REMARKS ON SPRING VEGETATION (THE *MONTIO-CARDAMINETEA* CLASS) IN THE REPUBLIC OF NORTH MACEDONIA

Poznámky k vegetaci pramenišť (třída *Montio-Cardaminetea*) v Severní Makedonii

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Abstract:
Presented here are phytosociological relevés from two bryophyte--dominated spring communities of the *Montio-Cardaminetea* class in the Republic of North Macedonia. Both vegetation types had been insufficiently documented or had not even been distinguished in the region. The first alliance, *Lycopodo europaei-Cratoneurion commutati*, comprises vegetation of calcium-rich woodland springs with calcium carbonate precipitation. The second alliance, *Cratoneurion commutati*, represents high-mountain calcium-rich spring communities. According to our knowledge, neither of the alliances had previously been documented by phytosociological relevés in the country.

Keywords:
Balkan Peninsula, bryophytes, *Cratoneurion commutati*, *Lycopodo--Cratoneurion*, phytosociological relevé, plant communities, vegetation classification

INTRODUCTION

Springs are island-like habitats developed at sites with permanent water flow. Bryophytes are important components and frequent dominants of spring vegetation (Persson 1961, Hadač 1983, Zeichmeister & Mucina

1994, Hájek 2000). From the point of view of vegetation classification following the Braun-Blanquet phytosociological approach, plant communities of cold oligotrophic water-springs and mountain brooks in the nemoral to arctic zones and in the oromediterranean belt of Europe are traditionally placed within the *Montio-Cardaminetea* class (Mucina et al. 2016).

Vegetation of the *Montio-Cardaminetea* class has been studied with varying intensity in different European regions and countries. For example, there are only a few studies on spring vegetation in the Republic of North Macedonia. Horvat (1960) reported two alliances within the class: *Cardamino-Montion* comprising spring vegetation on siliceous bedrock and *Cratoneurion commutati* comprising spring communities on calcium--rich bedrock. In the same vegetation survey, the latter alliance was represented only by the '*Saxifraga aizoides* Hr. 1935' association that was delimited by the presence of *Saxifraga aizoides* and *Palustriella falcata.* The same vegetation units were distinguished also by Amidžic et al. (2012) in the Shar Planina Mts. Both the aforesaid studies, however, provide only a syntaxonomical synopsis accompanied by a description of individual vegetation types without a presentation of full phytosociological relevés (vegetation plots). From the southern part of North Macedonia, Čarni & Matevski (2010) further described the alliance of *Pinguiculo balcanicae--Cardaminion raphanifoliae* (including the association of *Pediculari limnogenae-Saxifragetum stellaris* Čarni et Matevski 2010), which harbours a wide array of Balkan endemics. Finally, one relevé, sampled in the Korab Mts and assigned to the *Cratoneurion commutati* alliance, was published by Puglisi et al. (2013). The authors, however, focused solely on the moss layer and did not consider vascular plants.

During our extensive phytosociological research of fen vegetation in the central and western part of the Balkan Peninsula in 2014, we recorded two phytosociological relevés from two springs, the vegetation of which was later classified in the two alliances: *Lycopodo europaei-Cratoneurion commutati* (association *Brachythecio rivularis-Cratoneuretum* Dierßen 1973) and *Cratoneurion commutati* (community with *Palustriella decipiens*). To our best knowledge, the first alliance had not previously been recognized in North Macedonia whereas the latter had been only poorly documented (cf. Puglisi et al. 2013). This short paper aims to report the occurrence of both alliances by providing their full species composition accompanied by a description of the physical characteristics of the localities.

METHODS

The cover of both bryophytes and vascular plants in vegetation plots was estimated using the nine-grade Braun-Blanquet scale (van der Maarel 1979). Geographic coordinates were obtained using a portable GPS device (WGS-84 system). Water pH and conductivity were measured *in situ* (i.e.

directly in springs) using portable instruments (GMH Greisinger). The nomenclature follows Ros et al. (2007) for hepatics, Ros et al. (2013) for mosses and the Euro+Med database (2006–2020) for vascular plants. Names of syntaxa are in accordance with Mucina et al. (2016), the first comprehensive and critical account of European high-rank syntaxa; in other cases, author citations are quoted with the first reference.

RESULTS AND DISCUSSION

Moss-rich calcareous woodland spring (*Lycopodo europaei-Cratoneurion commutati*)

The following phytosociological relevé was sampled near the Ribnica settlement in the north-western part of the country.

Relevé 1. Ribnica, 1.6 km ESE of the settlement, near the road from Ribnica to Nistrovo, 960 m a.s.l., coordinates: 41°42'57.8"N, 20°37'43.5"E ± 20 m; 8 m^2; pH: 7.7; conductivity: 288 µS/cm; 27 July 2014; T. Peterka, V. Kalníková, S. Palpurina & Z. Plesková.
E_{total} (65%), E_0 (65%): *Palustriella commutata* 4, *Pellia endiviifolia* 2a, *Eucladium verticillatum* 1, *Cratoneuron filicinum* +, *Rhizomnium punctatum* +.

This spring-like community occurred on a rocky wall with nearly vertical inclination, down-flowing water and calcium carbonate precipitation (Fig. 1). The locality was surrounded by broadleaved woodlands.

