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Bryophyte Diversity Within Urban Areas: Case Study of the City of Belgrade (Serbia)

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Abstract: The bryophyte diversity and urban bryophyte flora of the city of Belgrade was studied. In total 210 taxa were recorded, with 23 hepatics and 187 mosses. Comparing to some other urban areas of Europe, bryophyte diversity of the Belgrade metropolitan belongs among the richest in Europe, however bryophytes are not abundant. Among bryophytes of Belgrade city, there are 14 nationally red-listed species and two internationally threatened. According to the frequency of records, the Belgrade bryophytes are classified to rare, common and spread. Rare species within the urban area are 94, 69 are common to find and only 24 are spread and easy to record in Belgrade wide area. Urban metropolitan areas are different from native but gives various condition in small shelters for rich diversity of small organisms like bryophytes.

Key words: Diversity, bryophytes, mosses, hepatics, urban flora, Belgrade

INTRODUCTION

Urban areas comprise many ecological situations which differs among each other. Considering the small size of the microhabitats, it can not offer potentially many resources for the proper development of huge plants. However, small plants like bryophytes i.e., liverworts and mosses are widely adapted to such sites and even more appreciate the absence of other competitive plants. Therefore, bryophyte flora of urban areas represent significant part of the city vegetation.

The urban bryophyte vegetation is interesting not only by its floristic composition, but to presence of rare and significant taxa, vegetation relationships and from phyto-geographical point of view.

The city of Belgrade (serb. Beograd) is the capital of Serbia having about 2 million inhabitants (ca. 21% of the Serbian population). It is located in the south-eastern of Europe, where, the Pannonian plain meets the Balkan Peninsula, at the confluence of the Sava and Danube rivers (44°49'14" North, 20°27'44" East). Belgrade lies 116.75 m (383 ft) above sea level. The city has an urban area of 360 km² (139 sq miles), while together with its metropolitan area it covers 3,223 km² (1,244.4 sq miles). Central Belgrade has hilly terrain, while the highest point of Belgrade proper is Torlak Hill at 303 m (994 ft). The mountains of Avala (511 m (1,677 ft)) and Kosmaj (628 m (2,060 ft)) lie south of the city. Across the Sava and Danube, the land is mostly flat, consisting of alluvial plains and loess cliffs and plateaus.

It is one of the oldest cities in Europe and since ancient times it has been an important traffic focal point,

an intersection of the roads of Eastern and Western Europe. Its territory is divided into 17 municipalities and covers 3.6% of the territory of Serbia.

Belgrade has a moderate continental climate with a year-round average temperature of 11.7°C (53.1°F) and four well defined seasons.

The hottest month is July, with an average temperature of +22.1°C (71.8°F). There are, on average, 31 days a year when the temperature is above 30°C and 95 days when the temperature is above 25°C. Belgrade receives about 700 mm (27.56 inches) of precipitation a year. The average annual number of sunny hours is 2,096. The sunniest months are July and August, with an average of about 10 sunny hours a day, while December and January are the gloomiest, with an average of 2-2.3 sunny hours a day. The highest ever recorded temperature in Belgrade was +43.1°C, while on the other end, the lowest temperature was -21°C. Mean atmospheric pressure in Belgrade is 1,001 millibars and mean relative humidity is 69.5%.

Autumn is longer than spring, with longer sunny and warm periods - the so-called Indian summer. Winter is not so severe, with an average of 21 days with temperature below zero. January is the coldest month, with average temperature of 0.4°C. Spring is short and rainy. Summer arrives abruptly and is hot and dry (Jovanović, 1994) (Fig. 1).

Hydrological network of Belgrade is well developed. Geology is mainly limestone, but loess, sandstone and even some serpentine fragments can be found and substrate over are very diverse.

