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# A CONTRIBUTION TO THE BRYOPHYTE FLORA OF CROATIA IV. ŽUMBERAČKA GORA MTS

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**Abstract**: A bryological field survey in the Žumberačka gora Mts carried out in July, 2014 resulted in a list of 168 species (34 liverworts and 134 mosses). Two species are reported for the first time from Croatia (*Pseudoleskeella rupestris, Riccardia incurvata*). Three species are included in the Red data book of European bryophytes (*Mannia triandra*, *Anomodon rostratus*, and *Rhynchostegiella tenuicaulis*). *Mannia triandra* is listed in the Bern Convention and the EU Habitats and Species Directive, as well.

**Key words**: bryophyte, diversity, habitats, liverworts, mosses, new records for Croatia, Southeast Europe, threatened species

## INTRODUCTION

With the overview of the bryophyte flora of the Žumberačka gora Mts, the authors intend to provide another contribution to the recently renewed bryological research in Croatia. To date, the following studies have been published – contributions to the bryophyte flora of the Gorski kotar region, the Northern Velebit Mt (Papp *et al.* 2013*a*, *b*) and the National Park Plitvička jezera (lakes) and adjacent areas (Alegro *et al.* 2014*a*), in addition to accounts of taxa new for the bryophyte flora of Croatia (Papp and Sabovljević 2009, Modrić Surina *et al.* 2012, Alegro *et al.* 2012, Papp *et al.* 2013*c*, Alegro *et al.* 2014*b*, *c*, *d*). During this recent period of research over 40 species new for the bryophyte flora of Croatia were found, which clearly indicates the urgent need of a systematic bryological survey of Croatia. This also corresponds with a comparative statistical analysis of the bryophyte diversity in Southeast Europe (Sabovljević *et al.* 2011), which showed that in Croatia a significantly higher number of bryophyte species should be expected than currently known. The present study of the bryophyte flora of the Žumberačka gora Mts is the first report for an area outside the Dinaric part of Croatia, therefore it is of great importance from the phytogeographical point of

view. This is emphasized by the almost complete lack of previous bryological data except for a few sporadic, decades-old findings (Horvat 1932, Pavletić 1955). In the present paper we publish the complete list of bryophytes (including the localities and habitats of the field trip in 2014) native to the Žumberačka gora Mts.

## MATERIAL AND METHODS

### Study area

The Žumberačka gora Mts are situated in the northwestern part of Central Croatia (Fig. 1) and continue in part in Slovenia, where it is called Gorjanci Mts. It is a 40 km long dissected massif between the rivers Sava and Kupa in Croatia, and the River Krka in Slovenia, with an elevation range between 180 m (Kupa River valley) and 1178 m (Sveta Gera summit). The largest part of this area is karstic with numerous surface and underground karst relief forms, with over 150 speleological features (pits and caves) as recorded by Buzjak (2006). There are numerous karst forms – dolines, blind and dry valleys, caves, shafts and hydrogeological features – underground circulation with sinkholes and karst springs (Bočić and Buzjak 1998).

The geological structure of the terrain is dominated by sedimentary rocks ranging stratigraphically from the mid-Upper Permian to recent Quaternary alluvial and travertine sediments. The largest part of the Žumberačka gora Mts is covered by Upper Triassic sediments, dominated by dolostones and Upper Cretaceous sediments in the form of carbonate-clastic flysch and limestone. Structurally, this is a boundary between the Inner Dinarides and the Zagorje-Mid-Transdanubian shear zone, overthrusting on the External Dinarides (Pamić and Tomljenović 1998).

The Žumberačka gora Mts are characterised by a moderately warm, rainy climate without any extremely dry period. The mean annual temperature varies between 6 °C in the highest mountain parts and 11 °C in the lowest southeastern areas (Zaninović *et al.* 2004). The mean air temperature of January varies from −1 °C to less than −2 °C in the highest parts, and the mean air temperature in July varies from 20 °C to less than 18 °C in the highest parts. The highest precipitation occurs in June and October, and the lowest in March with an average annual precipitation between 1100 and 1700 mm (Penzar and Penzar 1982).

Phytogeographically, the Žumberačka gora Mts are transitional between the SE Alps and the NW Dinarides and represents a bridge between the Alps and the Dinarides with many alpine elements on low altitudes and dinaric ones on the NW border of their distribution (Horvat 1929, Trinajstić 1995). The overall area belongs to the colline and montane forest belt (Horvat 1962, Šugar 1972, Vukelić 2012). The first one is characterized by the predominance of forests of sessile oak and common hornbeam (*Epimedio-Carpinetum betuli* (Horvat

1938) Borhidi 1963, 16.04% of total surface), and the second one by beech forests (*Aremonio-Fagion* (Horvat 1938) Borhidi in Török, Podani et Borhidi 1989, 38.43%). However, due to the complex relief and geological structure many other forest communities occur extrazonally or azonally, among which thermophilous ones, embracing many sub-Mediterranean elements are especially interesting. They form communities of downy oak and hop-hornbeam (*Querco pubescenti-Ostryetum carpinifoliae* Horvat 1938, 2.44%) and of hop-hornbeam and beech (*Ostryo-Fagetum sylvaticae* M. Wraber ex Trinajstić 1972). On acidic soils forests of sessile oak and sweet chestnut (*Querco-Castaneetum sativae* Horvat 1938, 1.25%), and beech forests with oakforest woodrush (*Luzulo luzuloidis-Fagetum sylvaticae* Meusel 1937, 18.20%) occur. Coniferous forests (*Picea abies* (L.) H. Karst. and *Pinus sylvestris* L.) were planted after World War II, and their total surface is only 0.85%. Other important habitat types are grasslands, but they are undergoing rapid succession toward shrub- and forest vegetation due to the abandonment of traditional land use. The total surface of open grasslands is 12.12% and they belong to three main types: dry limestone grasslands (*Bromo-Plantaginetum mediae* Horvat 1931, 7.90%), mesophilous grasslands (*Arrhenatheretum elatioris* Br.-Bl. ex Scherrer 1925, 3.96%) and heathlands (*Genisto sagittalis-Callunetum* Horvat 1931, 0.26%). Mixed rural landscapes and settlements occupy only 6.43% of total surface. Vegetation types are cited according to Jelaska *et al.* (2005). Other habitat types of low total cover, such as basiphilous fens, gorges, rocks, waterfalls, brooks and rivulets are of great importance for plant and general biodiversity.

In 1999 the Žumberačka gora Mts and the adjacent Samoborsko gorje Mts became protected as Nature Park.

