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EPIPHYTIC MOSSES IN THE CENTRE OF TIRANA CITY (ALBANIA)

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Abstract: This study is aiming to give a general overview about epiphytic moss communities of trees in the main streets of Tirana's city centre and its adjacent park. Altogether 145 trees were investigated for epiphytic mosses during the spring of 2016. Altogether 553 moss samples were collected resulting in a total of 40 moss taxa, 19 taxa for strictly urban area and 39 for park area, with 18 taxa being in common for both communities. For the strictly urban area the five most common species were *Orthotrichum diaphanum*, *Syntrichia papillosa*, *Fabronia pusilla*, *Homalothecium sericeum* and *Syntrichia laevipila*. From the other side, the five most common species of the Park area were *Hypnum cupressiforme*, *Homalothecium sericeum*, *Syntrichia papillosa*, *S. laevipila* and *Leucodon sciuroides*. The values of biodiversity indices were higher for the park area, and the similarity between these two communities was of average degree. Among the epiphytic mosses recorded some are resistant to air pollution and others are sensitive to it. The question if the differences seen between the two communities are only a consequence of microclimatic conditions remains open, as a long term monitoring of biodiversity dynamics will be needed on the one hand and a standardised method to check for correlations between biological parameters and chemical-physical parameters on the other hand.

Key words: urban flora, biodiversity, air pollution, Albania

INTRODUCTION

In Europe there are plenty of studies of urban bryofloras. In the study of the Belgrade bryoflora (Sabovljević and Grdović 2009) abundant literature for European cities is given where studies of urban bryoflora are conducted, such as: Berlin and Brandenburg (Schaepe 1986, Benkert *et al.* 1995), Brussels (Vanderpoorten 1997), Vienna (Hohenwallner and Zechmeister 2001*a*, *b*, Zechmeister *et al.* 2001, Hohenwallner 2000*a*, *b*), in many urban areas of Spain (Ballesteros Segura and Ron 1985, Casas and Saiz 1982, Esteve *et al.* 1977, Fiol 1983, Ron *et al.* 1987, 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, Rams *et al.* 2000), Portugal (Bento-Pereira and Sergio 1983, Sergio 1981, Sergio and Bento-

Pereira 1981), and Italy (Carcano 1989, Cortini-Pedrotti 1989, Aleffi 1991, Aleffi and Taruschio 1996, Dia and Not 1991, Mazimpaka 2006, Lo Giudice 1992, Lo Giudice *et al.* 1997, Pokorny *et al.* 2006). Furthermore, many studies of urban and suburban areas of England exist, with some of these studies repeated in different periods (Paton 1969, Bates 1995, Porley 1996). Duckett and Pressel (2009) discussed the changes in the bryophyte diversity in the city of London in the last 150 years. Other ecological studies have shed light on the importance and peculiarity of bryophytes of urban areas (Gilbert 1968, 1970, 1989, Nickl-Navratil 1960, Vareschi 1936, Brandes 1983, Franzen 2001, Humer-Hochwimmer and Zechmeister 2001, Solga *et al.* 2006*a*, *b*, Solga and Frahm 2006, Sabovljević *et al.* 2005, 2007, Grdović and Stevanović 2006, Vukojević *et al.* 2005, 2006, Frahm and Sabovljević 2007).

Urban and industrial areas are colonised by bryophytes, which are more or less resistant to high concentrations of toxic elements in the air, such as SO_2, SH_2, NO_X, etc. (Lo Giudice *et al.* 1997, Gilbert 1968).