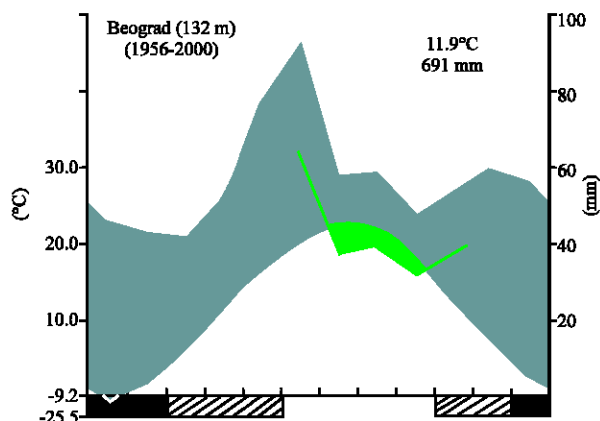


Fig. 1: Climate diagram of Belgrade (Beograd)

Earlier, there are a few sporadic bryophyte records from the wide area of Belgrade (Soška, 1949; Pavletić, 1955). Grdović and Stevanović (2006) gave contribution to the urban bryoflora of downtown area in Belgrade citing 58 species.

In this study and extensive list of species recorded in wide city area of Belgrade is given as well as the urban bryophyte ecology. The study represent the first extensive investigation of the urban bryophytes within South Eastern Europe.

Up to date studies on bryophytes of urban areas are known for only a few huge urban areas e.g., Berlin and Brandenburg (Schaepe, 1986; Benkert *et al.*, 1995), Brussels (Vanderpoorten, 1997), Wien (Hohenwallner and Zechmeister, 2001a, b; Zechmeister *et al.*, 2001; Hohenwallner, 2000a, b).

Among Southern European urban areas an extensive data on urban bryophyte floras of Western Mediterranean towns in Spain (Ballesteros Segura and Ron, 1985; Casas and Saiz, 1982; Esteve *et al.*, 1977; Fiol, 1983; Heras and Soria, 1990; Lara and Mazimpaka, 1989; Lara *et al.*, 1991; Mazimpaka *et al.*, 1988, 1993; Soria and Ron, 1990, 1995; Soria *et al.*, 1992; Vicente *et al.*, 1986; Viera and Ron, 1986), Portugal (Bento-Pereira and Sérgio, 1983; Sérgio, 1981; Sérgio and Bento-Pereira, 1981) and Italy (Carcano, 2004, 1989; Cortini Pedrotti, 1989; Aleffi, 1991; Aleffi and Taruschio, 1996; Dia and Not, 1991; Lo Giudice, 1992; Giudice *et al.*, 1997; Pokorny *et al.* 2006) are well documented.

A few, but very important studies on urban bryophyte ecology give insights into the biological peculiarities and significance of these plants in urban environment (Gilbert, 1968, 1970, 1989; Nickl-Navratil, 1960; Vareschi, 1936; Brandes, 1983; Franzen, 2001; Humer-Hochwimmer and Zechmeister, 2001; Solga *et al.*, 2005, 2006 a, b; Solga and Frahm, 2006; Sabovljević *et al.*,

2005, 2007; Vukojević *et al.*, 2005, 2006; Frahm and Sabovljević, 2007).

MATERIALS AND METHODS

During 2000-2007 an extensive bryophyte collection were made in the metropolitan region of the Belgrade city, which includes territories of all municipalities of Belgrade (Stari Grad, Vracar, Savski Venac, Zvezdara, Cukarica, Palilula, Novi Beograd, Zemun, Surcin, Voždovac, Rakovica, Obrenovac, Grocka and partly (northern areas of) Barajevo, Sopot and Mladenovac). A random sampling in different habitats and microhabitats within the urban area including larger green surface were used to collect as much as possible data on urban bryophyte flora and discover the its diversity within the city of Belgrade.

Nomenclature follows Sabovljević and Natcheva (2006) and Ros *et al.* (2007) for hepatics and Hill *et al.* (2006) for mosses. The exception are made within *Hypnum cupressiforme* complex and *Syntrichia ruraliformis* (following Sabovljević *et al.*, 2008).

All the bryophyte collected are assigned to one of four main habitat types (following classification of habitat types proposed by Ron *et al.* (1987): (1) reophilic (species adapted to water flow and inhabited water proximity); (2) rupestrian and chasmophytic (species growing on concrete and mortar, tiles and bricks, wet, shaded, sunny and dry limestone or acidic rocks and walls); (3) terrestrial (sunny, dry, humid and nitrified soils); (4) epiphytic (tree bases, trunks). The city is for the purpose of easier comparison divided to five zones: (A) old city; (B) modern city; (C) inner parks and green surfaces; (D) outer parks, gardens and yards and (E) the rivers Danube and Sava sides with attachments trough the city. The bryophytes collected are classified as: R) Rare (one or two record(s)); K) common (3-7 records) and S) Spread (more than 7 records, within studied area).