## Methods

The field work in the Žumberačka gora Mts was performed from 23–26 July, 2014. The study area is presented in Figure 1, and particular collecting sites are listed below. Due to the high habitat diversity of the area, collecting sites were scattered throughout ecologically different habitats in order to sufficiently document the bryophyte diversity. To achieve this goal, different forest types (beech forest, oak-hornbeam forest, downy oak-hop-hornbeam forest and spruce forest), shrubberies, dry grasslands, fens, waterfalls and riparian zones of rivulets and brooks, rocks, gorges and cave entrances were included in the research. The collected specimens are deposited in both the Bryophyte Herbarium of the Hungarian Natural History Museum, Budapest (BP) and the *Herbarium Croaticum* of the University of Zagreb (ZA). The nomenclature follows Schumacker and Váňa (2005) for liverworts (except for genera *Lophocolea* and *Leiocolea*, which follow Grolle and Long 2000, and for *Conocephalum salebrosum,* which fol-

lows Szweykowski *et al.* (2005)) and Hill *et al.* (2006) for mosses. New species for the bryophyte flora of Croatia is given according to general checklists of Southeast Europe and the Mediterranean (Ros *et al.* 2007, 2013, Sabovljević 2003, Sabovljević and Natcheva 2006, Sabovljević *et al.* 2008) and taking into consideration new records (Papp and Sabovljević 2009, Modrić Surina *et al.* 2012, Alegro *et al.* 2012, 2014*a*, *b*, *c*, Papp *et al.* 2013*a*, *b*, *c*).

The system of biogeographic elements is accepted after Hill *et al.* (2007), and supplemented by Smith (2004), Düll (1999), and Nebel and Philippi (2000, 2001, 2005).

For the evaluation of the bryophytes' conservation status in the neighbouring countries and Europe the comprehensive work of Hodgetts (2015) was used with the following abbreviations; CR (critically endangered), EN (endangered), VU (vulnerable), NT (near threatened), DD (data deficient), R (rare).

## Collecting sites

1. Žumberačka gora Mts, Kuta secondary old growth forest at Petričko selo, Illyrian montane beech forest (ass. *Lamio orvalae-Fagetum sylvaticae* (Horvat 1938) Borhidi 1963), 45.79627° N, 15.42369° E, 915 m, 23.07.2014.

2. Žumberačka gora Mts, Pogana jama pit at Kuta, pit and surrounding limestone rocks, 45.79161° N, 15.43128° E, 875 m, 23.07.2014.


**Fig. 1**. The investigated area.

3. Žumberačka gora Mts, Jarak at Sošice village, basiphilous fen belonging to the ass. *Eriophoro-Caricetum paniceae* Horvat 1964 with *Eriophorum latifolium* Hoppe, *E. angustifolium* Honck., *Tofieldia calyculata* (L.) Wahlenb., *Carex hostiana* DC., *Carex lepidocarpa* Tausch, *Pinguicula alpina* L. and others, 45.76178° N, 15.36764° E, 710 m, 24.07.2014.

4. Žumberačka gora Mts, Sopotski slap waterfall near Sošice village, shaded and moist limestone rocks in hop-hornbeam-beech forest (ass. *Ostryo-Fagetum sylvaticae*), 45.76431° N, 15.39742° E, 560 m, 24.07.2014.

5. Žumberačka gora Mts, between Sopote and Tomaševci villages, Obradovac spring, source and surrounding moist dolomite screes, 45.77083° N, 15.41222° E, 590 m, 24.07.2014.

6. Žumberačka gora Mts, along the path from Stari grad village towards Stari grad Žumberak castle, mosaic of dry limestone grasslands (ass. *Bromo-Plantaginetum mediae*), shrubberies and forests (on thermophilous slopes shrubberies and low forest of the ass. *Querco pubescenti-Ostryetum carpinifoliae*, and on more mesophilous positions beech forest of the ass. *Lamio orvalae-Fagetum*), 45.76644° N, 15.41497° E and 45.75925° N, 15.42008° E, 480 m, 25.07.2014.

7. Žumberačka gora Mts, at Kupčina Žumberačka rivulet, path alongside the rivulet, mostly inside sessile oak-hornbeam forest (ass. *Epimedio-Carpinetum betuli*) with willows (*Salix alba* L., *S. purpurea* L., *S. fragilis* L.) and common alder (*Alnus glutinosa* (L.) Gaertn.) in riparian zone, 45.73678° N, 15.41231° E, 280 m, 25.07.2014.

8. Žumberačka gora Mts, Jarak gorge, steep slopes above the brook inside Illyrian montane beech forest (ass. *Lamio orvalae-Fagetum*), 45.75906° N, 15.37161° E, 680 m, 26.07.2014.

9. Žumberačka gora Mts, towards Sveta Gera peak, planted spruce (*Picea abies*) forest in beech belt, 45.75992° N, 15.34842° E, 860 m, 26.07.2014.

10. Žumberačka gora Mts, Tomaševci village, lime trees (*Tilia cordata* Mill.) in front of the chapel, 45.76175° N, 15.43556° E, 650 m, 26.07.2014.

## RESULTS

168 bryophytes (34 liverworts and 134 mosses) were collected in the Žumberačka gora Mts (Appendix 1). Two taxa are reported here for the first time in Croatia.

### Phytogeography of the bryophyte flora of the Žumberačka gora Mts

As presented in the spectra of biogeographic elements (Figs 2 and 3) the bryophyte flora of the Žumberačka gora Mts is dominated by boreo-temperate (35.1%) and circumpolar (55.4%) species. This corresponds to the general phytogeographical position of the research area in the broadleaf zone of the Eurosiberian–North

American region. Since phytogeographically the bryophytes have much broader distributions than the vascular plants, the features of the areas can be depicted less detailed than those based on vascular plants. However, the Southeast European position and presence of the thermophilous habitats (forests and shrubberies with *Quercus pubescens* Willd. and *Ostrya carpinifolia* Scop., dry limestone grasslands and fringe vegetation) is reflected in temperate (21.4%), southern-temperate (11.3%) and Mediterranean-Atlantic (4.2%) elements. Some of these species, such as *Cololejeunea rosettiana*, *Didymodon luridus*, *Eucladium verticillatum*, *Gymnostomum viridulum*, *Pleurochaete squarrosa*, *Trichostomum crispulum*, *Weissia brachycarpa*, and others are characteristic for thermophilous and limestone habitats. On the other hand, cave and pit entrances, shaded rocks, fens and coniferous forests are favorable for boreo-arctic montane (8.3%), wide boreal (4.1%) and boreal-montane (7.1%) elements. The species growing on shaded rocks include *Isopterygiopsis pulchella*, *Jungermannia atrovirens*, *Leiocolea collaris*, *Mnium thomsonii*, *Myurella julacea*, *Orthothecium intricatum*, *O. rufescens*, *Plagiopus oederianus*, *Platydictya jungermannioides*, *Scapania aequiloba*, and others. The boreo-arctic montane and wide boreal species, like those growing in fens, one of the rarest and most endangered habitat types in Croatia, are of special importance from biogeographical and conservational points of view. Such species are: *Aneura pinguis*, *Bryum pseudotriquetrum, Climacium dendroides, Philonotis seriata*, and *Tomentypnum nitens*.

