

CONTRIBUTIONS TO THE BRYOPHYTE FLORA OF SERBIA: OVČAR, KABLAR, AND VUJAN MTS

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Abstract: 140 bryophyte taxa (10 liverworts and 130 mosses) were recorded during a field trip led to a bryologically completely unexplored territory of Serbia in the vicinity of Čačak town, namely the Ovčar, Kablar, and Vujan Mts. 13 species are of conservation interest; rare, threatened in the Balkans or even in Europe. The bryophyte flora of the studied mountains can be characterised by high number of common species of the temperate zone of Europe. Almost half of the species found belong to this category. Another 20% of the species found are subboreal, boreal species, while more than 20% of the species collected have Mediterranean, sub-Mediterranean character.

Key words: liverworts, mosses, rare species, threatened species, the Balkans

INTRODUCTION

During the last two decades research of the Serbian bryophyte flora had intensified significantly (PANTOVIĆ & SABOVLJEVIĆ 2017), which contributed to the increase in knowledge of the local distribution of bryophyte species. This has further allowed more detailed studies, like for example of their regional bryogeographical patterns (PANTOVIĆ *et al.* 2019), or rarity and conservation status of certain species in the country (SABOVLJEVIĆ *et al.* 2018). Despite recent progress, large areas of Serbia are bryologically still completely unexplored. Additionally, data on distribution of many species is highly deficient. Keeping this in mind, aim of this study was to give an insight to the bryophyte flora of the western-central part of Serbia with no previous bryophyte records: the Vujan, Ovčar, and Kablar mountains in the vicinity of Čačak town. Three species (*Schistidium lancifolium*, *Syntrichia subpapillosissima*, *Tortella fasciculata*)

were found for the first time in Serbia on the basis of this collection, which has been reported in PAPP *et al.* (2019a).

MATERIAL AND METHODS

Description of the studied area

The municipality of Čačak is situated in Central Serbia. It lies at the contact point of the area of Šumadija and the inner Dinarides at an altitude of 204 to 985 m a.s.l. The central part of the municipality is the Čačak ravine, surrounded by Mt Vujan on the north, Mt Jelica on the south, Mt Ovčar and Mt Kablar on the west, and an open plane to Kraljevo ravine on the east (NIKOLIĆ 2013).

The Ovčar–Kablar Gorge is situated seventeen kilometres to the west of Čačak town. It represents the narrowest part of the valley of the Zapadna Morava River located between Mt Ovčar (985 m) on the southeast and Mt Kablar (889 m) on the northwest. The river meanders through the gorge for about 15 kilometres, from Tučkovo village, to the confluence of the Kamenica and Zapadna Morava rivers, with a maximum depth of 710 m in the central part (BOŽIĆ & TOMIĆ 2015). The course of the river was managed and two artificial lakes were created: the Ovčar Lake and the Međuvršje Lake. The Ovčar–Kablar Gorge is known for its cultural and natural sights: there are ten monasteries situated on the slopes of the mountains, thermal mineral springs and numerous caves in the limestone parts of the area. The gorge is protected by law as a ‘Landscape of exceptional features’.

The main morphological characteristics of the Ovčar–Kablar Gorge are the pronounced bends of the Zapadna Morava River with its carved meanders (BOŽIĆ & TOMIĆ 2015). Mt Ovčar is predominantly composed of limestone and dolomite, with smaller parts of igneous rocks. Steep limestone slopes are facing to the West Morava River (ĐORDJEVIĆ & TRUMBULOVIĆ 2015). Ultramafic metamorphic rocks (or serpentinites) typical for western Serbia, are more prevalent in Mt Kablar. Relatively large areas of diabase formations could also be found in both Mt Ovčar and Mt Kablar.

To the north of Čačak town the Brđani Gorge is located between Mt Vujan and the Ilijak hill. It is about 5 km long. The geological composition of Mt Vujan is very heterogeneous as well. Here, limestone and serpentine areas have a wide contact zone. However, it is mostly composed of serpentinite. Soils that develop on this ultramafic bedrock have alkaline to neutral reaction. They are rather shallow and of low fertility, with the presence of rock particles (VIĆENTIJEVIĆ-MARKOVIĆ 2004).

The climate type of this part of Serbia is a semi-arid variant of temperate-continental climate. Winters are relatively cold and moderately humid, while summers are hot and semi-arid. The mean annual precipitation for this area varies between 620 and 760 mm, and the mean annual temperatures between 9.5 °C and 11.5 °C (STEVANOVIĆ & STEVANOVIĆ 1995). The wettest month is May. The mountains surrounding Čačak cause to some extent lower temperatures, especially in certain periods of the day and the year. They also represent barrier for the strong winds.

Characteristics of the relief, especially geological bedrock type, have caused large floristical diversity, and the presence of a specific plant group of serpentinophytes (for example *Halacsya sendtneri* Dörf., *Notholaena marantae* (L.) R. Br., *Alyssum markgrafii* O. E. Schulz, *Silene longiflora* Ehrh. (VIĆENTIJEVIĆ-MARKOVIĆ 2004)). This relatively small area is also characterised by large habitat diversity. Various forests communities are present on the slopes of the mentioned mountains (mesophilic forests *Fagetum submontanum* Rudski 1949, *Orno-Ostryetum* Aich. 1933, and thermo-mesophilic oak forests *Ostryo-Quercetum cerris* Rexhepi et Ružić 1985, *Quercetum cerris* E. V. 1971, *Quercetum frainetto-cerris* Rudski 1949). In the parts where forests are degraded, the dominant vegetation type is grassland (for example *Arrhenatheretum elatioris* Br.-Bl. 1919, *Brachypodietum pinnati* Libb. 1933). A new association of serpentine rocky grassland (*Stipetum novaki* Kabaš et D. Lakušić 2013) was described from the Brđani Gorge recently (KABAŠ *et al.* 2013). Calcicolous chasmophyte communities are present on limestone rocky ground and cliffs.