For the comparison with bryoflora richness of other cities we randomly chose some western, central and south European cities: Cologne (Sabovljević and Sabovljević, in press) and Rolandseck (Frahm, 2006) in Germany; Trento in Italy (Pokorny *et al.*, 2006), Vienna in Austria (Hohenwallner and Zechmeister, 2001a, b), Madrid (Mazimpaka *et al.*, 1988), Granada (Esteve *et al.*, 1977) and Murcia (Rams *et al.*, 2000) in Spain, Szczecin (Fudali, 1994) in Poland and Bruxelles (Vanderpoorten, 1997) in Belgium.

Bryophyte catalogue: For the each taxa found in the city of Belgrade (wide area), information of the city zones, they lived and habitat, they were growing, are given. Hepatics and mosses are listed separately and alphabetically. Specimens are deposited in Belgrade University Herbarium (BEOU) and the herbarium of Faculty of Veterinary Medicine.

RESULTS

The bryophyte flora of the Belgrade city counts 210 species of which 187 belongs to mosses and 23 to hepatics. They are listed bellow (see the chapter Material and Methods for the abbreviations):

Belgrade bryophyte species

Hepatics

1. *Calypogeia azurea* Stotler et Crotz. D4 - (R)
2. *Chiloscyphus polyanthos* (L.) Corda D4 - (R).
3. *Cololejeunea rossettiana* (C. Massal.) Schiffn. - D2, D3 - (R)
4. *Conocephalum conicum* (L.) Dumort. B2, C2, C3, D1 - (K)
5. *Fossombronina wondraczekii* (Corda) Lindb. D3 - (R)
6. *Frillania dilatata* (L.) Dumort. D4 - (K)
7. *Jungermannia* sp. - D3 - (R)
8. *Lejeunea cavifolia* (Ehrh.) Lindb. D4 (R)
9. *Lophocolea bidentata* (L.) Dumort. D4 - (K)
10. *Lophocolea heterophylla* (Schrad.) Dumort. D4 - (K)
11. *Lunularia cruciata* (L.) Lindb. A3, B3 - (R)
12. *Marchantia polymorpha* L. D1 - (K)
13. *Metzgeria furcata* (L.) Dumort. D2, D4 - (K)
14. *Pellia endiviifolia* (Dicks.) Dumort. - D1, D3 - (K)
15. *Pellia epiphylla* (L.) Corda D4 - (K)
16. *Plagiochila porelloides* (Torrey ex Nees) Lindenb. D3 - (K)
17. *Porella platyphylla* (L.) Pfeiff. D2, D4 - (K)
18. *Radula complanata* (L.) Dumort. D4 - (K)
19. *Radula lindenbergiana* Gottsche ex C. Hartm. D4 - (R)
20. *Riccia fluitans* L. D1, D3 - (R)
21. *Riccia sorocarpa* Bisch. D3 - (R)
22. *Ricciocarpus natans* (L.) Corda - E1 (R)
23. *Scapania nemorea* (L.) Grolle - D3 - (R)

Mosses

1. *Aloina aloides* (Koch ex Schultz) Kindb. A3, B3 - (K)
2. *Aloina ambigua* (Bruch and Schimp.) Limpr. A3, B3 - (K)
3. *Aloina rigida* (Hedw.) Limpr. A3, B3 - (K)
4. *Amblystegium confervoides* (Brid.) Schimp. D2, D4, E4 - (K)
5. *Amblystegium serpens* (Hedw.) Schimp. A1, A2, A3, A4, B3, C2, C3, C4, D1, D2, D3, D4, E2, E4 - (S)
6. *Amblystegium subtile* (Hedw.) Schimp. C4, D2, D3, D4, E4 - (S)
7. *Anomodon attenuatus* (Hedw.) Huebener D1, D4 - (R)
8. *Anomodon longifolius* (Schleich. ex Brid.) Hartm. C4 - (R)