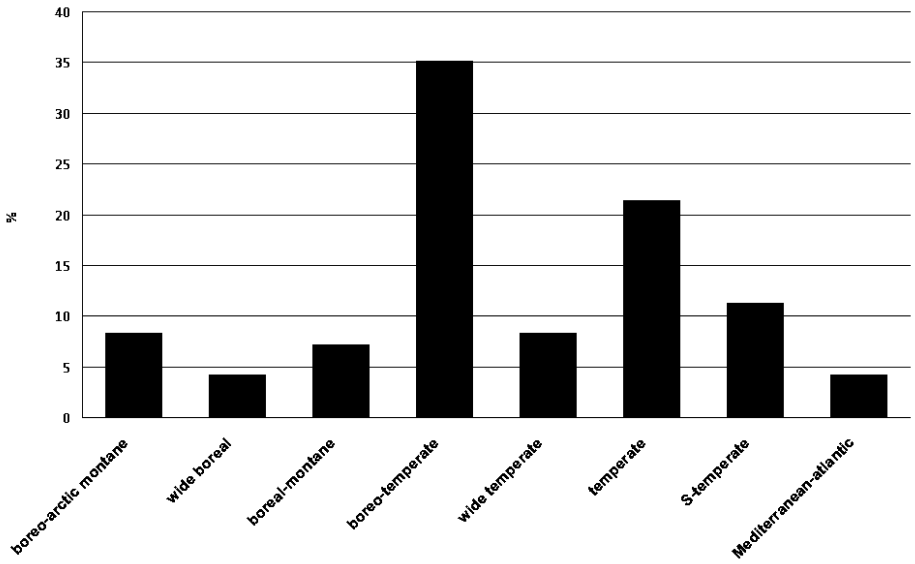


**Fig. 2.** Spectrum of the biogeographic elements of the bryophyte flora in the Žumberačka gora Mts.

The spectrum of biogeographic elements according to the eastern limit category (Fig. 3) is highly dominated by circumpolar species (55.4%) followed by European ones (29.2%), and by others with significantly lower shares. It is interesting that the share of suboceanic and Eurosiberian species is the same (5.36%) reflecting the transitional position of the Žumberačka gora Mts. This is also very well documented in the composition of the vascular flora (Horvat 1929, Trinajstić 1995). The only true oceanic species is *Gymnostomum viridulum*, which grows on shaded limestone rocks. The main factor of restricting the occurrence of oceanic species is the limestone bedrock, which due to its porosity have soils rapidly drying out in the summer, (in spite the relatively high amount of yearly precipitation of 1,100–1,700 mm), and the rather cold winters, which correspond to a more continental climate. The majority of suboceanic species are Mediterranean-Atlantic elements (*Cololejeunea rosettiana*, *Didymodon luridus*, *Eurhynchium striatum*, *Plasteurhynchium striatulum*, *Pleurochaete squarrosa, Porella arboris-vitae*), which also indicates their adaptation to the relatively dry conditions. The other species are boreo-temperate (*Calypogeia azurea*, *Cololejeunea calcarea*) or temperate elements (*Orthotrichum lyellii*).

## Species reported for the first time in Croatia

The field trip in the Žumberačka gora Mts resulted in the record of two species new for the bryophyte flora of Croatia: *Pseudoleskeella rupestris* and *Riccardia incurvata*.

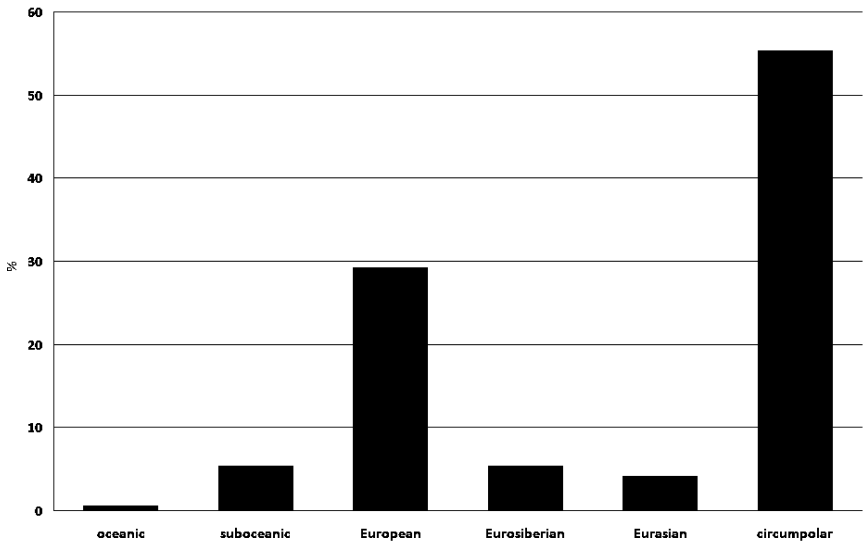


**Fig. 3.** Spectrum of the biogeographic elements of the bryophyte flora in the Žumberačka gora Mts according to eastern limit category.

*Pseudoleskeella rupestris* is a circumpolar boreal-montane moss distributed throughout Europe (Smith 2004), but rare in Southern Europe (Frey *et al.* 2006). This moss has recently been reported from the Balkans, from Montenegro (Dragićević *et al.* 2008), Albania (Papp *et al.* 2010), and Serbia (Papp *et al.* 2014*a*). Here, the species was found on shaded limestone rocks along the Sopotski slap waterfall. The waterfall is overgrown by beech forest with hop-hornbeam (ass. *Ostryo-Fagetum sylvaticae*), and has a very rich bryophyte flora consisting of 51 species.

*Riccardia incurvata* is a European boreal-montane liverwort (Hill *et al.* 2007), with its area of distribution extending to North America, however it is absent from the Mediterranean area (Frey *et al.* 2006). In Southeast Europe it is also rare, known only from Bulgaria, Romania, and Serbia (Sabovljević and Natcheva 2006). It has recently been reported from FYR Macedonia (Papp and Erzberger 2012). It is red listed in Bulgaria (VU), Romania (EN) (Hodgetts 2015), Hungary, where it is mentioned in the national red list as DD (Frey *et al.* 2006, Hodgetts 2015), and in several other European countries in different categories (Hodgetts 2015). In the Žumberačka gora Mts it was found near Sošice village, in basiphilous fens belonging to the ass. *Eriophoro-Caricetum paniceae*, where it grows with several other rare bryophyte species such as *Philonotis seriata* and *Tomentypnum nitens*.

## Conservation merits of the bryophyte flora

The Žumberačka gora Mts have an important conservation value thanks to the presence of *Mannia triandra*, a liverwort species listed in the Bern Convention and the European Union Habitats and Species Directive (thus the species is one of a total of four among the Croatian bryophytes). Other species listed in the Red data book of European bryophytes (ECCB 1995) are *Anomodon rostratus* (R = rare), and *Rhynchostegiella tenuicaulis* (K = insufficiently known).