Methods

Our collecting trip was made in June 2016. Various habitat types, such as streams, calcareous and siliceous rock formations, grasslands, and forests were investigated, and bryophytes were collected from different substrates (soil, exposed and shaded rocks, tree bark, and decaying wood). The investigated area can be seen in Figure 1.

The collected specimens are deposited in the Herbarium of the Hungarian Natural History Museum, Budapest (BP) and in the Belgrade University Herbarium (BEOU). Nomenclature of bryophytes follows HODGETTS (2015), except for *Tortella fasciculata*, which follows KÖCKINGER & HEDENÄS (2017). Where species distributions are indicated for SE Europe, the following abbreviations are used: ALB = Albania, BG = Bulgaria, BIH = Bosnia and Herzegovina, GR = Greece, HR = Croatia, MK = Macedonia, MNE = Montenegro, RO = Romania, SLO = Slovenia, SRB = Serbia, TR = European part of Turkey. Abbreviations of red list categories are as follows: RE = regionally extinct, CR

= critically endangered, EN = endangered, VU = vulnerable, NT = near threatened, DD = data deficient. Country distributions and national red list categories are taken from HODGETTS (2015), with updates where relevant. The European distribution type of the species is given according to DÜLL (1983, 1984, 1985).

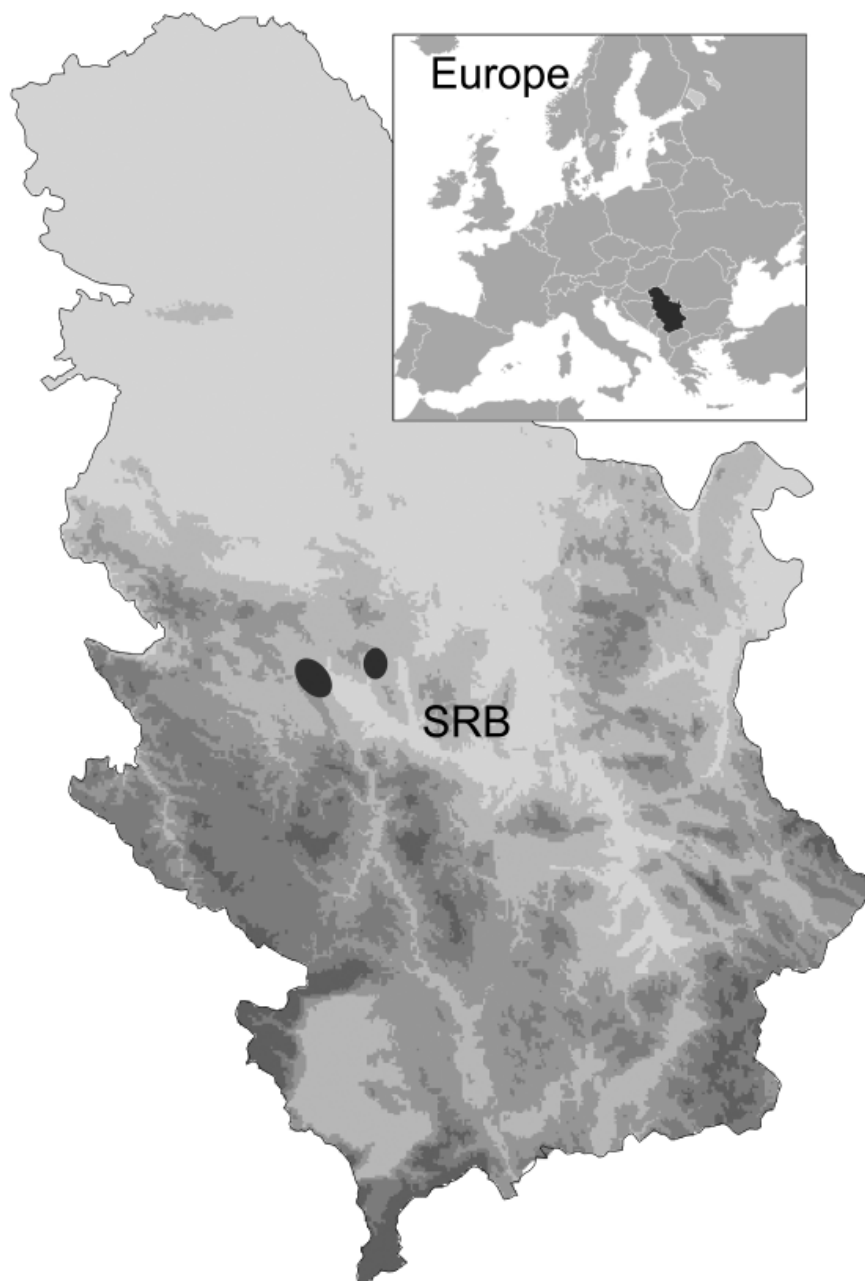


Fig. 1. Location of the investigated area.

