Article

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Contribution to the bryophyte flora of the Temštica river valley (E. Serbia) with notes to its conservation values

Abstract

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Stara planina Mt. is one of the most important areas in Serbia considering bryophyte richness and specific flora. However, its foothill regions are somewhat neglected in the bryofloristic research. Focus of this study was Temštica river, located on the slopes of Stara planina Mt. The study is based on the specimens collected in the field, but also previously published bryophyte records were compiled to the species list. All together, total of 174 bryophyte species is known from Temštica river valley. Of these, 54 taxa were recorded in the area for the first time. Following three species are considered threatened on European level: *Bryum funkii*, *Philonotis marchica* and *Sciuro-hypnum ornellanum*, while significant number of found species is red-listed throughout region and European countries. River valleys proved to be important areas for preservation of specific bryophyte flora. These results represent basis for further bryological research, conservation measures and monitoring of endangered species.

Key words: Europe, the Balkans, Stara planina Mt., bryoflora, rare taxa, mosses, liverworts

Introduction

The period from the last decade of the 20th century was marked by intensive research of bryophyte flora in Serbia. This so called *modern period* of research (Pantović & Sabovljević 2017) is characterized by the publication of a large number of bryofloristic papers (e.g. Veljić & al. 1996; Papp & Sabovljević 2001; Grdović & Blaženčić 2001; Sabovljević & Cvetić 2003; Grdović 2005; Papp & al. 2006; Veljić & al. 2008; Pantović & Sabovljević 2013; Pantović & al. 2014) The formation of the Bryophyte collection of the Herbarium of the University of Belgrade (BEOU) and the BRYO database (Pantović & Sabovljević 2017), as well as the analysis of data from published works, enabled the survey of all identified bryophyte taxa, which was published in Serbian national checklist of liverworts (Pantović & al. 2020) and mosses (Pantović & al. 2021). Based on these data, a total of 1 hornwort, 138 liverwort taxa (132 species, 4 subspecies, 2 varieties) and 673

moss taxa (638 species, 7 subspecies, 28 varieties) have been recorded in Serbia so far. The 23% of the European, and 48.53% of the Southeast Europe liverwort flora is present in Serbia (Pantović & al. 2020), while the number of mosses represents 45% of the European flora and 70.5% of the flora of Southeast Europe (Pantović & al. 2021). This relatively large number of bryophyte species can be explained by different ecological conditions that are present in Serbia and in the Balkan Peninsula in general, which as a result, causes high biological diversity (Stevanović & al. 2003). However, it should be noted that the flora of bryophytes in some areas of Serbia is still insufficiently researched (Pantović & al. 2021).

One of the best bryologically explored areas of Serbia is region of Eastern Serbia, especially its mountainous parts. According to the BRYO database (Pantović & Sabovljević 2017), highest number of records was collected from this region. Beside Stara planina Mt., Vidlič Mt. and Suva planina Mt. were in the focus of bryophyte flora investigation (e.g. Papp & Erzberger 2009; Ilić & al. 2015). First research of the bryophyte flora of Stara planina Mt. began at the end of the 19th century (Jurišić 1899; Simić, 1900; Matouschek, 1901; Katić, 1909), then continued with sporadic records in the middle of the 20th century (Grebenščikov 1950; Gigov 1956; Čolić & al. 1963; Čolić 1965; Popović 1966; Mišić 1981). However, the most thorough and detailed study of the bryophyte flora of this area has been done in the recent period by Papp & Erzberger (2007). During this research, a total of 322 bryophyte taxa were recorded, of which 62 liverworts and 260 mosses. With previous historical records, all together 344 bryophyte species (63 liverworts and 281 mosses) are known from the Stara planina Mt. (Ivančević & al. 2007).

Nevertheless, focus of the majority of the previous bryological studies were mostly high alpine areas of the Stara planina Mt., while its lower parts like hilly slopes and river valleys remained less investigated. Only Katić (1909) and Papp & Erzberger (2007) included few localities in the valley of Temštica river (Fig. 1) in their field exploration. These are ecologically divergent and significant habitats due to climate inversion and Mediterranean influence penetration deep in the continental part of the Balkans. Additionally these habitats are under the treats of Small Hydropower constructions. Having that in mind, the aim of this study was to explore in more detail bryophyte flora of Temštica river basin, bringing in spotlight important species that inhabit these habitats.

Characteristics of Temštica river basin

The river Temštica (Fig. 1) is located on the slopes of Stara planina Mts. It flows through the village Temska, which is 15 km to the north of the town Pirot. Temštica represents the lower course of the river Visočica. Temštica flows into the Nišava near the village of Staničenje, at an altitude of 331 m. The Temštica basin has a very large drop, so the stream is composed of many rapids and waterfalls. In terms of geological composition, Permian red sandstones and conglomerates have a large distribution in the lower course of the river. In addition to these dominant rocks, limestones, sandstones and marls appear. This predominantly water-resistant geological composition enabled the development of a rather dense network of surface flows.