*Mannia triandra* is a circumpolar subcontinental-supalpine element (Düll 1999). It is widely distributed in Central and Southern Europe with its centre of distribution in the Alps, where it sporadically reaches altitudes as high as 2600 m (Frey *et al.* 2006) and grows on soils in limestone crevices (Frey *et al.* 2006). It is known from almost all Southeast European countries except Greece and the European part of Turkey (Sabovljević and Natcheva 2006, Ros *et al.* 2007), but in most countries no existing populations have been reported. One locality of *M. triandra* was quoted for Croatia (Biokovo Mts in Dalmatia, Southern Croatia) at the beginning of the 20th century (Schiffner 1906, 1909), but the species has never been recorded again. Moreover, three specimens originating from Croatia and deposited in the Herbarium BP (No 26926, 26927 and 26928, loc. *Omiš, in*

*rupibus umbrosis humidis ad margines fontibus*, leg. L. Vajda 02.06.1971) were revised by the authors of this paper and identified as *Lunularia cruciata*. Therefore, localities in the Žumberačka gora Mts yielded the only certain findings of *M. triandra* in Croatia. It was found on shaded limestone rocks along the Sopotski slap waterfall, which is characterized by a rich bryophyte flora. The other locality is alongside the path between Stari grad (Kekić draga) village and Stari grad castle. It grows on bare soil slopes in sheltered positions on the path edges, together with *Reboulia hemisphaerica*.

*Anomodon rostratus* is a sub-Mediterranean-montane species (Düll 1999) occurring on shaded limestone rocks and in rock crevices. In the Red data book of European bryophytes it is treated as rare (ECCB 1995). In Southeast Europe it is known from Bosnia-Herzegovina, Bulgaria, Croatia, Romania, Serbia, and Slovenia (Sabovljević *et al.* 2008, Ros *et al.* 2013). It was reported for the first time in Croatia (Velebit Mts) by Degen (1938), which was confirmed during recent surveys (Papp *et al.* 2013*b*). Later it was found in the National Park Plitvička jezera (lakes), in beech-fir virgin forests in Čorkova uvala and Medveđak, where it grows on strongly shaded limestone rocks within the forests, especially at the bottom of dolines (Alegro *et al.* 2014*a*). In the Žumberačka gora Mts it was found in a very similar habitat, on shaded limestone rocks by the entrance of Pogana jama pit and in Jarak gorge, within old growth beech forest.

*Rhynchostegiella tenuicaulis* is a montane species of the European temperate zone (Düll 1985). It is included in the Red data book of European bryophytes in the insufficiently known category (ECCB 1995). In Southeast Europe it was known only from Bulgaria, Greece, and Romania (Sabovljević *et al.* 2008). Recently, it has been reported from Albania (Marka *et al.* 2013), Croatia (Papp *et al.* 2013*c*), and Montenegro (Papp *et al.* 2014*b*). In Croatia it is known from the Northern Velebit Mt (Papp *et al.* 2013*b*), where it grows on limestone rocks in the Klepina duliba forest and in the Jovanovića snižnica ice hole, and from Čorkova uvala virgin forest within National Park Plitvička jezera (lakes) (Alegro *et al.* 2014*a*). In the Žumberačka gora Mts it was found in the old growth forest of Kuta, on shaded limestone rocks.

The basiphilous fen Jarak (at Sošice village) is very important locality from the conservation point of view. It is rich in species that are rare in Southeast Europe. Among them two species (*Philonotis seriata, Tomentypnum nitens*) have only recently been reported from Croatia.

*Philonotis seriata* is a boreo-arctic montane species with Eurosiberian distribution (Smith 2004) up to Greenland and North America (Sauer 2001). It is known from all Southeast European countries except Kosovo and the European part of Turkey (Sabovljević *et al.* 2008, Hodgetts 2015). In Europe it is treated as regionally extinct (RT) in the Netherlands and Belgium, while in Slovenia it

is quoted as vulnerable (VU) (Hodgetts 2015). In 2013 it was recorded for the first time in Croatia, in a basiphilous fen at Leska near Crni lug in the Gorski kotar region (Papp *et al.* 2013*c*), where it grows together with *Tomentypnum nitens*, which is discussed next. In the Žumberačka gora Mts it grows also in a basiphilous fen belonging to the ass. *Eriophoro-Caricetum paniceae*, near Sošice village. This is one of the few basiphilous fens in Croatia which supports many plant species rare at national level. Besides *P. seriata,* 28 other bryophyte species were found there in the scope of this research.

*Tomentypnum nitens* is a boreal species (Düll 1985) known from many Southeast European countries, i.e. Bosnia-Herzegovina, Bulgaria, Montenegro, Romania, Serbia, Slovenia, and the European part of Turkey (Sabovljević *et al.* 2008, Hodgetts 2015), but currently it occurs mostly in very small populations. It is endangered (EN) in Bulgaria and Serbia, and near threatened (NT) in Slovenia. It is also endangered (EN) in Hungary (Hodgetts 2015). In Croatia only two very restricted localities are known. The first one is in Gorski kotar, where it grows in a small basiphilous fen at Leska near Crni lug village (Papp *et al.* 2013*c*), the second one is in a peat bog in the National Park Plitvička jezera (lakes) (Alegro *et al.* 2014*a*), and the third one is reported here. In the Žumberačka gora Mts the species grows also in a basiphilous fen, and the population is small, restricted to a few patches. While the fen community in Gorski kotar belongs to the ass. *Carici-Blysmetum compressi* Eggler 1933, and in the Plitvička jezera (lakes) to the ass. *Drosero-Caricetum echinatae* Horvat (1950) 1962, the community in the Žumberačka gora Mts is an ass. *Eriophoro-Caricetum paniceae*, which embraces more calciphilous elements in comparison to the first one.

Other two rare species in Southeast Europe were found in the fen Jarak

*Aneura pinguis* is a circumpolar, wide-boreal liverwort (Hill *et al.* 2007) inhabiting more or less permanently moist habitats (Frey *et al.* 2006). It is known from almost all Southeast European countries except Kosovo and the European part of Turkey (Ros *et al.* 2007, Hodgetts 2015), but it is rare due to the lack of adequate habitats. It is red listed in several European countries: VU (Canary Islands), NT (Italy, Germany and Hungary) and DD (Sardinia) (Hodgetts 2015). A small population of *A. pinguis* was found in the basiphilous fen Jarak. Another recently discovered locality in Croatia is an acidophilous bog Đon Močvar near the town of Topusko.

*Fissidens adianthoides* is a circumpolar boreo-temperate species (Hill *et al.* 2007) widespread but not frequent in wet habitats throughout Europe (Frey *et al.* 2006). It is red listed as VU (the Netherlands), NT (Germany and Hungary), DD (Azores, Canary Islands, Spain and Montenegro) (Hodgetts 2015). It has

regularly been found in wet habitats during recent surveys in Croatia (Papp *et al.* 2013*a*, *b*; Alegro *et al.* 2014*a*), so it seems that it is not rare in adequate habitats.