Site details

- 1) Serbia, Mt Vujan near Čačak, at Vujan monastery, 43.97756° N, 20.45394° E, 530 m, 20.06.2016.
- 2) Serbia, Mt Vujan near Čačak, towards the peak, 43.980834° N, 20.45903° E, 710 m, 20.06.2016.
- 3) Serbia, Mt Vujan near Čačak, along the asphalt road above Vujan monastery, 43.97389° N, 20.45161° E, 540 m, 20.06.2016.
- 4) Serbia, Mt Vujan near Čačak, along the asphalt road under Vujan monastery, 43.97378° N, 20.44853° E, 470 m, 20.06.2016.
- 5) Serbia, Mt Kablar near Čačak, along the road, 43.90756° N, 20.17622° E, 455 m, 21.06.2016.
- 6) Serbia, Mt Kablar near Čačak, under the peak, 43.91653° N, 20.18750° E, 800 m, 21.06.2016.
- 7) Serbia, Mt Kablar near Čačak, Vidikovac on the peak, 43.91253° N, 20.19131° E, 885 m, 21.06.2016.
- 8) Serbia, under Mt Kablar near Čačak, bank of Kamenica River, 43.92919° N, 20.23156° E, 320 m, 21.06.2016.
- 9) Serbia, towards Uspenije and Jovanje monasteries near Čačak, on the bank of Zapadna Morava River, 43.91950° N, 20.21794° E, 300 m, 21.06.2016.
- 10) Serbia, Mt Ovčar near Čačak, at Sretenje monastery, 43.89533° N, 20.20650° E, 670 m, 22.06.2016.
- 11) Serbia, Mt Ovčar near Čačak, under the peak, 43.89117° N, 20.21064° E, 835 m, 22.06.2016.

RESULTS AND DISCUSSION

A total of 140 bryophyte taxa (10 liverworts and 130 mosses) were recorded during our field trip. The complete list of species can be found in the Appendix. 13 species are of conservation interest, i.e. rare, threatened in the Balkans or even in Europe.

Species of conservation interest

Isopaches bicrenatus (Schmidel ex Hoffm.) H. Buch – This western boreal liverwort is widely distributed in Europe on acidic soil (SMITH 1990), but it is red-listed in many countries especially in Central Europe, e.g., EN in the Netherlands, Slovakia, VU in Switzerland, NT in Italy, the Czech Republic, Germany, and Hungary. In southeastern Europe it is known from BG, HR, GR, MNE, RO, SRB, SLO. It has recently been rarely recorded in the Balkans, in Serbia it has extant populations in the Golija Biosphere Reserve (PAPP & ERZBERGER 2005), the

Kopaonik Mts (PAPP *et al.* 2004), Stara Planina (PAPP & ERZBERGER 2007), and the mountains around Lake Vlasina (PAPP *et al.* 2012). During the fieldtrip it was collected from acidic soil on the roadside in Mt Vujan.

Anomodon rostratus (Hedw.) Schimp. – This sub-Mediterranean-montane species is included in the Red data book of European bryophytes (ECCB 1995). It occurs in the Mediterranean areas, and Central and Eastern Europe, but it is red-listed in many countries. It is known from France, Italy, Spain (VU), Austria (EN), Belgium, the Czech Republic (DD), Germany (CR), Switzerland (VU), Slovakia (NT), Hungary (NT), Ukraine, and the Caucasus. In SE Europe it was reported from BIH, BG (CR), HR, RO (NT), SRB (VU), SLO. There are only few recently known populations in the Balkans. In HR it was reported from the Northern Velebit Mts (PAPP *et al.* 2013b), Plitvice Lakes National Park (ALEGRO *et al.* 2014), and the Žumberačka gora Mts (ALEGRO *et al.* 2015). It has extant population in the Strandzha Mts (BG) (PAPP *et al.* 2011). In Serbia it was recorded in the Tara National Park (PAPP & SABOVLJEVIĆ 2002), in Valjevo region (Petnica) (PAPP & SABOVLJEVIĆ 2001), Mt Avala (SABOVLJEVIĆ & CVETIĆ 2003) and in the Djerdap National Park (PAPP *et al.* 2006). During the fieldtrip it was collected from shaded limestone rocks in Mt Ovčar.

Buxbaumia viridis (Moug. ex Lam. et DC.) Brid. ex Moug. et Nestl. – This boreal species is included in the Red data book of European bryophytes (ECCB 1995) and also listed in the EU Habitat Directive. It does not seem to be rare in the SE European countries, it has several extant populations even in SRB, for example in the Tara National Park (PAPP & ERZBERGER 2012), Golija Biosphere Reserve (PAPP & ERZBERGER 2005), Pešter plateau (PAPP *et al.* 2014), and Mt Stolovi above the Ibar gorge (PAPP *et al.* 2016a). During the fieldtrip it was collected from decaying wood in Mt Ovčar.

Dicranella howei Renauld et Cardot – This Atlantic-Mediterranean species is known from almost all SE countries except MK and RO. Lately, it has also been reported from MK (PAPP *et al.* 2019b). It is frequent in the coastal areas of SE Europe in ALB, GR, and HR, but rarely reported in Serbia. It has only one record from Sićevačka klisura (PAPP & ERZBERGER 2009). During the fieldtrip it was collected on the roadside in Mt Vujan and on soil among serpentine rocks on the bank of the Zapadna Morava River.