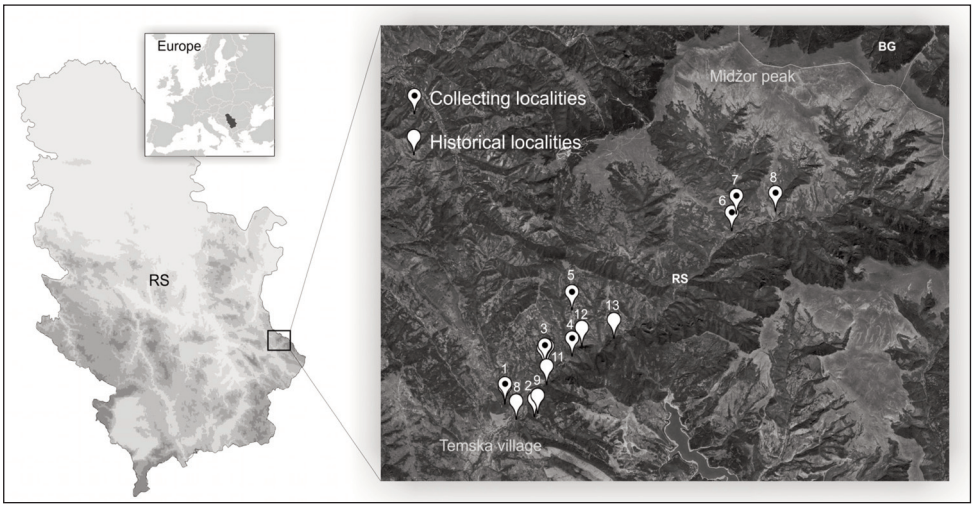

Fig. 1. Map of the Temštica river valley with indicated investigated localities. (Abbreviations: RS - Republic of Serbia, BG - Bulgaria).

Climate of the Temštica river valley is continental in its lower parts, while in its higher parts it has montane characteristics. Based on the temperatures in the surrounding meteorological stations (Knjaževac and Pirot), the average January air temperatures range from -10 to 2ºC, and the average July air temperatures from 15 to 20 ºC. Air temperatures during summer months are relatively high, because mountain ridge blocks cold air masses from the north-east. Autumn is warmer than the spring. July is the warmest month. The amount of precipitation is unevenly distributed among months and parts of the basin. It increases from the lower through the upper parts o of the river basin. For example, in the lower parts of the river valley mean annual precipitation is 700-800mm, whilst in its upper parts at an altitude of 1000 to 1500 m above sea level is up to 1000mm. Wettest month is May, and driest August. (Stanković 1997).

Specifics climate, geomorphological, geological and edaphic characteristics are causing a great diversity of flora and vegetation. Following the changes in climate on the vertical profile, 5 high-altitude vegetation belts are clearly distinguished in the mountain massif of Stara planina Mt.: oak, beech, spruce, subalpine and alpine (Ivančević & al. 2007). Because of this exceptional geographical and biological features, Stara planina Mt. is protected by national legislation as Nature Park “Stara planina”, under Protection category I (area of national and international importance).

Material and methods

Material was collected during May of 2013. Different habitat types and substrates (e. g. soil, exposed and shaded rocks, tree bark and decaying wood) were investigated. Specimens were deposited at the Bryophyte collection (BEOU). Investigated localities are

given in the list below. For this study we also included previously published bryophyte records collected in the valley of Temštica river by Katić (1909) and Papp & Erzberger (2007), which are indicated in the list of species. First records for the area are marked with an asterisk (*). Nomenclature of the taxa follows Hodgetts & al. (2019), and Pantović & al. (2020) for liverworts, and Pantović & al. (2021) for mosses.

Collecting localities:

1. Temačko hill N 43°15'77.5", E 22°33'0.41", 680 m
2. Above Sv. Đorđe monastery, N 43°16'0.93", E 22°33'55.8", 490 m
3. Krstac, N 43°16'71.7", E 22°34'19.5", 560 m
4. Tumba, N 43°17'22.5", E 22°34'65.4", 570 m
5. Sadinje, N 43°17'84.9", E 22°34'65.7", 900 m
6. Toplodolska river, N 43°20'11.6", E 22°40'0.92", 650 m
7. Kula, N 43°19'93.4", E 22°39'68.1", 900 m
8. Orlja, N 43°20'38.0", E 22°40'81.2", 800 m

Historical localities (previously visited sites by other authors)

9. Temska Monastery, N 43°16'5.8", E 22° 34' 2.3", 404 m (Katić, 1909)
10. Temstica stream, above Temska village, N 43°15'56.9", E 22°33'21.2", 401 m (Papp & Erzberger 2007)
11. Bukovački do stream, above Temska village, N 43°16'44.5", E 22°34'18.1", 457 m (Papp & Erzberger 2007)
12. Temštica stream at Temska village, N 43°17'36.7", E 22°35'23.6", 507 m (Papp & Erzberger 2007)
13. Temštica stream, between Temska and Topli Do villages, N 43°17'47.7", E 22°36'23.6", 525 m (Papp & Erzberger 2007)

Results

All together 174 species (21 liverworts and 153 mosses) are known from Temštica river valley, including historical findings. During this field investigation, a total of 86 bryophyte taxa (5 liverworts and 81 mosses) were recorded. Out of these, 3 liverworts and 51 moss taxa were recorded for the first time in the area of Temštica valley. Known localities and habitats are given for each taxon.