In the Žumberačka gora Mts several other bryophyte species were found which are, in general, rare in Southeast Europe. All of them, except for *Gymnostomum viridulum*, are boreal elements which become rare toward the south, inhabiting specific, mostly shaded habitats with cooler microclimate. On the other hand, *Gymnostomum viridulum* is an oceanic species, and its distribution is limited by summer drought. These rarities were collected on shaded limestone rocks, rock crevices or on soils among limestone rocks and they occur usually in small populations as in the Žumberačka gora Mts.

*Apometzgeria pubescens* is a circumpolar boreal-montane liverwort (Hill *et al.* 2007) growing on shaded, mostly calcareous rocks and it is especially widespread in the Alps (Frey *et al.* 2006). In Croatia it has recently been recorded, but usually in small populations, on shaded limestone rocks in the Gorski kotar region (Papp *et al.* 2013*a*), the Northern Velebit Mts (Papp *et al.* 2013*a*) and in the National Park Plitvička jezera (lakes) (Alegro *et al.* 2014*a*). In the Žumberačka gora Mts it was found in a similar habitat. It is quoted in red lists of the following European countries: EN (Sweden), VU (Northern Ireland, Romania), NT (Italy), DD (Czech Republic, Bulgaria, Hungary, and Slovenia), R (Poland) (Hodgetts 2015).

*Didymodon ferrugineus* is a European boreo-temperate moss (Hill *et al.* 2007) scattered over the limestone regions of Europe and growing on moist, shady rocks, walls and earthy ledges (Frey *et al.* 2006). It is red listed in some European countries: VU (Luxemburg, Bulgaria, and Hungary), NT (Finland) and DD (Montenegro and Serbia) (Hodgetts 2015). In Croatia there is a recently recorded small population in the Gorski kotar region (Papp *et al.* 2013*a*), where it grows on the concrete wall of a canal, while in the Žumberačka gora Mts it was found in natural habitats, on shaded limestone rocks.

*Entodon concinnus* is a circumpolar boreal-montane species (Hill *et al.* 2007) growing in chalk and limestone grasslands throughout most of Europe, and becoming rare towards the north (Frey *et al.* 2006). It is on the red lists of the following countries: CR (Hungary), EN (the Netherlands), VU (Bulgaria), NT (Slovakia and Romania) and DD (San Marino) (Hodgetts 2015). In the Žumberačka gora Mts it was found on soils among limestone rocks, while in the Gorski kotar region it was recorded on limestone rocks (Papp *et al.* 2013*a*).

*Gymnostomum viridulum* is a Mediterranean-Atlantic species (Hill *et al.* 2007) growing on calcareous rocks, in rock crevices and encrusted soils (Frey *et al.* 2006). It is red listed in the following countries: EN (Austria and Slovenia), VU (Czech Republic, Switzerland, and Bulgaria), and NT (Hungary) (Hodgetts 2015). In the Žumberačka gora Mts it was found on a shaded limestone rock, and this is its first record during our recent field research.

*Isopterygiopsis pulchella* is a circumpolar boreo-arctic montane species (Hill *et al.* 2007) scattered throughout the higher mountains, rare at lower elevations, and growing in rock crevices and caves (Frey *et al.* 2006). The species is red listed as CR (Czech Republic), EN (Estonia), VU (Bulgaria), NT (Slovakia), and DD (Hungary) (Hodgetts 2015). In the Žumberačka gora Mts a small population was found on shaded limestone rocks similarly as in the Gorski kotar region (Papp *et al.* 2013*a*), in the Northern Velebit Mts (Papp *et al.* 2013*b*), and in the National Park Plitvička jezera (lakes) (Alegro *et al.* 2014*a*).

*Myurella julacea* is a circumpolar boreo-arctic montane species (Hill *et al.* 2007) growing on soil covered rocks and rock crevices of calcareous regions in North Europe and the higher mountains of Central Europe, rarely at lower elevations, and in the mountains of South Europe (Frey *et al.* 2006). It is redlisted as EN (Ireland, Northern Ireland and Czech Republic), VU (Romania) and NT (Germany and Hungary). Shaded limestone rocks are the habitat of this species in the Žumberačka gora Mts, as in the Gorski kotar region (Papp *et al.* 2013*a*), while in the Northern Velebit Mts it was found in subalpine limestone grasslands.

*Platydictya jungermannioides* is a circumpolar boreo-arctic montane species (Hill *et al.* 2007) of shady, moist calcareous rocks, rock crevices, and caves, mostly in the mountains (Frey *et al.* 2006). Regarding red lists it is treated as RE (Belgium), CR (Czech Republic), EN (Luxemburg), VU (Bulgaria), NT (Ireland, Northern Ireland, Germany and Romania), and DD (Hungary) (Hodgetts 2015). It was found on shaded limestone rocks in the Žumberačka gora Mts, as in the Gorski kotar region (Papp *et al.* 2013*a*).

## CONCLUSIONS

The Žumberačka gora Mts possess a remarkable bryophyte diversity with 168 recorded species. Compared with other areas recently studied, this number of taxa is somewhat lower than e.g. the Gorski kotar region with 231 taxa (Papp *et al.* 2013*a*), Northern Velebit Mts with 191 taxa (Papp *et al.* 2013*b*), and Plitvička jezera (lakes) including some adjacent areas with 207 species (Alegro *et al.* 2014*a*). The reason for this may be the somewhat drier climate, the absence of virgin forests, and the comparatively lower altitudes. Nevertheless, the bryophyte diversity is high and is distributed throughout different habitat types. *Anomodon rostratus*, *Rhynchostegiella tenuicaulis* as European red listed species are bound to shaded limestone rocks within old growth forests, gorges, and pit entrances, emphasizing the importance of these habitats in nature conservation.

Furthermore, the shaded limestone rocks in Sopotski slap are the habitat of *Pseudoleskeella rupestris*, a species new in the bryophyte flora of Croatia, and

of *Mannia triandra*, a species listed in the Bern Convention and the European Union Habitats and Species Directive, and in the Red data book of European bryophytes. The very rich bryophyte flora of this small locality, consisting of 51 species, additionally emphasizes its importance for bryophyte diversity in the Žumberačka gora Mts. *M. triandra* also occurs on bare soils of shaded slopes along a path in Stari grad village, which is a very vulnerable habitat, and easily destroyable either by abandonment and ongoing vegetation succession or by occasional construction works.

Another locality of great importance for bryophyte (and vascular plant) diversity is the basiphilous fen Jarak near Sošice village, which besides a rich bryophyte flora of 28 species, is the habitat of rarities in Southeast Europe, such as *Philonotis seriata*, *Tomentypnum nitens*, and *Riccardia incurvata,* the last one a species new for the bryophyte flora of Croatia.

It needs to be stressed that the Žumberačka gora Mts have a great conservation value for the occurrence of *Mannia triandra*, a species listed in the Bern Convention and the European Union Habitats and Species Directive. Furthermore, the presence of other species rare in Southeast Europe, and the general composition of the bryophyte flora demonstrating the transitional phytogeographical position of the Žumberačka gora Mts, additionally marks the importance of this area for bryophyte diversity and its conservation.