Ditrichum pallidum (Hedw.) Hampe – This sub-Mediterranean species has a sporadic distribution in Europe. It is known from Denmark, Sweden (RE), France, Italy, Austria, Belgium (threatened), the Czech Republic (VU), Germany (VU), Luxemburg, the Netherlands, Poland, Slovakia (DD), Switzerland (EN), Hungary, and Ukraine. In SE Europe it was reported from almost all countries except ALB, GR, and MK. It is red-listed in BG (EN), RO (NT), and DD in MNE. But according to our recent knowledge it is not rare in the Strandzha Mts (BG) (PAPP *et al.*

2011). In Serbia it has recent records from the Belgrade area (GRDOVIĆ 2005, SABOVLJEVIĆ & GRDOVIĆ 2009). During the fieldtrip it was collected from soil among serpentine rocks in an oak forest near the peak of Mt Vujan.

Fissidens exilis Hedw. – This species of the temperate zone of Europe is widely distributed, but red-listed in many countries, e.g. EN in Austria, VU in Ireland and North Ireland, NT in Finland, Norway, Germany, Slovakia, Switzerland, Hungary, and Estonia, rare in Lithuania, DD in Portugal and Spain. In SE Europe it is known from BIH, BG (DD), HR, MNE (DD), RO (NT), SRB, SLO. In Serbia it has recent records from the Belgrade area (GRDOVIĆ 2005, SABOVLJEVIĆ & CVETIĆ 2003) and the Djerdap National Park (PAPP *et al.* 2006). During the fieldtrip it was collected on the roadside in Mt Vujan.

Orthotrichum schimperi Hammar – This epiphyte species was previously treated as a synonym of *Orthotrichum pumilum* Sw. in many flora works (FREY *et al.* 1995, SCHÄFER-VERWIMP 2001) and it has not received adequate attention in the Balkans in recent researches. However, in the latest European checklist (HILL *et al.* 2006) it appears on species rank. It is known from mainly historic records from ALB, BIH, GR, HR, RO, SRB, SLO. During the fieldtrip it was collected from *Fagus* bark in Mt Vujan.

Schistidium lancifolium (Kindb.) H. H. Blom – This species has long been considered as a taxon within the *S. apocarpum* complex (BLOM 1996), hence its distribution pattern in Europe is still unexplored. According to the recent knowledge it is known only from Finland, Sweden, Italy, Austria (risk assumed), Germany (DD), Poland, Hungary (NT), Ukraine, and Russia. In SE Europe it is reported only from MK and on the basis of the present collection from SRB (PAPP *et al.* 2019a). It was collected from sandstone rock in Mt Vujan.

Schistidium pruinatum (Wilson ex Schimp.) G. Roth – This species is widely distributed in Europe, but as it has also long been considered as a taxon within the *S. apocarpum* complex (BLOM 1996), in many countries it is still placed in the data deficient (DD) or not evaluated (NE) categories. In SE Europe it is known from ALB (DD), BG (DD), GR, MK, MNE (DD), RO (EN), SRB. In Serbia it is reported from the Djerdap National Park from andesite rock (PAPP *et al.* 2006) and from the Stara Planina Mts from sandstone rock (PAPP & ERZBERGER 2007). During the fieldtrip it was collected from serpentine rocks on the bank of the Zapadna Morava River.

Sciuro-hypnum flotowianum (Sendtn.) Ignatov et Huttunen – This subcontinental-montane species has sporadic distribution in Europe. It is known from Norway (EN), France, Italy, Spain (DD), Austria (EN), Belgium, the Czech Republic (DD), Germany (NT), Lichtenstein, Luxemburg (VU), the Netherlands (RE), Poland (rare), Slovakia (DD), Switzerland (VU), Hungary (VU), Ukraine, Caucasus, and Crimea. In SE Europe it is reported from BIH, BG (VU), GR,

MNE (DD), RO, SRB, SLO. Later on, it was also reported from HR (PAPP *et al.* 2013a). In Serbia it has recent records from the Valjevo region (Petnica) (PAPP & SABOVLJEVIĆ 2001), Belgrade area (GRDOVIĆ 2005, SABOVLJEVIĆ & GRDOVIĆ 2009), Djerdap National Park (PAPP *et al.* 2006) and the Suva Mts (PAPP & ERZBERGER 2009). During the fieldtrip it was collected under the peak of Mt Kablar.

Serpoleskea confervoides (Brid.) Schimp. – This boreal-montane species is widely distributed in Europe and known from almost all SE European countries except ALB. It is data deficient (DD) in MNE and SRB. Probably it is overlooked due to its small size. In Serbia it has recent data from the Belgrade area (GRDOVIĆ 2005, SABOVLJEVIĆ & GRDOVIĆ 2009), Djerdap National Park (PAPP *et al.* 2006), Suva Mts (PAPP & ERZBERGER 2009) and Pešter plateau (PAPP *et al.* 2014). During the fieldtrip it was collected from shaded limestone rocks in Mt Ovčar.

Syntrichia subpapillosissima (Bizot et R. B. Pierrot ex W. A. Kramer) M. T. Gallego et J. Guerra – This Atlantic–Mediterranean species previously was treated at intraspecific level, but GALLEGO *et al.* (2002) raise this taxon to species rank. It is known from France, Portugal, Spain, Austria, and Germany. In SE Europe it is recorded in GR (GALLEGO 2005), HR (PAPP *et al.* 2013a), MK (PAPP *et al.* 2016b), BG (PAPP *et al.* 2018a), MNE (PAPP *et al.* 2019c) and it has recently been reported on the basis of this collection from SRB (PAPP *et al.* 2019a). It was collected in limestone grasslands near the peaks of Mt Kablar and Mt Ovčar.