Complete list of bryophyte taxa

Marchantyophyta (Liverworts):

Apopellia endiviifolia (Dicks.) Nebel & D. Quandt – 10: limestone rocks at a waterfall; 11, 13: sandstone rocks at the stream (Papp & Erzberger 2007)

Chiloscyphus pallescens (Ehrh. ex Hoffm.) Dumort. –13: sandstone rocks at the stream (Papp & Erzberger 2007)
**Chiloscyphus polyanthos* (L.) Corda – 3: soil
Conocephaluum conicum (L.) Dumort. – 3: soil; 13: wet sandstone rocks (Papp & Erzberger 2007)
**Conocephalum salebrosum* Szweykowski, Buczkowska & Odrzykoski – 3: soil by the stream
Frullania dilatata (L.) Dumort. –10: on the bark of *Populus* (Papp & Erzberger 2007)
Isopaches bicrenatus (Schmidel) H. Buch – 11: on soil (Papp & Erzberger 2007)
Lophocolea bidentata (L.) Dumort. var. *bidentata* – 12: wet sandstone rocks (Papp & Erzberger 2007)
Lophocolea heterophylla (Schrad.) Dumort. –10: limestone rocks at the stream (Papp & Erzberger 2007)
Lophocoelea minor Nees – 3: soil; 10: limestone rocks; 11: on soil (Papp & Erzberger 2007)
Lophozia ventricosa (Dicks.) Dumort. –12: wet sandstone rocks (Papp & Erzberger 2007)
Marchantia polymorpha L. subsp. *polymorpha* –13: sandstone rocks at the stream (Papp & Erzberger 2007)
Marsupella emarginata (Ehrh.) Dumort. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Mesoptychia badensis (Gottsche ex Rabenh.) L. Söderstr. & Váňa. – 10: limestone rocks (Papp & Erzberger 2007)
Plagiochila porelloides (Torrey ex Nees) Lindenb. –10: sandstone rocks, rock crevices; 11, 12: sandstone rocks at the stream sandstone rocks; 13: on the bark of *Salix* (Papp & Erzberger 2007)
**Riccardia multifida* (L.) Gray. – 2: rock
Riccia glauca L. – 11: on soil (Papp & Erzberger 2007)
Scapania lingulata H. Buch – 11: sandstone rocks at the stream (Papp & Erzberger 2007)
Scapania nemorea (L.) Grolle – 12: wet sandstone rocks (Papp & Erzberger 2007)
Solenostoma hyalinum (Lyell) Mitt. – 11: on soil near waterfall (Papp & Erzberger 2007)
Trilophozia quinquedentata (Huds.) Bakalin –12: wet sandstone rocks (Papp & Erzberger 2007)

Bryophyta (Mosses):
Abietinella abietina (Hedw.) M. Fleisch. – 7: soil; 10: on soil (Papp & Erzberger 2007)
Alleniella besseri (Lobarz.) S. Olsson, Enroth & D. Quandt. –10: limestone rocks at the stream (Papp & Erzberger 2007)
Alleniella complanata (Hedw.) S. Olsson, Enroth & D. Quandt – 10: limestone rocks (Papp & Erzberger 2007)
Amblystegium serpens (Hedw.) Schimp. – 7: boulder; 10, 11: limestone rocks at the stream; 13: on the bark of *Salix* (Papp & Erzberger 2007)
Anomodon viticulosus (Hedw.) Hook. & Taylor – 10: limestone rocks at the stream; 13: on the bark of *Salix* (Papp & Erzberger 2007)
Atrichum undulatum (Hedw.) P. Beauv. – 11: on soil (Papp & Erzberger 2007)
Barbula unguiculata Hedw. – 3: rock; 10: calcareous soil (Papp & Erzberger 2007)
Bartramia ithyphylla Brid. –12: sandstone rocks, rock crevices (Papp & Erzberger 2007)