9. *Anomodon viticulosus* (Hedw.) Hook. and Taylor D3, D4 - (K)
10. *Atrichum undulatum* (Hedw.) P. Beauv. D3 - (K)
11. *Barbula convoluta* Hedw. B2, C2, D2, D4, E2 - (K)
12. *Barbula unguiculata* Hedw. A2, A3, C2, D2, D4, E2 - (K)
13. *Brachytheciastrum velutinum* (Hedw.) Ignatov and Huttunen A2, A3, C2, D1, D3, D4 - (K)
14. *Brachythecium albicans* (Hedw.) Schimp. D3 - (R)
15. *Brachythecium campestre* (Mull.Hall.) Schimp. D2 - (R)
16. *Brachythecium glareosum* (Bruch ex Spruce) Schimp. D2, D3, D4 - (K)
17. *Brachythecium rivulare* Schimp. C2, D2, D3 - (R)
18. *Brachythecium rutabulum* (Hedw.) Schimp. A2, A3, B3, C2, C3, D2, D3, D4 - (S)
19. *Brachythecium salebrosus* (Hoffm. Ex F. Weber and D. Mohr) Schimp. A3, B3, C2, D2, D4 - (S)
20. *Bryoerytrophylum recurvirostre* (Hedw.) P. C. Chen A3, B3, C3 - (K)
21. *Bryum algovicum* Sendtn. ex Mull.Hal. C2, D2 - (R)
22. *Bryum archangelicum* Bruch and Schimp. E2 - (R)
23. *Bryum argenteum* Hedw. A2, A3, A4, B2, C2, C3, C4, D2, D4, E2 - (S)
24. *Bryum atrovirens* agg. A3, C2 - (K)
25. *Bryum caespiticium* Hedw. A2, A3, C2, D2, D3, E2, E4 - (S)
26. *Bryum caespiticium* Hedw. aff. *Bryum badium* (Brid.) Schimp. A2 - (R)
27. *Bryum capillare* Hedw. A2, B3, C2, C4, D2, D4, E2 - (S)
28. *Bryum creberrimum* Taylor C3, D2, E4 (R)
29. *Bryum dichotomum* Hedw. A2, A3, C2, D2, E2, E4 (K)
30. *Bryum intermedium* (Brid.) Blandow - B2, C2, C3, D2 - (K)
31. *Bryum kunzei* Hornsch. A2, A3 - (K)
32. *Bryum moravicum* Podp. D4 - (K)
33. *Bryum pallens* Sw. B2, D2, D4, E2 - (K)
34. *Bryum pallescens* Schleich. ex Schwagr. B2, C2, D2, D4 - (K)
35. *Bryum pseudotriquetrum* (Hedw.) P. Gaertn. et al. D2, E2, E4 - (K)
36. *Bryum subapiculatum* Hampe C3 - (R)
37. *Bryum turbinatum* (Hedw.) Turner D2 - (R)
38. *Callicladium haldanianum* (Grew.) H. A. Crum D4 - (R)
39. *Calliigonella cuspidata* (Hedw.) Loeske D3 - (R)
40. *Campyliadelphus chrysophyllus* (Brid.) R. S. Chopra D3, E4 - (R)
41. *Campylophyllum calcareum* (Crundw. and Nyholm) Hedenas D4 - (R)
42. *Ceratodon purpureus* (Hedw.) Brid. A2, A3, A4, C2, C3, C4, D2, D3, E2 - (S)
43. *Cirriphyllum piliferum* (Hedw.) Grout. C2, D3 - (R)