* * *

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**Összefoglaló**: 2014 júliusában a mohaflóra felmérésére került sor a Žumberačka gora hegységben, amely Horvátország középső részének északnyugati határán terül el, és Szlovéniába is áthúzódik. Nagyrészt karsztterület, a legmagasabb tengerszint feletti magassága 1178 m (Sveta Gera csúcs). Fitogeográfiailag átmenetet képez az Alpok és a Dinári-hegység között. A területről 168 fajt (34 májmoha és 134 lombosmoha) mutattunk ki, két faj (*Pseudoleskeella rupestris*, *Riccardia incurvata*) új Horvátország mohaflórájára nézve. Három faj az Európai Moha Vörös Könyvben (*Mannia triandra*, *Anomodon rostratus*, *Rhynchostegiella tenuicaulis*), ezenkívül a *Mannia triandra* a Berni Egyezményben és az Európai Unió Élőhelyvédelmi Irányelv listáján is szerepel.

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## **Appendix 1.** List of bryophyte taxa found in the Žumberačka gora Mts

### Hepaticae

*Aneura pinguis* (L.) Dumort. – 3: in fen; 5: at the source
*Apometzgeria pubescens* (Schrank) Kuwah. – 1, 2: on shaded limestone rock
*Blepharostoma trichophyllum* (L.) Dumort. – 9: on decaying wood
*Calypogeia azurea* Stotler et Crotz – 1: on soil, on wet soil in a dolina and on decaying wood; 9: on decaying wood
*Cephalozia bicuspidata* (L.) Dumort. – 9: on decaying wood
*Cephaloziella divaricata* (Sm.) Schiffn. – 6: on soil
*Cephaloziella rubella* (Nees) Warnst. subsp. *sullivantii* (Austin) K. Müller – 9: on decaying wood
*Cololejeunea calcarea* (Lib.) Schiffn. – 1, 2, 4, 8: on shaded limestone rock
*Cololejeunea rossettiana* (C. Massal.) Schiffn. – 1: on shaded limestone rock
*Conocephalum salebrosum* Szweykowski, Buczkowska et Odrzykoski – 1: on wet soil in a dolina; 2: on limestone rock in a stream; 4, 8: on shaded limestone rock; 6: limestone rock in a stream; 7: on wet limestone rock at a mill
*Frullania dilatata* (L.) Dumort. – 1: on the bark of *Acer*; 6: on the bark of *Fagus*
*Jungermannia atrovirens* Dumort. – 2, 4, 8: on shaded limestone rock; 8: on limestone rock in a stream
*Lejeunea cavifolia* (Ehrh.) Lindb. – 6, 7: on shaded limestone rock
*Lophocolea bidentata* (L.) Dumort. – 3: in fen; 4: on shaded limestone rock
*Lophocolea heterophylla* (Schrad.) Dumort. – 1, 8, 9: on decaying wood

*Lophocolea minor* Nees – 6: on soil
*Leiocolea collaris* (Nees) Schljakov – 2, 4, 6, 8: on shaded limestone rock; 9: on soil
*Mannia triandra* (Scop.) Grolle – 4: on shaded limestone rock; 6: on soil
*Marchantia polymorpha* L. subsp. *ruderalis* Bischl. et Boisselier – 3: in fen
*Metzgeria conjugata* Lindb. – 1, 4, 6, 8: on shaded limestone rock; 8: on the bark of *Fagus*; 9: on decaying wood
*Metzgeria furcata* (L.) Dumort. – 1: on the bark of *Fagus*
*Nowellia curvifolia* (Dicks.) Mitt. – 9: on decaying wood
*Pedinophyllum interruptum* (Nees.) Kaal. – 2, 4, 8: on shaded limestone rock; 7: on wet limestone rock at a mill
*Pellia endiviifolia* (Dicks.) Dumort. – 3: in fen; 4: on shaded limestone rock; 6: limestone rock at a stream; 7: on wet limestone rock at a mill; 9: on soil
*Pellia epiphylla* (L.) Corda – 1: on wet soil in a dolina
*Plagiochila asplenioides* (L. emend. Taylor) Dumort. – 1: on wet soil in a dolina; 8: on shaded limestone rock
*Plagiochila porelloides* (Torrey ex Nees) Lindb. – 1, 4, 8: on shaded limestone rock; 9: on decaying wood
*Porella arboris-vitae* (With.) Grolle – 8: on shaded limestone rock
*Porella platyphylla* (L.) Pfeiff. – 4, 7: on shaded limestone rock; 6, 8: on decaying wood, on the bark of *Fagus*
*Preissia quadrata* (Scop.) Nees – 3: in fen; 4: on shaded limestone rock
*Radula complanata* (L.) Dumort. – 1: on shaded limestone rock; 6: on decaying wood; 9: on the bark of *Fagus*
*Reboulia hemisphaerica* (L.) Raddi – 2: on shaded limestone rock; 6: on soil
*Riccardia incurvata* Lindb. – 3: in fen
*Scapania aequiloba* (Schwaegr.) Dumort. – 2: on shaded limestone rock

## Musci

*Abietinella abietina* (Hedw.) M. Fleisch. – 6: on soil
*Amblystegium confervoides* (Brid.) Schimp. – 1, 4, 8: on shaded limestone rock
*Anomodon attenuatus* (Hedw.) Huebener – 1, 4, 6, 7: on shaded limestone rock; 6, 8: on the bark of *Fagus*; 7: on wet limestone rock at a mill
*Anomodon longifolius* (Schleich. ex Brid.) Hartm. – 1, 8: on shaded limestone rock
*Anomodon rostratus* (Hedw.) Schimp. – 2, 8: on shaded limestone rock
*Anomodon viticulosus* (Hedw.) Hook. et Taylor – 1, 2, 4, 6, 8: on shaded limestone rock; 7: on wet limestone rock at a mill
*Atrichum undulatum* (Hedw.) P. Beauv. – 1: on wet soil in a dolina; 9: on soil
*Barbula convoluta* Hedw. – 6: on soil
*Barbula crocea* (Brid.) F. Weber et D. Mohr – 4, 6, 7: on shaded limestone rock; 5: at the source
*Barbula unguiculata* Hedw. – 6: on soil; 7: on soil among limestone rocks
*Bartramia pomiformis* Hedw. – 2: on shaded limestone rock
*Brachytheciastrum velutinum* (Hedw.) Ignatov et Huttunen – 1, 6, 9: on soil
*Brachythecium glareosum* (Bruch ex Spruce) Schimp. – 6: on soil
*Brachythecium mildeanum* (Schimp.) Schimp. – 3: in fen
*Brachythecium populeum* (Hedw.) Schimp. – 1: on shaded limestone rock
*Brachythecium rivulare* Schimp. – 2, 8: on limestone rock in a stream; 3: in fen; 4: on shaded limestone rock; 7: on wet limestone rock at a mill
*Brachythecium rutabulum* (Hedw.) Schimp. – 1: on wet soil in a dolina and on decaying wood; 3: in fen; 6: on soil; 7: on wet limestone rock at a mill; 8: on shaded limestone rock