Bartramia pomiformis Hedw. –11: sandstone rocks, rock crevices; 12: wet sandstone rocks (Papp & Erzberger 2007)
**Brachythecium campestre* (Müll. Hal.) Schimp.– 1: boulder
Brachythecium glareosum (Bruch ex Spruce) Schimp. – 10: limestone rocks at the stream (Papp & Erzberger 2007)
**Brachythecium mildeanum* (Schimp.) Schimp. – 3: rock by the stream
Brachythecium rivulare Schimp. – 1, 3: rock by the stream; 13: wet sandstone rocks; 4: on wet soil; 8: at the stream; 10: on wet calcareous rock (Papp & Erzberger 2007)
Brachythecium rutabulum (Hedw.) Schimp. –11: on soil and sandstone rocks at the stream; 13: on the bark of *Salix* (Papp & Erzberger 2007)
**Brachythecium salebrosum* (Hoffm. ex F. Weber & D. Mohr) Schimp – 3, 7: rock by the stream
Bryoerythrophyllum recurvirostrum (Hedw.) P. C. Chen –11: sandstone rocks at the stream; 13: on the bark of *Salix* (Papp & Erzberger 2007)
**Bryum argenteum* Hedw. – 6, 7, 8: boulder
**Bryum dichotomum* Hedw. –6: boulder
**Bryum elegans* Nees – 6: soil
**Bryum funkii* Schwägr. – 6: soil, 7: soil
**Bryum ruderale* Crundw. & Nyholm – 3: rock
**Buckia vaucheri* (Lesq.) D. Ríos, M. T. Gallego & J. Guerra. – 1: boulder
Calliergonella cuspidata (Hedw.) Loeske – 3: soil, 7: soil; 10: on moist calcareous soil (Papp & Erzberger 2007)
Campylophyllopsis calcarea (Crundw. & Nyholm) Ochyra– 11: sandstone rocks at the stream (Papp & Erzberger 2007)
**Cerotodon purpureus* (Hedw.) Brid – 1, 7: soil, 3, 6: boulder
**Chionoloma tenuirostre* (Hook. & Taylor) M. Alonso, M. J. Cano & J. A. Jiménez – 3: rock
**Cinclidotus aquaticus* (Hedw.) Bruch & Schimp. – 3: rock by the stream
Cinclidotus fontinaloides (Hedw.) P. Beauv. – 3: rock by the stream; 13: sandstone rocks at the stream (Papp & Erzberger 2007)
**Cinclidotus riparius* (Host ex Brid.) Arn. – 3: rock by the stream
**Cirriphyllum crassinervium* (Taylor) Loeske & M. Fleisch. – 3: rock by the stream, 7: boulder
Climacium dendroides (Hedw.) F. Weber & D. Mohr – 3: soil; 11: on soil (Papp & Erzberger 2007)
Cratoneuron filicinum (Hedw.) Spruce –10: moist calcareous rock; 11: sandstone rocks at the stream (Papp & Erzberger 2007)
Ctenidium molluscum (Hedw.) Mitt. –10: limestone rocks (Papp & Erzberger 2007); 9: limestone rock (Katić, 1909)
Cynodontium bruntonii (Sm.) Bruch & Schimp. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Dicranella heteromalla (Hedw.) Schimp. –12: wet sandstone rocks (Papp & Erzberger 2007)
Dicranella staphylina H. Whitehouse – 11: on soil (Papp & Erzberger 2007)
Dicranella varia (Hedw.) Schimp. – 10: limestone rocks (Papp & Erzberger 2007)
Dicranodontium denudatum (Brid.) E. Britton – 12: wet sandstone rocks (Papp & Erzberger 2007)