44. *Cratoneuron filicinum* (Hedw.) Spruce D1 - (R)
45. *Crossidium crassinerve* (De Not.) Jur. A3, D3 - (R)
46. *Crossidium laxefilamentosum* W. Fray and Kurschner A3, D3 - (R)
47. *Crossidium squamiferum* (Viv.) Jur. A2 - (R)
48. *Ctenidium molluscum* (Hedw.) Mitt. C2 - (R)
49. *Cynodontium polycarpon* (Hedw.) Schimp. D2 - (R)
50. *Dichodontium pellucidum* (Hedw.) Schimp. D2, D3 - (K)
51. *Dicranella heteromalla* (Hedw.) Schimp. D3 - (K)
52. *Dicranella varia* (Hedw.) Schimp. D2 - (K)
53. *Dicranum scoparium* Hedw. B3, D3 - (R)
54. *Didymodon cordatus* Jur. A3, C3, D3 - (R)
55. *Didymodon fallax* (Hedw.) R. H. Zander A3, C2, D4 - (K)
56. *Didymodon insulanus* (De Not.) M.O. Hill. A3, B3, D2, D3, E2 - (K)
57. *Didymodon luridus* Hornsch. A2, B3, C2 - (K)
58. *Didymodon rigidulus* Hedw. A2, B2, B3, C2 - (S)
59. *Didymodon spadiceus* (Mitt.) Limpr. D1, D2 - (R)
60. *Didymodon tophaceus* (Brid.) Lisa D1, D2 - (R)
61. *Didymodon vinealis* (Brid.) R. H. Zander A2, A3, B2, B3, C2, D2, D3, D4, E4 - (S)
62. *Ditrichum flexicaule* (Schwagr.) Hampe B3, D3, D4 - (K)
63. *Ditrichum heteromallum* (Hedw.) E. Britton B3, D3, D4 - (K)
64. *Ditrichum pallidum* (Hedw.) Hampe B3, D4 - (R)
65. *Ditrichum pussillum* (Hedw.) Hampe D2, D4 - (R)
66. *Drepanocladus polygamus* (Schimp.) Hedenas C1 - (R)
67. *Encalypta streptocarpa* Hedw. D2, D3 - (K)
68. *Encalypta vulgaris* Hedw. B3 - (R)
69. *Enthostodon* sp. B1, D1 - (R)
70. *Entodon concinnus* (De Not.) Paris D1 1
71. *Eucladium verticillatum* (With.) Bruch and Schimp. D2 - (R)
72. *Eurhynchiastrum pulchellum* (Hedw.) Ignatov and Huttunen A2, C3, D2, D3 - (K)
73. *Eurhynchium striatum* (Hedw.) Schimp. C2, C3, D4 - (K)
74. *Fissidens adianthoides* Hedw. C3, D3 - (K)
75. *Fissidens bryoides* Hedw. D3 - (R)
76. *Fissidens dubius* P. Beauv. C3, D2 - (K)
77. *Fissidens taxifolius* Hedw. C3, D3 - (K)
78. *Funaria hygrometrica* Hedw. A2, A3, B3, C3 - (S)
79. *Grimmia orbicularis* Bruch ex Wilson D2 - (R)
80. *Grimmia pulvinata* (Hedw.) Sm. A2, B2, C2, D2, D4, E2, E4 - (S)
81. *Grimmia trichophylla* Grev. B3, D1, E2 - (K)
82. *Gymnostomum aeruginosum* Sm. D1, D2 - (R)