The EuroVegChecklist (Mucina et al. 2016) classifies the vegetation of springs with calcium carbonate precipitation under woodland canopies within the *Lycopodo europaei-Cratoneurion commutati* alliance. The alliance is further recognized in several national or regional vegetation overviews in Central Europe (e.g. Dierßen 1973, Hájková & Hájek 2011). In accordance with the above-mentioned vegetation surveys, we provisionally classify the vegetation within the association *Brachythecio rivularis-Cratoneuretum commutati.* Diagnostic species of this vegetation type are the calcicole bryophytes *Palustriella commutata* (frequent dominant), *Eucladium verticillatum* and *Pellia endiviifolia* (Hájková & Hájek 2011). Bryophytes mostly predominate over herbs; the herb layer might be even absent, as in our case. For a syntaxonomical synopsis see Appendix 1. Stands with a high cover of *P. endiviifolia* can also be classified into a separate association named *Pellio endiviifoliae-Cratoneuretum commutati* Rivola 1982 (e.g. Valachovič 2001). We provisionally consider association of *Pellio endiviifoliae-Cratoneuretum commutati* synonymous with that of *Brachythecio rivularis-Cratoneuretum commutati*, as there are rather small floristic and ecological differences between these associations. However, the relationship of these two syntaxa deserves further research and goes beyond the scope of our contribution.

Both the alliance and subordinate association might have been previously overlooked in North Macedonia because of their assignment to the broadly delimited *Cratoneurion commutati* alliance. However, the *Cratoneurion commutati* was originally described as the vegetation of alpine and subalpine springs (Koch 1928; see also Geissler 1976, Hájková & Hájek 2011), whereas the *Lycopodo-Cratoneurion* comprises woodland springs below the timberline, frequently with an admixture of woodland species. Nevertheless, the assessment of the real distribution area of the alliance in Europe might be possible only based on a broad-scale synthesis of spring vegetation plot data.

Calcareous spring in the subalpine belt (*Cratoneurion commutati*)

The following relevé was sampled at the Begovo Pole site. This important wetland area is located 6 km to the west of the village of Gorno Jabolchishte and 2–3 km to the north-northeast of the Solunska Glava peak (2,538 m a.s.l.) of the Jakupica range. For further information on the locality see Micevski et al. (2008) or Peterka et al. (2016).

Relevé 2. Gorno Jabolchishte: Begovo Pole, ca 1,965 m a.s.l., coordinates: 41˚43 '30.0"N, 21˚25 '06.0"E ± 2 m; 4 m^2; pH: 7.6; conductivity: 210 µS/cm; 25 July 2014; T. Peterka & Z. Plesková.
E_{total} (85%), E_0 (85%): *Palustriella decipiens* 5.
E_1 (5%): *Deschampsia cespitosa* 1, *Carex nigra* +, *Epilobium* sp. +, *Equisetum palustre* +, *Nardus stricta* +.

With respect to the location of the spring at the timberline, calcium-rich water, as suggested by high pH and conductivity, and the prevalence of *Palustriella decipiens* in the moss layer, we consider this plant community closely related to the *Cratoneurion commutati* alliance. Horvat (1960) already distinguished this alliance in North Macedonia; however, he reported only one association denoted as '*Saxifraga aizoides* Hr. 1935'. This vegetation type might correspond to the association *Cratoneuro--Saxifragetum aizoidis* Nordhagen 1936, which is characterized by the constant presence of *Saxifraga aizoides* and by the occurrence on steep slopes, screes, or gravel substrates with running water (Hadač 1983, Valachovič 2001). For this reason, this vegetation type seems to be different from that recorded at Begovo Pole. The syntaxonomical overview of wetlands in high mountains in Bulgaria (Hájková et al. 2006) classifies springs with *Palustriella decipiens* in the rather broadly delimited association of *Cratoneuretum falcati* Gams 1927. However, Bulgarian stands frequently harbour other spring specialists such as *Carex ferruginea*, *Silene pusilla* and *Viola biflora*. Relevés recorded originally by Gams (1927) further considerably differs from our plot by the absence of *P. decipiens*, the dominance of *P. falcata* in the moss layer and the presence of fen specialist species (e.g. *Carex davalliana*, *Eriophorum angustifolium*,

E. scheuchzeri). For these reasons, we provisionally refer to the spring vegetation in Begovo pole as a '*Palustriella decipiens* community'. A similar approach to the classification of stands dominated by *P. decipiens* was taken, for example, by Philippi (1975). This again suggests that further research and a syntaxonomical evaluation of Balkan springs based on the analysis of phytosociological relevés are needed.

SHRNUTÍ

Prameništní vegetace třídy *Montio-Cardaminetea* byla v Severní Makedonii prozatím spíše opomíjena. V tomto příspěvku přinášíme informaci o výskytu svazu *Lycopodo europaei-Cratoneurion commutati* a jemu podřízené asociace *Brachythecio rivularis-Cratoneuretum commutati*. Tato vegetace zahrnuje společenstva vápnitých lesních pramenišť, na kterých dochází ke srážení pěnovce. V Severní Makedonii nebyl svaz *Lycopodo-Cratoneurion* dosud samostatně rozlišován. Fytocenologickým snímkem dokumentujeme take subalpínské vápnité prameniště blízké svazu *Cratoneurion commutati* s převahou druhu *Palustriella decipiens*.

Fig. 1. Rocky wall with down-flowing water and spring-like vegetation of the *Lycopodo europaei-Cratoneurion commutati* alliance near the Ribnica settlement, 27 July 2014. Photo by V. Kalníková.

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Appendix 1. Syntaxonomical synopsis of recorded phytosociological units.

Montio-Cardaminetea Br.-Bl. et Tx. ex Klika et Hadač 1944
Montio-Cardaminetalia Pawłowski et al. 1928
Cratoneurion commutati Koch 1928
Palustriella decipiens community
Lycopodo europaei-Cratoneurion commutati Hadač 1983
Brachythecio rivularis-Cratoneuretum Dierßen 1973