Tortella fasciculata (Culm.) Culm. – According to recent taxonomic treatment (KÖCKINGER & HEDENÄS 2017) the taxon traditionally named *Tortella bambergi* auct. consists of two species: *Tortella fasciculata* (Culm.) Culm. and *T. pseudofragilis* (Thér) Köckinger et Hedenäs. *T. fasciculata* is a sub-Atlantic–sub-Mediterranean floristical element in Europe. In SE Europe it has been recently reported from ALB (PAPP *et al.* 2018b), HR (ALEGRO *et al.* 2019), MNE (PAPP *et al.* 2019c) and on the basis of the present collection from SRB (PAPP *et al.* 2019a). It was collected from limestone rocks in Mt Kablar and Mt Ovčar, and from sandstone rock in Mt Vujan.

CONCLUSIONS

The bryophyte flora of the studied mountains can be characterised by high number of common species of the temperate zone of Europe. Almost half of the species found belong to this category. Additional 20% of the species found are subboreal, boreal species, among them some rarities e.g. *Isopaches bicrenatus*, *Serpoleskea confervoides*, and the European red-listed *Buxbaumia viridis*. The ratio of subcontinental species was ca 5%, but a rare species of this category (*Sciurohypnum flotowianum*) was also recorded during this study. More than 20% of the species collected have Mediterranean or sub-Mediterranean character and

among them rare species in the Balkans or even in Europe can be found e. g. *Anomodon rostratus*, which is also red-listed in Europe (ECCB 1995), *Dicranella howei*, *Ditrichum pallidum*, *Syntrichia subpapillosissima*, *Tortella fasciculata*. Some of them are probably overlooked, under-collected, and not so rare as their known distribution data suggest. But most of them are still not frequent in Serbia, however, an expansion of their distribution area towards north can be expected due to climate warming. To trace the distribution changes of these species would be an interesting task in the near future and it highlights the importance of comprehensive bryophyte flora explorations in the country. As there was no previous record from this territory of Serbia, the main result of this study is the 140 species found, which represent new records to this region.

We are glad to publish this paper in honour of the 60th birthday of László Lőkös, lichenologist, who was many times our travel fellow in the expeditions led to the Balkan region and helped a lot during our fieldwork. He was also with us in this trip in the mountains around Čačak town.

Acknowledgement – We are indebted to Peter Erzberger (Berlin) for his help in the determination or confirmation of some problematic specimens.

Összefoglaló: 140 mohafajt (10 májmohát és 130 lombosmohát) mutattunk ki a szerbiai Čačak város körüli hegyekben 2016-ban tett gyűjtőútunk során. Ezekben a hegyekben (Ovčar, Kablar és Vujan hegységek) semmilyen korábbi mohászati kutatás nem folyt, így az összes közölt adat új a területre. 13 faj (*Isopaches bicrenatus*, *Anomodon rostratus*, *Buxbaumia viridis*, *Dicranella howei*, *Ditrichum pallidum*, *Fissidens exilis*, *Orthotrichum schimperii*, *Schistidium lancifolium*, *Schistidium pruinosum*, *Sciuro-hypnum flotowianum*, *Serpoleskea confervoides*, *Syntrichia subpapillosissima*, *Tortella fasciculata*) ritka, veszélyeztetett a Balkánon vagy egész Európában. A vizsgált hegyek mohafldrájának csaknem a felét az Európai mérsékelt területek közönséges fajai teszik ki. A szubboreális, boreális fajok részvétele a fajösszetételben 20%, a mediterrán, szubmediterrán fajok aránya pedig meghaladja a 20%-ot.

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Appendix – Complete list of bryophyte records (the numerals following the species names refer to the collection sites described above).

Liverworts

- Cephaloziella divaricata* (Sm.) Schiffn. – 2: serpentine rock
- Frullania dilatata* (L.) Dumort. – 1: *Fraxinus* bark; 2: serpentine rock; 7: bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree; 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
- Isopachtes bicrenatus* (Schmidel ex Hoffm.) H. Buch – 3: acidic soil
- Lophocolea bidentata* (L.) Dumort. – 7: shaded limestone rock
- Lophocolea heterophylla* (Schrad.) Dumort. – 1: bark of *Quercus cerris*; 6: soil
- Metzgeria furcata* (L.) Corda – 1: *Acer* bark; 6: soil; 10: shaded limestone rock
- Plagiochila porelloides* (Torr. ex Nees) Lindenb. – 5, 6: soil; 7: shaded limestone rock
- Porella cordaeana* (Huebener) Moore – 1: siliceous rock; 10: shaded limestone rock
- Porella platyphylla* (L.) Pfeiff. – 1: *Acer* and *Fraxinus* bark; 5: bark of *Quercus pubescens*; 7: shaded limestone rock; 10: shaded limestone rock and bark of *Acer pseudoplatanus*
- Radula complanata* (L.) Dumort. – 7: shaded limestone rock and bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree; 10: shaded limestone rock, bark of *Acer pseudoplatanus* and *Ulmus*