83. *Gymnostomum calcareum* Nees and Hornsch. A2, B2 - (R)
84. *Herzogiella seligeri* (Brid.) Z. Iwats. D4, E4 - (K)
85. *Hilpertia velenovskyi* (Schiffn.) R. H. Zander - A3 - (R)
86. *Homalia trichomanoides* (Hedw.) Brid. D4 - (R)
87. *Homalothecium aureum* (Spruce) H. Rob. A3 - (R)
88. *Homalothecium lutescens* (Hedw.) H. Rob. D1, D2, D3, D4, C2, C4, E2, E4 - (S)
89. *Homalothecium philippeanum* (Spruce) Schimp. C2, C4, D2, D4 - (K)
90. *Homalothecium sericeum* (Hedw.) Schimp. B2, B3, C2, D2, D3, D4 - (S)
91. *Homomalium incurvatum* (Schrad. ex Brid.) Loeske D4, E4 - (K)
92. *Hygroamblystegium tenax* (Hedw.) Jenn. A1, C2, D1, D2, D4 - (K)
93. *Hygroamblystegium varium* (Hedw.) Monk. A3, C2, C4, D2, D4, E2, E4 - (S)
94. *Hygrohypnum luridum* (Hedw.) Jenn. D1 - (R)
95. *Hypnum andoi* A.J.E.Sm. D4 - (R)
96. *Hypnum cupressiforme* Hedw. var *cupressiforme* A2, A4, B2, C2, C4, D2, D3, D4, E2, E4 - (S)
97. *Hypnum jutlandicum* Holmen and E. Warncke D4 - (R)
98. *Hypnum lacuinoisum* (Brid.) Hoffm. ex Brid. C4, D4 - (K)
99. *Hypnum resupinatum* Taylor D4 - (K)
100. *Hypnum tectorum* Brid. - D4 - (R)
101. *Isopterygyopsis muelleriana* (Schimp.) Z. Iwats. C4, D2, D4 - (K)
102. *Isopterygyopsis pulchella* (Hedw.) Z. Iwats. D4 - (R)
103. *Isothecium alopecuroides* (Lam. ex Dubois) Isov. C2, D2 - (K)
104. *Isothecium myosuroides* Brid. C2, D2, D3, D4 - (S)
105. *Kindbergia praelonga* (Hedw.) Ochrya A3, C3, D3, D4 - (K)
106. *Leptodictium riparium* (Hedw.) Warnst. A2, B3, C2, C4, D1 - (K)
107. *Lescuraea mutabilis* (Brid.) Lindb. ex I. Hagen D2, D3, D4 - (R)
108. *Leskea polycarpa* Hedw. A2, B2, C4, D1, D2, D3, D4, E2, E4 - (S)
109. *Leucodon sciuroides* (Hedw.) Schwagr. D4 - (R)
110. *Mnium stellare* Hedw. D3 - (R)
111. *Orthothecium intricatum* (Hartm.) Schimp C4 - (R)
112. *Orthothecium rufescens* (Dicks. ex Brid.) Schimp. D2 - (R)
113. *Orthotrichum affine* Schrad. ex Brid. C2, D1, D4, E2 - (K)
114. *Orthotrichum anomalum* Hedw. A2, B2, C2, D2, D4 - (S)
115. *Orthotrichum cupulatum* Hoffm. ex Brid. C2, E4 - (R)
116. *Orthotrichum diaphanum* Schrad. ex Brid. A2, B2, C2, C4, D1, D2, D4, E2, E4 - (S)