*Brachythecium tommasinii* (Sendtn. ex Boulay) Ignatov et Huttunen – 1, 2, 8: on shaded limestone rock
*Bryoerythrophyllum recurvirostrum* (Hedw.) P. C. Chen – 2, 6, 8: on shaded limestone rock; 6: on soil
*Bryum argenteum* Hedw. – 6: on dry limestone grassland
*Bryum capillare* Hedw. – 4, 6: on shaded limestone rock; 7: on soil among limestone rocks
*Bryum pseudotriquetrum* (Hedw.) P. Gaertn., B. Mey. et Scherb. – 3: in fen; 5: at the source
*Calliergonella cuspidata* (Hedw.) Loeske – 3: in fen
*Campyliadelphus chrysophyllus* (Brid.) R. S. Chopra – 4, 7: on shaded limestone rock; 6: on soil
*Campylium protensum* (Brid.) Kindb. – 4: on shaded limestone rock
*Campylium stellatum* (Hedw.) Lange et C. E. O. Jensen – 3: in fen
*Campylophyllum calcareum* (Crundw. et Nyholm) Hedenäs – 6: on shaded limestone rock
*Cirriphyllum crassinervium* (Taylor) Loeske et M. Fleisch. – 1, 8: on shaded limestone rock
*Climacium dendroides* (Hedw.) F. Weber et D. Mohr – 3: in fen
*Cratoneuron filicinum* (Hedw.) Spruce – 2, 6, 8: on limestone rock in a stream; 3: in fen; 7: on wet limestone rock at a mill
*Ctenidium molluscum* (Hedw.) Mitt. – 1, 4, 6, 8: on shaded limestone rock
*Dicranella varia* (Hedw.) Schimp. – 5: at the source; 6, 9: on soil
*Dicranum montanum* Hedw. – 7, 9: on decaying wood
*Dicranum scoparium* Hedw. – 3: in fen
*Didymodon acutus* (Brid.) K. Saito – 6: on dry limestone grassland
*Didymodon fallax* (Hedw.) R. H. Zander – 6, 9: on soil; 8, 9: on shaded limestone rock
*Didymodon ferrugineus* (Schimp. ex Besch.) M. O. Hill – 4, 6: on shaded limestone rock
*Didymodon luridus* Hornsch. – 6: on shaded limestone rock
*Didymodon rigidulus* Hedw. – 2, 4, 6: on shaded limestone rock
*Didymodon spadiceus* (Mitt.) Limpr. – 2, 4: on shaded limestone rock; 7: on wet limestone rock at a mill
*Ditrichum flexicaule* (Schwägr.) Hampe – 6: on soil
*Ditrichum gracile* (Mitt.) Kuntze – 7: on soil among limestone rocks
*Encalypta streptocarpa* Hedw. – 2, 4, 6, 8: on shaded limestone rock; 7: on soil among limestone rocks; 9: on soil
*Entodon concinnus* (De Not.) Paris – 6: on soil; 7: on soil among limestone rocks
*Eucladium verticillatum* (With.) Bruch et Schimp. – 4: on shaded limestone rock; 5: at the source
*Eurhynchium angustirete* (Broth.) T. J. Kop. – 1, 9: on decaying wood, on shaded limestone rock
*Eurhynchium striatum* (Hedw.) Schimp. – 4, 8: on shaded limestone rock; 7: on soil among limestone rocks
*Fissidens adianthoides* Hedw. – 3: in fen
*Fissidens bryoides* Hedw. – 6: on soil; 7: on soil among limestone rocks
*Fissidens crassipes* Wilson ex Bruch et Schimp. subsp. *crassipes* – 8: on limestone rock in a stream
*Fissidens dubius* P. Beauv. – 2, 4, 6, 8: on shaded limestone rock; 7: on soil among limestone rocks
*Fissidens gracilifolius* Brugg. -Nann. et Nyholm – 1, 9: on shaded limestone rock
*Fissidens taxifolius* Hedw. – 1, 9: on soil
*Fissidens viridulus* (Sw. ex anon.) Wahlenb. var. *viridulus* – 8: on shaded limestone rock
*Funaria hygrometrica* Hedw. – 6: limestone rock in a stream
*Grimmia pulvinata* (Hedw.) Sm. – 6: on dry limestone grassland
*Gymnostomum aeruginosum* Sm. – 2, 4: on shaded limestone rock; 5: at the source
*Gymnostomum calcareum* Nees et Hornsch. – 4, 7, 8: on shaded limestone rock
*Gymnostomum viridulum* Brid. – 6: on shaded limestone rock
*Herzogiella seligeri* (Brid.) Z. Iwats. – 1, 9: on decaying wood
*Homalia trichomanoides* (Hedw.) Brid. – 7: on the bark of *Corylus avellana*
*Homalothecium lutescens* (Hedw.) H. Rob. – 6: on soil