Mosses

- Abietinella abietina* (Hedw.) M. Fleisch. – 7, 11: limestone grassland; 9: serpentine rock
- Alleniella besseri* (Lobarz.) S. Olsson, Enroth et D. Quandt – 10: shaded limestone rock
- Amblystegium serpens* (Hedw.) Schimp. – 1: sandstone rock, *Fraxinus* bark and decaying wood; 8: bark of *Populus* tree; 9: serpentine rock
- Anomodon attenuatus* (Hedw.) Huebener – 5: bark of *Quercus pubescens*; 10: shaded limestone rock and bark of *Acer pseudoplatanus*
- Anomodon longifolius* (Schleich. ex Brid.) Hartm. – 10: shaded limestone rock
- Anomodon rostratus* (Hedw.) Schimp. – 10: shaded limestone rock
- Anomodon viticulosus* (Hedw.) Hook. et Taylor – 1: sandstone rock; 5: soil; 8: bark of *Populus* tree; 10: shaded limestone rock
- Atrichum angustatum* (Brid.) Bruch et Schimp. – 2: soil among serpentine rocks in *Quercus* forest

- Atrichum undulatum* (Hedw.) P. Beauv. – 1: soil at the roadside; 2: soil among serpentine rocks in *Quercus* forest; 5, 6: soil
- Barbula convoluta* Hedw. – 7: limestone grassland
- Barbula convoluta* Hedw. var. *sardoa* Schimp. – 6: soil
- Barbula unguiculata* Hedw. – 1: soil at the roadside; 4: sandstone rock; 5, 6: soil; 9: serpentine rock; 11: limestone grassland
- Brachytheciastrum velutinum* (Hedw.) Ignatov et Huttunen – 1: soil at the roadside; 6: soil; 10: soil and decaying wood; 11: shaded sandstone rock
- Brachythecium albicans* (Hedw.) Schimp. – 7: limestone grassland; 11: sandstone outcrop
- Brachythecium glareosum* (Bruch ex Spruce) Schimp. – 1: soil at the roadside; 6: soil; 7: shaded limestone rock; 9: serpentine rock
- Brachythecium rutabulum* (Hedw.) Schimp. – 1: soil at the roadside and siliceous rock; 6: soil; 10: shaded limestone rock
- Brachythecium tommasinii* (Sendtn. ex Boulay) Ignatov et Huttunen – 7, 10: shaded limestone rock
- Bryoerythrophyllum recurvirostrum* (Hedw.) P. C. Chen – 7: shaded limestone rock
- Bryum argenteum* Hedw. – 7, 11: limestone grassland
- Bryum elegans* Nees – 7: shaded limestone rock
- Bryum radiculosum* Brid. – 4: sandstone rock (det. P. Erzberger)
- Buxbaumia viridis* (Moug. ex Lam. et DC.) Brid. ex Moug. et Nestl. – 10: decaying wood
- Campylidium calcareum* (Crundw. et Nyholm) Ochyra – 5, 6: soil
- Ceratodon purpureus* (Hedw.) Brid. – 2: soil among serpentine rocks in *Quercus* forest; 10: shaded limestone rock; 11: limestone grassland
- Cratoneuron filicinum* (Hedw.) Spruce – 1: at the outflow of a well
- Ctenidium molluscum* (Hedw.) Mitt. – 6: soil and limestone rock; 10: shaded limestone rock
- Dicranella heteromalla* (Hedw.) Schimp. – 1: soil at the roadside; 2: soil among serpentine rocks in *Quercus* forest; 3: acidic soil; 6: soil
- Dicranella howei* Renaud et Cardot – 1: soil at the roadside; 9: serpentine rock
- Dicranella schreberiana* (Hedw.) Dixon – 6: soil
- Dicranella varia* (Hedw.) Schimp. – 5: soil
- Dicranum tauricum* Sapjegin – 1: bark of *Quercus cerris*
- Didymodon cordatus* Jur. – 7: limestone grassland
- Didymodon fallax* (Hedw.) R. H. Zander – 1: soil at the roadside; 5: soil
- Didymodon insulanus* (De Not.) M. O. Hill – 1: soil at the roadside; 6: limestone rock
- Didymodon luridus* Hornsch. – 1: at the outflow of a well and soil at the roadside; 4: sandstone rock; 9: serpentine rock; 10: shaded limestone rock
- Didymodon rigidulus* Hedw. – 5: sandstone rock; 11: limestone grassland
- Didymodon sinuosus* (Mitt.) Delogne – 1: sandstone rock and siliceous rock; 7: shaded limestone rock; 10: at the outflow of a well, shaded limestone rock and bark of *Acer pseudoplatanus*
- Didymodon tophaceus* (Brid.) Lisa – 1: at the outflow of a well; 4: sandstone rock
- Ditrichum pallidum* (Hedw.) Hampe – 2: soil among serpentine rocks in *Quercus* forest; 3: acidic soil
- Ecalypta streptocarpa* Hedw. – 6: soil and limestone rock; 9: serpentine rock; 10: shaded limestone rock
- Ecalypta vulgaris* Hedw. – 7, 11: limestone grassland
- Fissidens bryoides* Hedw. – 1: soil at the roadside; 5: sandstone rock; 6: soil
- Fissidens dubius* P. Beauv. – 4: sandstone rock; 10: shaded limestone rock
- Fissidens exilis* Hedw. – 1: soil at the roadside
- Fissidens pusillus* (Wilson) Milde – 1: sandstone rock and siliceous rock
- Fissidens taxifolius* Hedw. – 1: soil at the roadside; 5, 10: soil; 6: soil and decaying wood