117. *Orthotrichum lyellii* Hook. and Taylor D4, E4 - (K)
 118. *Orthotrichum patens* Bruch ex Brid. D4 - (R)
 119. *Orthotrichum pumilum* Sw. D2, E4 - (R)
 120. *Orthotrichum rupestre* Schleich. ex Schwagr. D2, D4 - (K)
 121. *Orthotrichum speciosum* Nees E4 - (R)
 122. *Orthotrichum stramineum* Hornsch. ex Brid. E4 - (R)
 123. *Orthotrichum striatum* Hedw. D2, D3, E4 - (R)
 124. *Orthotrichum tenellum* Bruch ex Brid. D2 - (R)
 125. *Oxyrrhynchium hians* (Hedw.) Loeske B3, C2, C3, D2, D3 - (S)
 126. *Oxyrrhynchium speciosum* (Brid.) Warnst. C3, D1, D2 - (K)
 127. *Oxystegus tenuirostris* (Hook. and Taylor) A. J. E. Sm. D2 - (R)
 128. *Palustriella commutata* (Hedw.) Ochyra D1 - (R)
 129. *Phascum cuspidatum* Hedw. A3, B3, C3, D3 - (K)
 130. *Physcomitrella patens* (Hedw.) Bruch and Schimp. - B1, B3, D3 - (R)
 131. *Physcomitrium pyriforme* (Hedw.) Bruch and Schimp. - D1, D3 - (R)
 132. *Plagiomnium affine* (Blandow ex Funck) T.J. Kop. E2 - (R)
 133. *Plagiomnium cuspidatum* (Hedw.) T. Kop. C3 - (R)
 134. *Plagiomnium elatum* (Bruch and Schimp.) T.J. Kop. D3, D4 - (R)
 135. *Plagiomnium medium* (Bruch and Schimp.) T.J. Kop. D3 - (R)
 136. *Plagiomnium rostratum* (Schrad.) T. J. Kop. E2 - (R)
 137. *Plagiomnium undulatum* (Hedw.) T. J. Kop. B3, C3, D3 - (K)
 138. *Plagiothecium cavifolium* (Brid.) Z. Iwats. D3 - (R)
 139. *Plasteurhynchium meridionale* (Schimp.) M.Fleisch. A2 - (R)
 140. *Platyhypnidium riparioides* (Hedw.) Dixon C3, D3 - (K)
 141. *Pleuridium acuminatum* Lindb. D3 - (R)
 142. *Pleurochaete squarrosa* (Brid.) Lindb. - C3, D3 - (K)
 143. *Pohlia cruda* (Hedw.) Lindb. D2 - (R)
 144. *Pohlia melanodon* (Brid.) A. J. Shaw. - B1, B3 - (R)
 145. *Polytrichum commune* Hedw. D3 - (R)
 146. *Pseudocrossidium hornschurchianum* (Schultz) R. H. Zander C3, D3 - (K)
 147. *Pseudoleskella nervosa* (Brid.) Nyholm D2, D4 - (K)
 148. *Pterygynandrum filiforme* Hedw. D2, D4 - (K)
 149. *Pylaisia polyantha* (Hedw.) Schimp. C4, D2, D3, D4, E4 - (S)
 150. *Rhynchostegiella tenella* (Dicks.) Limpr. C1, C2, D2 - (K)
 151. *Rhynchostegiella teneriffae* (Mont.) Dirkse and Bouman C2 - (R)
 152. *Rhynchostegium confertum* (Dicks.) Schimp. A2, A3, D3, D4, E3 - (R)
 153. *Rhynchostegium megapolitanum* (Blandow ex F. Weber and D. Mohr) Schimp. E2 - (R)
 154. *Schistidium apocarpum* (Hedw.) Bruch and Schimp. A2, B2, C2, D2, E2 - (S)
 155. *Schistidium crassipilum* H. H. Blom A2, B2, C2, D2 - (K)
 156. *Schistidium elegantulum* H. H. Blom D2 - (R)
 157. *Schistidium helveticum* (Schkuhr) Deguchi A2, B2, C2, D2 - (K)
 158. *Sciuro-hypnum flotowianum* (Sendtn.) Ignatov and Huttunen C3 - (R)
 159. *Sciuro-hypnum plumosum* (Hedw.) Ignatov and Huttunen C3, D2, D4 - (R)
 160. *Sciuro-hypnum populeum* (Hedw.) Ignatov and Huttunen C2, C3, D4 - (K)
 161. *Scleropodium touretii* (Brid.) L.F. Koch C2, D3 - (R)
 162. *Syntrichia calcicola* J. J. Amann B2, C3, D2 (K)
 163. *Syntrichia laevipila* Brid. D2, D4, E2 - (K)
 164. *Syntrichia montana* Nees D2 - (R)
 165. *Syntrichia papillosa* (Wilson) Jur. D4, E4 - (K)
 166. *Syntrichia princeps* (De Not.) Mitt. C2 - (K)
 167. *Syntrichia ruraliformis* (Besch.) Cardot - C3, D2 - (R)
 168. *Syntrichia ruralis* (Hedw.) F. Weber and D. Mohr A2, D2, D4, E2 - (S)
 169. *Syntrichia virescens* (De Not.) Ochyra D4, E2 - (R)
 170. *Taxiphyllum wissgrillii* (Garov.) Wijk and Margad. D4 - (R)
 171. *Thuidium tamariscinum* (Hedw.) Schimp. D3 - (R)
 172. *Tortella fragilis* (Hook. and Wilson) Limpr. B3 - (R)
 173. *Tortella tortuosa* (Hedw.) Limpr. B3, D3 - (R)
 174. *Tortula inermis* (Brid.) Mont. C2 - (R)
 175. *Tortula lanceola* R. H. Zander C3, D3 - (R)
 176. *Tortula muralis* Hedw. var. *aestiva* Hedw. A3, C2, C4 - (R)
 177. *Tortula muralis* Hedw. var. *muralis* A2, A3, B3, C2, C4, D2, E2 - (S)
 178. *Tortula schimperii* M.J. Cano, O. Werner and J. Guerra - D3 - (R)
 179. *Tortula subulata* Hedw. B3, D2, D3 - (K)
 180. *Tortula truncata* (Hedw.) Mitt. C3, D4 - (K)
 181. *Trichodon cylindricus* (Hedw.) Schimp. D3 - (R)
 182. *Trichostomum brachydontium* Bruch A3, C2, C4, D2, E4 - (K)
 183. *Trichostomum crispulum* Bruch A2, A3, D3 - (K)
 184. *Ulotia crispa* (Hedw.) Brid. D2, D4 - (R)
 185. *Warnstorfia exannulata* (Schimp.) Loeske C4 - (R)
 186. *Weissia brachycarpa* (Nees and Hornsch.) Jur. D2, D4 - (R)
 187. *Weissia controversa* Hedw. D3 - (R)