*Homalothecium sericeum* (Hedw.) Schimp. – 1, 4, 6, 7, 8: on shaded limestone rock; 6: on dry limestone grassland; 8: on decaying wood
*Homomallium incurvatum* (Schrad. ex Brid.) Loeske – 1: on shaded limestone rock
*Hygrohypnum luridum* (Hedw.) Jenn. – 2, 8: on limestone rock in a stream; 4, 6: on shaded limestone rock
*Hypnum cupressiforme* Hedw. – 1, 8, 9: on decaying wood, on the bark of *Fagus*; 3: in fen; 6: on the bark of *Quercus pubescens*
*Hypnum cupressiforme* var. *lacunosum* Brid. – 6: on soil, on shaded limestone rock; 7: on soil among limestone rocks
*Isopterygiopsis pulchella* (Hedw.) Z. Iwats. – 8: on shaded limestone rock
*Isothecium alopecuroides* (Lam. ex Dubois) Isov. – 1: on shaded limestone rock and on the bark of *Acer*; 6, 8: on the bark of *Fagus*
*Leucodon sciuroides* (Hedw.) Schwägr. – 6, 7: on shaded limestone rock and on the bark of *Quercus pubescens*; 8: on the bark of *Fagus*
*Mnium lycopodioides* Schwägr. – 8: on shaded limestone rock
*Mnium marginatum* (Dicks.) P. Beauv. – 2, 4, 8: on shaded limestone rock; 7: on soil among limestone rocks
*Mnium stellare* Hedw. – 2: on shaded limestone rock
*Mnium thomsonii* Schimp. – 4, 8: on shaded limestone rock
*Myurella julacea* (Schwägr.) Schimp. – 6: on shaded limestone rock
*Neckera complanata* (Hedw.) Huebener – 1, 4, 6, 7: on shaded limestone rock; 6, 8: on the bark of *Fagus*
*Neckera crispa* Hedw. – 2, 4, 8: on shaded limestone rock; 7: on the bark of *Acer campestre*
*Orthothecium intricatum* (Hartm.) Schimp. – 2, 8: on shaded limestone rock
*Orthothecium rufescens* (Dicks. ex Brid.) Schimp. – 4: on shaded limestone rock
*Orthotrichum affine* Schrad. ex Brid. – 9: on the bark of *Fagus*
*Orthotrichum cupulatum* Hoffm. ex Brid. – 4: on shaded limestone rock
*Orthotrichum lyellii* Hook. et Taylor – 1: on the bark of *Acer*; 10: on the bark of *Tilia cordata*
*Orthotrichum obtusifolium* Brid. – 10: on the bark of *Tilia cordata*
*Orthotrichum pallens* Bruch ex Brid. – 9: on the bark of *Fagus*; 10: on the bark of *Tilia cordata*
*Orthotrichum pumilum* Sw. ex Anon. – 10: on the bark of *Tilia cordata*
*Orthotrichum speciosum* Nees – 1: on the bark of *Acer*; 6: on the bark of *Quercus pubescens*
*Orthotrichum stramineum* Hornsch. ex Brid. – 1: on the bark of *Acer* and *Fagus*; 6: on the bark of *Quercus pubescens*; 9: on the bark of *Fagus*
*Orthotrichum striatum* Hedw. – 1, 9: on the bark of *Fagus*; 6: on the bark of *Quercus pubescens*; 10: on the bark of *Fagus* and *Tilia cordata*
*Oxyrrhynchium hians* (Hedw.) Loeske – 4, 6, 8: on shaded limestone rock
*Palustriella commutata* (Hedw.) Ochyra – 3: in fen; 4: on shaded limestone rock; 5: at the source; 7: on wet limestone rock at a mill; 8: on limestone rock in a stream
*Palustriella falcata* (Brid.) Hedenäs – 3: in fen
*Philonotis seriata* Mitt. – 3: in fen
*Plagiomnium affine* (Blandow ex Funck) T. J. Kop. – 9: on soil
*Plagiomnium cuspidatum* (Hedw.) T. J. Kop. – 1: on wet soil in a dolina and on decaying wood; 6: on soil
*Plagiomnium elatum* (Bruch et Schimp.) T. J. Kop. – 3: in fen
*Plagiomnium rostratum* (Schrad.) T. J. Kop. – 7: on wet limestone rock at a mill; 8: on shaded limestone rock
*Plagiomnium undulatum* (Hedw.) T. J. Kop. – 1: on wet soil in a dolina; 3: in fen; 6: limestone rock in a stream; 7: on soil among limestone rocks; 8: on shaded limestone rock

*Plagiopus oederianus* (Sw.) H. A. Crum et L. E. Anderson – 2, 8: on shaded limestone rock
*Plagiothecium platyphyllum* Mönk. – 1: on wet soil in a dolina, on decaying wood and on shaded limestone rock; 3: in fen; 8: on shaded limestone rock and on the bark of *Fagus*; 9: on decaying wood
*Plasteurhynchium striatulum* (Spruce) M. Fleisch. – 1, 4, 8: on shaded limestone rock
*Platydictya jungermannioides* (Brid.) H. A. Crum – 4: on shaded limestone rock
*Platygyrium repens* (Brid.) Schimp. – 8: on decaying wood
*Platyhypnidium riparioides* (Hedw.) Dixon – 6: limestone rock in a stream; 7: on wet limestone rock at a mill
*Pleurochaete squarrosa* (Brid.) Lindb. – 6: on dry limestone grassland
*Pohlia melanodon* (Brid.) A. J. Shaw – 7: on wet limestone rock at a mill; 8: on shaded limestone rock
*Polytrichastrum formosum* (Hedw.) G. L. Sm. – 1: on soil, on wet soil in a dolina; 3: in fen; 8: on shaded limestone rock
*Pseudoleskeella catenulata* (Brid. ex Schrad.) Kindb. – 7: on shaded limestone rock
*Pseudoleskeella nervosa* (Brid.) Nyholm – 6: on decaying wood, on the bark of *Fagus*
*Pseudoleskeella rupestris* (Berggr.) Hedenäs et L. Söderstr. – 4: on shaded limestone rock
*Pterygynandrum filiforme* Hedw. – 1: on the bark of *Acer*; 6, 8: on the bark of *Fagus*; 8: on decaying wood
*Rhizomnium punctatum* (Hedw.) T. J. Kop. – 1: on wet soil in a dolina, on decaying wood and on shaded limestone rock; 3: in fen; 9: on decaying wood
*Rhynchostegiella tenuicaulis* (Spruce) Kartt. – 1: on shaded limestone rock
*Rhynchostegium murale* (Hedw.) Schimp. – 1, 8: on shaded limestone rock; 9: on soil
*Rhytidiadelphus triquetrus* (Hedw.) Warnst. – 3: in fen; 4: on shaded limestone rock
*Schistidium crassipilum* H. H. Blom – 2, 4, 6: on shaded limestone rock
*Schistidium elegantulum* H. H. Blom – 1: on shaded limestone rock
*Sciuro-hypnum reflexum* (Starke) Ignatov et Huttunen – 1: on wet soil in a dolina
*Scleropodium purum* (Hedw.) Limpr. – 3: in fen; 4: on shaded limestone rock; 6. on soil; 7: on soil among limestone rocks
*Seligeria pusilla* (Hedw.) Bruch et Schimp. – 2, 8: on shaded limestone rock
*Syntrichia calcicola* J. J. Amann – 6: on dry limestone grassland
*Syntrichia ruralis* (Hedw.) F. Weber et D. Mohr – 2: on shaded limestone rock
*Taxiphyllum wissgrillii* (Garov.) Wijk et Margad. – 1, 6, 8: on shaded limestone rock
*Thamnobryum alopecurum* (Hedw.) Gangulee – 1, 2, 8: on shaded limestone rock
*Thuidium assimile* (Mitt.) A. Jaeger – 3: in fen; 4: on shaded limestone rock; 6: on soil; 7: on soil among limestone rocks
*Thuidium recognitum* (Hedw.) Lindb. – 4, 8: on shaded limestone rock; 7: on soil among limestone rocks
*Thuidium tamariscinum* (Hedw.) Schimp. – 9: on decaying wood
*Tomentypnum nitens* (Hedw.) Loeske – 3: in fen
*Tortella inclinata* (R. Hedw.) Limpr. – 6: on soil
*Tortella tortuosa* (Hedw.) Limpr. – 4, 6, 8: on shaded limestone rock
*Tortula subulata* Hedw. – 6: on soil
*Trichostomum crispulum* Bruch – 4: on shaded limestone rock
*Ulota crispa* (Hedw.) Brid. – 1, 9: on the bark of *Fagus*
*Weissia brachycarpa* (Nees et Hornsch.) Jur. – 6: on shaded limestone rock
*Weissia controversa* Hedw. – 4: on shaded limestone rock; 6: on soil; 7: on soil among limestone rocks