Dicranum scoparium Hedw. –12: sandstone rocks, rock crevices (Papp & Erzberger 2007)
Didymodon fallax (Hedw.) R. H. Zander – 3: rock by the stream; 10: on soil; 11: sandstone rocks at the stream (Papp & Erzberger 2007)
Didymodon luridus Hornsch. –11: sandstone rocks at the stream (Papp & Erzberger 2007)
Didymodon rigidulus Hedw. – 1: boulder; 10: limestone rocks at the stream (Papp & Erzberger 2007)
Didymodon vinealis (Brid.) R. H. Zander – 7: soil; 11: sandstone rocks at the stream (Papp & Erzberger 2007)
**Ditrichium lineare* (Sw.) Lindb. – 3: rock
Encalypta streptocarpa Hedw. –10: limestone rocks (Papp & Erzberger 2007)
Eucladium verticillatum (With.) Bruch & Schimp. – 9: limestone cascade (Katić, 1909); 10, 11: limestone rocks at waterfalls (Papp & Erzberger 2007)
Exsertotheca crispa (Hedw.) S. Olsson, Enroth & D. Quandt – 10: limestone rocks (Papp & Erzberger 2007)
Fissidens crassipes Wilson ex Bruch & Schimp. subsp. *warnstorfii* (M. Fleisch.) Brugg.–Nann. – 11: sandstone rocks at the stream (Papp & Erzberger 2007)
Fissidens dubius P. Beauv. –10: limestone rocks at the stream (Papp & Erzberger 2007)
Fissidens gracilifolius Brugg.–Nann. & Nyholm – 10: limestone rocks at the stream (Papp & Erzberger 2007)
Fissidens pusillus (Wilson) Milde – 13: sandstone rocks at the stream (Papp & Erzberger 2007)
Fissidens taxifolius Hedw. –11: on soil (Papp & Erzberger 2007)
Flexitrichum flexicaule (Schwägr.) Ignatov & Fedosov –10: on soil (Papp & Erzberger 2007)
**Funaria hygrometrica* Hedw. – 1, 2, 5, 7, 8: soil
**Grimmia dissimulata* E. Maier. – 3, 6: rock
**Grimmia funalis* (Schwagr.) Bruch & Schimp. – 6: soil
Grimmia laevigata (Brid.) Brid. –12: sandstone rocks, rock crevices (conf. E. Maier) (Papp & Erzberger 2007)
**Grimmia lisae* De Not. – 2: rock by the stream, 3: boulder, 7: boulder
**Grimmia longirostris* Hook – 6: boulder
**Grimmia orbicularis* Bruch & Wilson – 3: soil
Grimmia ovalis (Hedw.) Lindb. – 12: sandstone rocks, rock crevices (conf. E. Maier) (Papp & Erzberger 2007)
Grimmia pulvinata (Hedw.) Sm. – 3, 7: rock by the stream; 12: sandstone rocks, rock crevices; 10: limestone rocks (Papp & Erzberger 2007)
Gymnostomum calcareum Nees & Hornsch. – 10: limestone rocks (Papp & Erzberger 2007)
**Hedwigia ciliata* (Hedw.) P. Beauv. – 3: rock
Homalothecium lutescens (Hedw.) H. Rob. – 10, 11: on soil (Papp & Erzberger 2007)
Homalothecium philippeanum (Spruce) Schimp. – 9: limestone rock (Katić, 1909)
Homalothecium sericeum (Hedw.) Schimp. – 1: rock, 2: rock; 10: limestone rocks; 13: on the bark of *Salix* (Papp & Erzberger 2007)
Hygroamblystegium fluviatile (Hedw.) Loeske – 3: rock and soil; 13: sandstone rocks at the stream (Papp & Erzberger 2007)
Hygroamblystegium tenax (Hedw.) Jenn. – 1, 2: rock by the stream; 11: wet sandstone rocks (Papp & Erzberger 2007)

Hygroamblystegium varium (Hedw.) Monk. – 3: soil; 10: limestone rocks at the stream (Papp & Erzberger 2007)
Hygrohypnum luridum (Hedw.) Jenn. – 11: sandstone rocks at the stream (Papp & Erzberger 2007)
Hylocomium splendens (Hedw.) Schimp. – 11, 12: on soil (Papp & Erzberger 2007)
Hypnum cupressiforme Hedw. – 3: soil, 5: boulder, 7: tree bark; 10, 11: on soil; 12: wet sandstone rocks; 13: on the bark of *Salix* (Papp & Erzberger 2007)
**Hypnum cupressiforme* Hedw. var. *lacunosum* Brid – 3: boulder, 7: boulder
**Imbribryum alpinum* (Huds. ex With.) N. Pedersen – 7: soil
**Kindbergia praelonga* (Hedw.) Ochyra – 3: soil
Leptobryum pyriforme (Hedw.) Wilson – 11: on soil (Papp & Erzberger 2007)
Leskea polycarpa Hedw. – 3: tree bark; 10: on the bark of *Populus* and *Juglans* (Papp & Erzberger 2007)
Leucodon sciuroides (Hedw.) Schwagr. – 6: tree bark; 10: on the bark of *Populus* and *Prunus cerasus* (Papp & Erzberger 2007)
Lewinskya affinis (Brid.) F. Lara, Garilleti & Goffinet. – 2, 3, 7: tree bark; 10: on the bark of *Juglans*, *Populus* and *Prunus cerasus*; 13: on the bark of *Salix* (Papp & Erzberger 2007)
Lewinskya striata (Hedw.) F. Lara, Garilleti & Goffinet –10: on the bark of *Prunus cerasus*; 13: on the bark of *Salix* (Papp & Erzberger 2007)
**Mnium marginatum* (Dicks.) P. Beauv. – 3: rock by the stream
Mnium stellare Hedw. –12: sandstone rocks, rock crevices; 11: sandstone rocks at the stream (Papp & Erzberger 2007)
Orthotrichum anomalum Hedw. – 3: boulder, 6: boulder, 7: rock; 9: limestone rock (Katić, 1909) 10: limestone rocks (Papp & Erzberger 2007);
Orthrothrichum cupulatum Hoffm. ex Brid. – 3: rock; 9: limestone rock (Katić, 1909); 10: limestone rocks (Papp & Erzberger 2007);
**Orthotrichum diaphanum* Schrad. ex Brid – 2: tree bark
Oxyrrhynchium hians (Hedw.) Loeske – 3: soil and rocks by the stream; 10: limestone rocks at the stream (Papp & Erzberger 2007)
**Oxyrrhynchium speciosum* (Brid.) Warnst. – 1, 3: rock
Palustriella commutata (Hedw.) Ochyra – 10, 11: limestone rocks at waterfalls (Papp & Erzberger 2007); 9: limestone cascade (Katić, 1909)
Palustriella falcata (Brid.) Hedenäs – 9: limestone cascade (Katić, 1909)
Philonotis capillaris Lindb.– 11: on soil (Papp & Erzberger 2007)
**Philonotis fontana* (Hedw.) Brid. – 1: soil
Philonotis marchica (Hedw.) Brid. – 10: near waterfall (Papp & Erzberger 2007) (Papp & Erzberger 2007)
**Plagiomnium cuspidatum* (Hedw.) T. J. Kop. – 3: soil
Plagiomnium ellipticum (Brid.) T. J. Kop. – 10: limestone rocks at a waterfall (Papp & Erzberger 2007)
Plagiomnium rostratum (Schrad.) T. J. Kop. – 1: soil; 10: limestone rocks at the stream (Papp & Erzberger 2007)
Plagiomnium undulatum (Hedw.) T. J. Kop. – 3: boulder, 3: rock by the stream, 7: soil; 11, 12, 13: sandstone rocks at the stream (Papp & Erzberger 2007)

