč, substratum siderite, area 1 m^2, trace metals Cu, Fe, As, altitude 790 m a.s.l., June 4, 1998.
9. Volovské vrchy Hills, Rudňany, substratum siderite, area 1 m^2, trace metals Cu, Fe, As, altitude 630 m a. s. l., June 4, 1998.
10. Ľubovnianska vrchovina, Podsadok, middle jurassic crinoidal limestone with patches of manganese minerals, area 2 x 2 m^2, trace metal Mn, altitude 730 m a. s. l., September 10, 1999.
11. The High Tatra Mts., Veľká Svišťovka, substratum mylonite, hydrothermal silicic veins with patches of ankerite and chalkopyrite, area 1 m^2, trace metals Cu, Fe, altitude 1725 m a. s. l., September 13, 1999.

The only heavy industry, smelter in Krompachy is approximately 10 km NNE from the site Nr 6 – Volovské vrchy Hills, near Slovinky. Production of the plant was much reduced during the last two decades. There is no another heavy industry or power stations within 50 km.

There are more forest bryophytes in Table 1 (*Polytrichum formosum, Pleurozium schreberi, Rhytidiadelphus squarrosus* and others), because some typically forest species can occur in sheltered situations in boulder cavities (Hallingbäck *et al.* 1995).

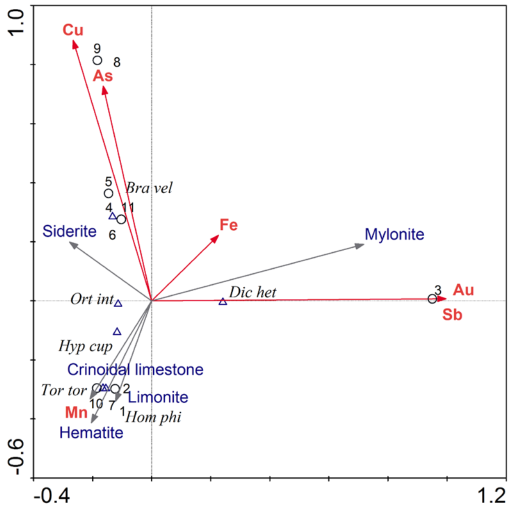

Fig. 1. Canonical correspondence analysis (CCA), triplot, ordination diagram of sampled sites, trace metals and selected plants. Species list: Bra vel – *Brachythecium velutinum*, Ort int – *Orthothecium intricatum*, Hyp cup – *Hypnum cupressiforme*, Tor tor – *Tortella tortuosa*, Hom phi – *Homalothecium philippeanum*, Dic het – *Dicranella heteromalla*.

The first axes explains 30.1 % of species-environment relation (Eigenvalue 0.90), this axis highly correlates with Sb (r=0.99) and explaines 15.0% of the variance of the bryophytes and is associated with mylonites (r=0.71).

The second axis explains 26.0% of species-environment relation (Eigenvalue 0.78), this axis correlates with Cu (r=0.87), in a lesser extent with As (r=0.77) and explaines 12.9% of the variance of the bryophytes.

For bryophytes is characteristic nutritional indepedence on the substratum, but in some cases is proved relation between bedrock chemistry and bryophytes occurence. Many publications have reported observations on what seemed to be copper-loving bryophytes. Such species belong mainly to the genera *Dryptodon, Gymnocolea, Merceya, Mielichhoferia* and *Scopelophila* (Cuny 2004). Highly correlated bryophyte with Cu is *Brachythecium velutinum* (p=0.002), all the other correlations are insignificant.

Acknowledgement

The investigation was founded by Norwegian Financial Mechanisms under the research project SK-0061.

References

Bates, J.W. 1978: The influence of metal availability on the bryophyte and macrolichen vegetation of four rock types on Skye and Rhum. *Journal of Ecology*, **66:** 457– 482.

Cuny, D., Denayera F. O., Foucaulta, B., Schumackerb, R., Coleinc, P. and Haluwyna, C. 2004: Patterns of metal soil contamination and changes in terrestrial cryptogamic communities. *Environmental Pollution*, **129:** 289–297.

Grecula, P. et al., 1995: Ložiská nerastných surovín Slovenského rudohoria, zväzok 1. Geocomplex, pp. 834.

Hallingbäck, T., Hodgetts, N., Raeymaekers, G., Schumacker, R., Sérgio C. and Urmi E. 1995: Red Data Book of European bryophytes. European Commitee for the Conservation of Bryophytes, Trondheim, pp. 291.

Humphrey, J. W., Davey, S., Peace, A. J., R. Ferris, R. and Harding K. 2002: Lichens and bryophyte communities of planted and semi-natural forests in Britain: The influence of site type, stand structure and deadwood. *Biological Conservation*, **107:** 165–180.

Kataeva, M. N., Alexeeva-Popova, N. V., Drozdova, I. V. and Beljaeva, A. I. 2004: Chemical composition of soils and plant species in the Polar Urals as influenced by rock type. *Geoderma*, **122:** 257–268.

Kubinská, A. and Janovicová, K. 1998: Bryophytes. In *Checklist of non-vascular and vascular plants of Slovakia* (eds. Marhold K. and Hindák F.), pp. 297–332. Veda, Bratislava.

Ter Braak, C. J. F. and Šmilauer, P. 2002: CANOCO reference manual and CanoDraw for Windows user's guide. Software for canonical community ordination (version 4.5). – Biometris, Wageningen & České Budějovice.

Weibull, H. and Rydin, H. 2005: Bryophyte species richness on boulders: relationship to area, habitat diversity and canopy tree species. *Biological Conservation* **122:** 71–79.

Xiang, J., Li, Z., Fang, Y., Wu, G., Li, W. and Fan, Y. 2010: Analysis of Ca, Mg and Zn Contents in Bryophytes from Different Geological Settings. *Procedia Environmental Sciences*, **2:** 1422–1428.