- Funaria hygrometrica* Hedw. – 1: soil at the roadside; 6: soil
- Grimmia orbicularis* Bruch ex Wilson – 4: sandstone rock
- Grimmia pulvinata* (Hedw.) Sm. – 1: at the outflow of a well and siliceous rock; 7: shaded limestone rock; 9: serpentine rock; 10: at the outflow of a well
- Grimmia tergestina* Tomm. ex Bruch et Schimp. – 7, 11: limestone grassland
- Herzogiella seligeri* (Brid.) Z. Iwats. – 6, 10: decaying wood
- Homalothecium philippeanum* (Spruce) Schimp. – 1: sandstone rock; 10: shaded limestone rock and bark of *Acer pseudoplatanus*
- Homalothecium sericeum* (Hedw.) Schimp. – 7: shaded limestone rock and bark of *Ostrya carpinifolia*; 9: serpentine rock; 10: shaded limestone rock and bark of *Fraxinus excelsior*; 11: limestone grassland
- Homomallium incurvatum* (Schrad. ex Brid.) Loeske – 1: sandstone rock, siliceous rock and bark of *Quercus cerris*; 5: sandstone rock; 6, 10: limestone rock
- Hypnum cupressiforme* Hedw. – 1: siliceous rock, decaying wood, bark of *Quercus cerris* and *Fraxinus*; 2: soil among serpentine rocks in *Quercus* forest; 5: soil and bark of *Quercus pubescens*; 6: soil; 7: shaded limestone rock and bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree; 9: serpentine rock; 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*; 11: limestone grassland
- Hypnum cupressiforme* Hedw. var. *lacunosum* Brid. – 11: sandstone outcrop
- Isothecium alopecuroides* (Lam. ex Dubois) Isov. – 1: siliceous rock and bark of *Quercus cerris*; 6: soil; 10: on the root of a tree
- Leskea polycarpa* Hedw. – 8: bark of *Populus* tree
- Leucodon sciuroides* (Hedw.) Schwägr. – 1: *Acer* bark; 5: bark of *Quercus pubescens*; 7: shaded limestone rock; 8: bark of *Populus* tree; 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
- Microeurhynchium pumilum* (Wilson) Ignatov et Vanderp. – 1: siliceous rock
- Mnium stellare* Hedw. – 10: shaded limestone rock
- Nyholmia obtusifolia* (Brid.) Holmen et Warncke – 1: *Fraxinus* bark; 8: bark of *Populus* tree; 10: bark of *Acer pseudoplatanus*
- Orthotrichum affine* Schrad. ex Brid. – 1: *Fraxinus* bark; 7: bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree; 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
- Orthotrichum anomalum* Hedw. – 7, 11: limestone grassland; 10: at the outflow of a well and bark of *Fraxinus excelsior*
- Orthotrichum cupulatum* Hoffm. ex Brid. – 7, 11: limestone grassland
- Orthotrichum diaphanum* Schrad. ex Brid. – 1: at the outflow of a well; 8: bark of *Populus* tree
- Orthotrichum lyellii* Hook. et Taylor – 1: *Fraxinus* bark; 10: bark of *Fraxinus excelsior*
- Orthotrichum pallens* Bruch ex Brid. – 1: *Acer* and *Fraxinus* bark; 7: bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree; 10: bark of *Acer pseudoplatanus*
- Orthotrichum pumilum* Sw. ex anon. – 1: *Fraxinus* bark; 10: bark of *Acer pseudoplatanus*
- Orthotrichum schimperi* Hammar – 1: *Fraxinus* bark
- Orthotrichum speciosum* Nees – 1: *Fraxinus* bark; 7: bark of *Ostrya carpinifolia*
- Orthotrichum stramineum* Hornsch. ex Brid. – 7: bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree; 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
- Orthotrichum striatum* Hedw. – 1: *Fraxinus* bark; 7: bark of *Ostrya carpinifolia*; 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
- Oxyrrhynchium hians* (Hedw.) Loeske – 1: soil at the roadside; 9: serpentine rock; 10: shaded limestone rock
- Oxyrrhynchium shleicheri* (R. Hedw.) Röhl – 1: soil at the roadside; 5, 6: soil
- Oxystegus tenuirostris* (Hook. et Taylor) A. J. E. Sm. – 1: siliceous rock
- Plagiomnium affine* (Blandow ex Funck) T. J. Kop. – 9: serpentine rock