Plasteurhynchium striatulum (Spruce) M. Fleisch. – 10: limestone rocks at the stream (Papp & Erzberger 2007)
Pleurozium schreberi (Willd. ex Brid.) Mitt. – 10: on soil; 12: wet sandstone rocks (Papp & Erzberger 2007)
Pogonatum aloides (Hedw.) P. Beauv. – 12: wet sandstone rocks (Papp & Erzberger 2007)
**Pohlia ludwigii* (Spreng. ex Schwagr.) Broth. – 3: soil, boulder
Pohlia lutescens (Limpr.) H. Lindb. – 11: on soil (Papp & Erzberger 2007)
Pohlia melanodon (Brid.) A. J. Shaw – 7: boulder; 10: on soil (Papp & Erzberger 2007)
Pohlia wahlenbergii (F. Weber & D. Mohr) A. L. Andrews – 10, 11: limestone rocks at a waterfall (Papp & Erzberger 2007)
Polytrichastrum alpinum (Hedw.) G. L. Sm. –12: sandstone rocks, rock crevices (Papp & Erzberger 2007)
Polytrichum commune Hedw. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Polytrichum formosum Hedw. – 11: on soil (Papp & Erzberger 2007)
Polytrichum piliferum Hedw. – 12: sandstone rocks, rock crevices (Papp & Erzberger 2007)
**Pseudoamblystegium subtile* (Hedw.) Vanderp. & Hedenäs – 3: tree bark
Pseudoscleropodium purum (Hedw.) M. Fleisch. – 10: on soil (Papp & Erzberger 2007)
Pseudotaxiphyllum elegans (Brid.) Z. Iwats. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Ptychostomum capillare (Hedw.) Holyoak & N. Pedersen – 1: rock crevices, 6, 7: rock by the stream; 10: limestone rocks; 12: on wet rocks (Papp & Erzberger 2007)
**Ptychostomum creberrimum* (Taylor) J. R. Spence & H. P. Ramsay – 7: tree bark
**Ptychostomum imbricatulum* (Müll. Hal.) Holyoak & N. Pedersen. – 3: soil, 7: boulder
**Ptychostomum inclinatum* (Sw. ex Brid.) J. R. Spence. – 7: boulder
Ptychostomum moravicum (Podp.) Ros & Mazimpaka – 7: soil and decaying wood; 10: limestone rocks at the stream (Papp & Erzberger 2007)
**Ptychostomum pallens* (Sw.) J. R. Spence. – 7: soil
Ptychostomum pseudotriquetrum (Hedw.) J. R. Spence & H. P. Ramsay ex Holyoak & N. Pedersen –10: limestone rocks at the stream (Papp & Erzberger 2007)
**Pulvigera lyellii* (Hook. & Taylor) Plášek, Sawicki & Ochyra – 4: tree bark
Racomitrium aciculare (Hedw.) Brid. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Racomitrium affine (F. Weber & D. Mohr) Lindb. –11, 12: wet sandstone rocks (det./conf. F. Müller) (Papp & Erzberger 2007)
**Racomitrium canescens* (Hedw.) Brid – 1, 3: boulder
Racomitrium heterostichum (Hedw.) Brid. –11, 12: wet sandstone rocks (rev./conf. F. Müller) (Papp & Erzberger 2007)
Racomitrium sudeticum (Funck) Bruch & Schimp. –12: wet sandstone rocks (rev./conf. F. Müller) (Papp & Erzberger 2007)
Rhabdoweisia fugax (Hedw.) Bruch & Schimp. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Rhizomnium punctatum (Hedw.) T. J. Kop. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Rhynchostegium riparioides (Hedw.) Cardot – 3: rock by the stream; 11, 13: wet sandstone rocks; 10: limestone rocks at a waterfall (Papp & Erzberger 2007)
Rhytidiadelphus triquetrus (Hedw.) Warnst. –12: wet sandstone rocks (Papp & Erzberger 2007)
Sanionia uncinata (Hedw.) Loeske –12: wet sandstone rocks (Papp & Erzberger 2007)