DISCUSSION

Belgrade has rich bryophyte flora. However, hepatics are not abundant and any species does not enter the category of spread (S) within the investigated area. This gives us the idea on Belgrade climate where the very dry long summers combined with disturbed and non adequate habitats prevent the large presence of hepatics.

Among 187 moss taxa recorded species found up to two times which means rare (R) are the most presented in Belgrade (94 taxa). The 24 spread taxa (S) were recorded more than 7 times within Belgrade city area. Common moss taxa to record in Belgrade city (recorded by us 3-7 times) are 69.

According to the data obtained, Belgrade has many small microhabitats and contains many significant populations of some threatened Serbian and European mosses.

Three species (*Callicladium haldanianum* (EN), *Hilpertia velenovskyi* (EN) and *Hypnum andoi* (VU) are nationally and/or internationally threatened taxa (Sabovljević *et al.*, 2004; ECCB, 1995). Further, eleven species are of lower risk in Serbia: *Crossidium crassinerve*, *C. laxefilamentosum*, *Ditrichum pallidum*, *D. pusillum*, *Hygroamblystegium tenax*, *Isopterygyopsis pulchella*, *Physcomitrella patens*, *Physcomitrium pyriforme*, *Rhynchostegiella teneriffae*, *Scelopodium touretii* and *Syntrichia papillosa*. One data deficient species was recorded as well: *Anomodon longifolius*.

Especially interesting habitats are Belgrade fragile loess cliffs sites in Zemun, Bežanija, Donji Kalemegdan and Višnjička Kosa with its specific cryptogamic flora and rare and endangered species like *Hilpertia velenovskyi* and *Crossidium laxefilamentosum*. The fragile ecology are already discussed by Sabovljević (2003a, 2004) and Pócs *et al.* (2004).

The second record for Serbia of *Schistidium elegantulum*, known previously only from the road edge in Obrež, Srem (Sabovljević, 2003b) was made, along the Sava on the concrete.

The bryologically richest site in wider Belgrade is Avala Mt. Data covers wider area of Avala Mt. can be found in Sabovljević and Cvetić (2003).

Comparing Belgrade bryophyte diversity to the other European cities, it is one of the highest (Fig. 2). Eventhough, the sizes and the geographical positions of the cities compared are not took into consideration the urban flora of Belgrade is very rich and interesting not only from the diversity point but also from the biogeographical, ecological and taxonomic point of view.

Further investigations in distribution and vegetational relationships among urban bryophytes are needed.

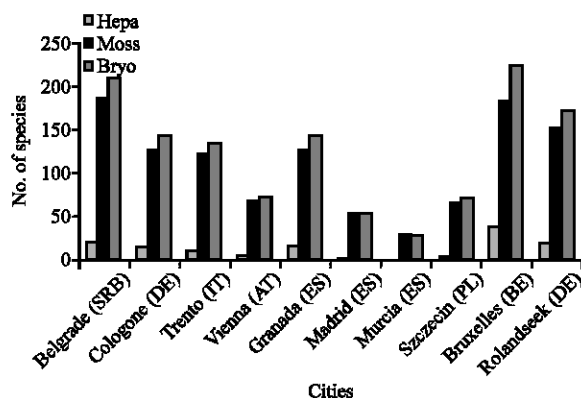


Fig. 2: Comparison of bryophyte diversity richness in some European cities (hepa-hepatics, moss-mosses, bryo - bryophytes)

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