- Plagiomnium cuspidatum* (Hedw.) T. J. Kop. – 4: sandstone rock; 7: shaded limestone rock
Plagiomnium rostratum (Schrad.) T. J. Kop. – 7, 10: shaded limestone rock
Plagiomnium undulatum (Hedw.) T. J. Kop. – 7: shaded limestone rock
Plagiothecium cavifolium (Brid.) Z. Iwats. – 5, 6: soil
Plagiothecium denticulatum (Hedw.) Schimp. – 1: soil at the roadside
Plagiothecium succulentum (Wilson) Lindb. – 5, 6: soil
Plasteurbhynchium striatulum (Spruce) M. Fleisch. – 10: shaded limestone rock
Platygyrium repens (Brid.) Schimp. – 1: bark of *Quercus cerris*
Pogonatum aloides (Hedw.) P. Beauv. – 1: soil at the roadside; 3: acidic soil; 6: soil
Pogonatum nanum (Hedw.) P. Beauv. – 2: serpentine rock
Polytrichum formosum Hedw. – 1: soil at the roadside; 2: soil among serpentine rocks in *Quercus* forest; 3: acidic soil; 5: soil
Polytrichum juniperinum Hedw. – 2: soil among serpentine rocks in *Quercus* forest; 11: limestone grassland and sandstone outcrop
Polytrichum piliferum Hedw. – 2: serpentine rock
Pseudocrossidium hornschuchianum (Schultz) R. H. Zander – 11: limestone grassland
Pseudoleskeella catenulata (Brid. ex Schrad.) Kindb. – 7: limestone grassland; 10: at the outflow of a well, shaded limestone rock, bark of *Acer pseudoplatanus* and *Fraxinus excelsior*; 11: limestone grassland
Pseudoleskeella nervosa (Brid.) Nyholm – 1: bark of *Quercus cerris*; 7: bark of *Ostrya carpinifolia*; 10: at the outflow of a well, shaded limestone rock, bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
Pseudoscleropodium purum (Hedw.) M. Fleisch. – 7: shaded limestone rock
Pterigynandrum filiforme Hedw. – 1: siliceous rock and bark of *Quercus cerris*; 10: bark of *Acer pseudoplatanus*
Ptychostomum capillare (Hedw.) Holyoak et N. Pedersen – 1: siliceous rock; 2: serpentine rock; 3: acidic soil; 6: soil; 7, 11: limestone grassland; 9: serpentine rock
Ptychostomum imbricatum (Müll. Hal.) Holyoak et N. Pedersen (= *Bryum caespiticium*) – 7, 10: shaded limestone rock; 11: limestone grassland
Ptychostomum moravicum (Podp.) Ros et Mazimpaka – 1: bark of *Quercus cerris* and decaying wood; 2: serpentine rock; 7: bark of *Ostrya carpinifolia*
Ptychostomum rubens (Mitt.) Holyoak et N. Pedersen – 6: soil; 7: shaded limestone rock
Pylaisia polyantha (Hedw.) Schimp. – 7: bark of *Ostrya carpinifolia*; 8: bark of *Populus* tree
Racomitrium canescens (Hedw.) Brid. – 11: sandstone outcrop
Rhizomnium punctatum (Hedw.) T. J. Kop. – 1: siliceous rock
Rhynchostegium confertum (Dicks.) Schimp. – 1: siliceous rock
Rhynchostegium murale (Hedw.) Schimp. – 5: sandstone rock; 10: at the outflow of a well
Rhytidadelphus triquetrus (Hedw.) Warnst. – 3: acidic soil
Schistidium apocarpum (Hedw.) Bruch et Schimp. – 1: siliceous rock (conf. P. Erzberger)
Schistidium brunnescens Limpr. subsp. *griseum* (Nees et Hornsch.) H. H. Blom – 7, 11: limestone grassland (all conf. P. Erzberger)
Schistidium crassipilum H. H. Blom – 1: at the outflow of a well, sandstone rock; 2: serpentine rock; 5: sandstone rock; 6: limestone rock; 11: limestone grassland; 10: shaded limestone rock
Schistidium elegantulum H. H. Blom – 2, 9: serpentine rock (all det. P. Erzberger); 7: limestone grassland (det. P. Erzberger)
Schistidium lancifolium (Kindb.) H. H. Blom – 1: sandstone rock (conf. P. Erzberger)
Schistidium pruinatum (Wilson ex Schimp.) G. Roth – 9: serpentine rock (conf. P. Erzberger)
Sciuro-hypnum flowianum (Sendtn.) Ignatov et Huttunen – 6: soil

- Sciuro-hypnum populeum* (Hedw.) Ignatov et Huttunen – 1: sandstone rock and siliceous rock; 6: limestone rock; 10: at the outflow of a well
- Serpoleskea confervoides* (Brid.) Schimp. – 10: shaded limestone rock
- Syntrichia montana* Nees – 7, 11: limestone grassland
- Syntrichia papillosa* (Wilson) Jur. – 1: *Fraxinus* bark
- Syntrichia ruralis* (Hedw.) F. Weber et D. Mohr – 10: bark of *Acer pseudoplatanus* and *Fraxinus excelsior*
- Syntrichia subpapillosissima* (Bizot et R. B. Pierrot ex W. A. Kramer) M. T. Gallego et J. Guerra – 7, 11: limestone grassland
- Taxiphyllum wissgrillii* (Garov.) Wijk et Margad. – 1: sandstone rock and siliceous rock
- Thuidium assimile* (Mitt.) A. Jaeger – 5: sandstone rock; 7: shaded limestone rock; 10: soil
- Tortella fasciculata* (Culm.) Culm. – 1: sandstone rock; 6: limestone rock; 7, 11: limestone grassland
- Tortella tortuosa* (Hedw.) Limpr. – 4: sandstone rock; 6: limestone rock; 7, 10: shaded limestone rock; 11: limestone grassland
- Tortula acaulon* (With.) R. H. Zander var. *pilifera* (Hedw.) R. H. Zander – 11: limestone grassland
- Tortula caucasica* Broth. (= *Pottia intermedia*) – 11: limestone grassland
- Tortula inermis* (Brid.) Mont. – 9: serpentine rock
- Tortula muralis* Hedw. – 1: at the outflow of a well; 4: sandstone rock; 7, 11: limestone grassland; 9: serpentine rock; 10: shaded limestone rock
- Tortula schimperii* M. J. Cano, O. Werner et J. Guerra – 1: soil at the roadside; 2: soil among serpentine rocks in *Quercus* forest; 3: acidic soil
- Tortula subulata* Hedw. – 6: soil; 9: serpentine rock; 11: shaded sandstone rock
- Weissia condensa* (Voit) Lindb. – 7, 11: limestone grassland
- Weissia controversa* Hedw. – 2: soil among serpentine rocks in *Quercus* forest