Schistidium apocarpum (Hedw.) Bruch & Schimp. –10: on soil over calcareous rock (conf./det. W. Schröder) (Papp & Erzberger 2007)
Schistidium crassipilum H. H. Blom –10: limestone rocks; 11: sandstone rocks; 12: wet sandstone rocks (conf. W. Schröder) (Papp & Erzberger 2007)
**Schistidium elegantulum* H. H. Blom – 3: rock by the stream
**Schistidium helveticum* (Schkuhr) Deguchi – 3: rock by the stream
**Schistidium rivulare* (Brid.) Podp. – 7: rock
**Sciuro – hypnum ornellanum* (Molendo) Ignatov & Huttunen – 6: boulder
Sciuro–hypnum populeum (Hedw.) Ignatov & Huttunen – 13: sandstone rocks at the stream (Papp & Erzberger 2007)
Syntrichia laevipila Brid. – 10: calcareous soil near waterfall (Papp & Erzberger 2007)
Syntrichia ruralis (Hedw.) F. Weber & D. Mohr – 2: rock; 12: sandstone rocks, rock crevices; 3: on the bark of *Fagus*; 10: on calcareous soil (Papp & Erzberger 2007)
**Syntrichia virescens* (De Not.) Ochyra – 6: tree bark
Thuidium assimile (Mitt.) A. Jaeger – 10, 11: on soil (Papp & Erzberger 2007); 9: soil (Katić, 1909)
**Thuidium delicatulum* (Hedw.) Schimp. – 7: tree bark, boulder
Thuidium recognitum (Hedw.) Lindb. – 11: on soil (Papp & Erzberger 2007)
Thuidium tamariscinum (Hedw.) Schimp. – 12: wet sandstone rocks (Papp & Erzberger 2007)
Tortella tortuosa (Hedw.) Limpr. – 2: rock; 10: on soil (Papp & Erzberger 2007)
**Tortula inermis* (Brid.) Mont. – 3: rock by the stream
Tortula muralis Hedw. – 10: limestone rocks; 11: sandstone rocks at the stream (Papp & Erzberger 2007)
**Tortula schimperi* M. J. Cano, O. Werner & J. Guerra – 6.boulder
Tortula subulata Hedw. – 12: sandstone rocks, rock crevices (Papp & Erzberger 2007)
**Trichostomum brachydontium* Bruch – 2: rock by the stream, 7: soil
**Trichostomum crispulum* Bruch – 1: boulder, 3: rock
**Weissia controversa* Hedw. – 1: rock by the stream, 3: rock by the stream
**Weissia longifolia* Mitt. – 1: boulder
**Zygodon rupestris* Schimp. ex Lorentz – 2: tree bark

Rare and important species

Following three moss species that grow in the Temštica river valley are considered threatened on the European level, according to the European red list (Hodgetts & al. 2019): *Bryum funkii* (VU), *Philonotis marchica* (EN) and *Sciuro-hypnum ornellanum* (EN). There are several more species regarded as threatened on the national level that are included in the Bryophyte red list of Serbia and Montenegro (Sabovljević & al. 2004). These are two liverworts, *Scapania lingulata* (EN) and *Mesoptychia badensis* (VU), as well as one moss species *Cynodontium bruntonii* (VU). However, it should be taken into account that this list is rather outdated and incomplete. Since its publication many bryofloristic papers and new species records have been published. For example, more than 200 new bryophyte taxa for the country were published during last two decades (Pantović & Sabovljević., 2017). Hence large number of newly reported taxa is not evaluated according to the IUCN criteria (Hallingback & al. 1996; Bergamini & al.

2019), nor included in the national list. Considering recent great increase in the exploration of Serbian bryophyte flora, updated red list of bryophytes is urgently needed.

Although not included in the national list, many of the species are considered regional rarities, and are red-listed in one or more European countries (Hodgetts & Lockhart 2020). Here are a few examples: liverwort *Isopaches bicrenatus* is listed as endangered (EN) in Netherlands, Slovakia and Slovenia and vulnerable (VU) in Canary Islands, Madeira and Switzerland, or mosses *Ditrichum lineare* which is listed as critically endangered (CR) in Ireland, Luxembourg, Northern Ireland and Romania, EN in Spain and Slovakia and VU in Bulgaria, Estonia and Switzerland; *Grimmia lisae* VU in Hungary and Luxembourg; *Pohlia ludwigii* EN in Finland, VU in Czech Republic, Romania and Spain; *Schistidium rivulare* CR in Montenegro and VU in Slovenia; *Weissia longifolia* EN in Finland, Norway, Madeira and Slovenia, VU in Ireland and Northern Ireland; *Zygodon rupestris* EN in Slovakia, and VU in Hungary and Switzerland and others.

Discussion

The region of Eastern Serbia, and Stara planina Mt. in particular, is distinguished by high species richness of bryophytes, as well as its specifics composition. For example, according to the BRYO database (Pantović & Sabovljević, 2017), 477 taxa, or 59% of bryophyte flora of Serbia is known from this region of the country. This exceptional bryophyte diversity can be explained by the rich geological bedrock, relief, favorable hydrological conditions, microclimate as well as diverse (micro)habitat types. For example, vertical wet sandstones and their cracks in the zone of subalpine pastures and meadows proved to be very important habitat rich in rare species and characterized by a specific composition of species (Papp & Erzberger 2007). Furthermore, highest percent of arcto-alpine bryophytes and boreal liverwort species is present in the region of Eastern Serbia (Pantović & al. 2019). At high altitudes and in conditions of high precipitation, taxa of the boreal and arctic areal type appear extrazonally. The connection of the Stara planina Mt. with the Carpathians is important for this, because from there the "northern" species can pass further south (Papp & al. 2007). The fact of great importance is that many of these species are nationally rare, known from only few sites in the country. Moreover, 21 bryophyte species (8 liverworts and 13 mosses) are in Serbia reported only from Stara planina Mt. (Pantović & al. 2020, 2021).

However, region of Stara planina Mt. and Eastern Serbia in general, is not important only for its alpine and subalpine habitats. Wider areas of river valleys proved to be as much as important. There, a fine zoning of bryophyte communities and species is observed, from strictly aquatic and hygrophilous species that grow in the immediate vicinity of water and can be periodically flooded, to the communities in exposed, dry habitats further away from the watercourse. For example, various acidic rocky habitats, both wet and exposed, are important substrate for several significant bryophyte species, such as red-listed liverwort *Scapania lingulata* and mosses *Grimmia lisae, Philonotis marchica* or *Sciuro-hypnum ornellanum*. *Scapania lingulata* is rare liverworth in Serbia, known from only two localities: Derventa canyon in Western Serbia (Papp & Sabovljević 2002) and Bukovački do stream on the slopes of Stara planina Mt. (Papp & Erzberger 2007). *Scapania lingulata* is

boreo-montane species, that grows as a pioneer on acid to basic substrates, sometimes easily confused for other species of the group (Blockeel & al. 2014). It is very rare in the Balkans, and considered near threatened (NT) in the new European Red List of Mosses, Liverworts and Hornworts (Hodgetts & al. 2019). *Grimmia lisae* has been recently reported for the first time for the Serbia, from the Ibar valley and Stolovi Mt. (Papp & al. 2016), where it has been found growing on ultramaphic rocks. So far, records from Temštica river valley represent the second locality of this species for the country. *Grimmia lisae* is European southern-temperate species that grows mostly on acidic rocks (like granite, andesite, schist, serpentine), or more rarely on limestone (Blockeel & al. 2014). In the region of Southeastern Europe, it is known from Albania, Bulgaria, Crete, Hungary, Macedonia, Montenegro, and Slovenia (Hodgetts & Lockhart 2020). In several neighboring countries, namely Albania, Bulgaria and Slovenia (Hodgetts & Lockhart 2020), it is considered data deficient (DD). European red-listed (EN) species, *S. ornellanum,* was previously known only from Povlen Mt. in western Serbia (Sabovljević & Sérgio 2002). Record from Temštica valley represents second locality for the country. It the neighboring countries, it is present only in Slovenia, where is considered endangered (Martinčič 2016). Another rare European species *Philonotis marchica* (EN), is protected in many countries in Europe, while in some countries in the region, it is insufficiently studied, hence marked as data deficient (DD), for example in Albania and Hungary (Hodgetts & Lockhart 2020). This Southern-temperate species is characteristic of wet sandstone rocks.

Conclusions

Based on the bryophyte richness and distribution of specific, rare and threatened taxa, Temštica river valley significantly contributes to the one of the richest area (Stara planina Mt.) in the sense of bryophyte species diversity and high conservation interest of bryophyte flora in Serbia. It represents one of the national centers of bryophyte diversity (i.e. hot spots) and should be furthermore protected within Important Bryophyte Areas (IBrA) network, similarly as in some other countries (Papp 2008). River valleys are areas important for the preservation of specific aquatic bryoflora, especially microhabitats such as rocky river banks, waterfalls, moist soil by the river and trees by the river. Due to unique and variable conditions on the banks of rivers, characteristic communities of rheophilic and riparial species of bryophytes are formed on the rocks and stones of the riverbed. Some of the species found in these (micro)habitats represent natural rarities, not only in Serbia but also in Europe, and a significant number of species is threatened in the countries within the region. The results of this study represent only the basis for additional bryological research of selected habitats and taxa, in order to define appropriate conservation measures, good protection policy and monitoring of threatened and signal species.

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