Bates (1995) presented the bryoflora of Berkshire based on samples systematically collected since 1982, and data from earlier studies as well; in this paper 434 taxa are reported starting with very old reports (year 1660), but 55 of these taxa have not been found since 1980 or earlier. Distribution maps show distribution patterns affected by calcium carbonate content in the soil, rainfall changes, presence of areas with old trees, and atmospheric pollution as well. Comparison of the actual bryoflora with earlier studies shows significant decrease in the bryophyte frequency in different habitats, including epiphytic substrates. On the other hand, the frequency of at least 7 liverworts and 50 moss species increased. These changes may be attributed to several anthropogenic effects and pollutants. Atmospheric pollution has particularly caused biodiversity loss among epiphytes, but with the decrease of SO_2 in recent decades several taxa have started to re-colonise lost territories of the past. For example, in another study (Richter *et al.* 2009) of the city of Halle (Germany) it is discussed that due the continuous decrease of atmospheric pollution re-colonisation of epiphytic bryophytes would start in "former deserts", the latter documented in previous studies (Müller 1993). Hohenwallner and Zechmeister (2001*b*) concluded that bryophytes in urban areas are sensitive to atmospheric pollution, but the latter is not the only factor; there are also other factors such as habitat changes and climate changes, particularly temperature and drought.

In Albania, bryological studies have been very scarce, mainly because of the lack of researchers (Marka *et al.* 2012), and studies on urban bryofloras have not been carried out so far. In such conditions, and also inspired by the above cited literature sources, we are presenting in this paper the first attempt to contribute to the knowledge of the urban bryophyte flora in the city of Tirana. This study is aiming to give a general overview about epiphytic moss communities of trees in the main streets of Tirana's city centre and its adjacent Park. These data might serve as a database for future investigations in order to monitor the possible changes in epiphytic bryoflora, dynamics of these changes, and finally the causes and consequences.

MATERIAL AND METHODS

Description of the investigated area

The city of Tirana started to grow from its previous village state in the 18th century, but most of its urban development started after being appointed the capital of Albania in 1925. Tirana is situated in the central part of Albania, 110 m above see level, in a wide flat valley surrounded by Mt Dajti in the east direction, Kërraba and Sauku Hills in the south, Vaqarri and Yzberishti Hills in the west and Kamza Hills in the north. Its surface is 31 km^2. Tirana, due to the influence of the Adriatic coast in the west, just at 34 km distance, has a typical Mediterranean climate. It has mild and humid winters and hot and dry summers. The mean temperatures are 7 °C for January (minimum −10.5 °C) and 24 °C for July (maximum 41.5 °C). Temperatures below zero usually occur for 5–6 days per year, and it is quite rare that ice or snow lasts more than a day. Annual mean precipitation is estimated to 1189 mm as rain, from late autumn to early spring (Kabo 1991).

Tirana has undergone several phases of urbanization, but particularly in the last 25 years it has been subjected to intensive urbanization, most of the time chaotic, which has caused severe damages to its green life, quality of social life and pollution. Thus, the number of inhabitants has grown considerably (almost tripled), construction of new buildings have caused the decrease of former green spaces, and the use of private cars has grown enormously, starting from a zero point in 1991. Today it is estimated that each day in Tirana circulate *ca.* 250,000 cars – most of which are second hand cars imported from EU countries – which have a high impact on pollution, particularly air pollution (AKM 2016).

Tirana, apart from the "Artificial Lake Park", due to its rapid and intensive urban development lacks big inward parks, or it used to have some modest parks, green patches, mainly in the city centre, or in the yards of small private villas, which however have been replaced by high buildings. Hence, the city's green life exists mainly on trees in pavements. But on the other hand only a few streets still have old trees, since most of the trees were planted in the last 15 years. The most common trees and shrubs on streets are *Platanus orientalis*, *Tilia* sp., *Acer* sp., *Quercus ilex*, *Pinus* sp., *Ligustrum vulgare*, *Prunus* sp., *Nerium oleander*, *Magnolia grandiflora*, etc.

Tirana's Artificial Lake Park situated in the south of the city was built around the 1950s. The Park's surface is 1,522,000 m^2, of which 365,000 m^2 is the surface of the lake. The dominant trees of the Park are *Robinia pseudoacacia*, *Quercus frainetto*, *Fraxinus excelsior*, *Cupressus sempervirens*, *Ligustrum lucidum*, *Pinus halepensis*, *Acer negundo*, *Cedrus atlantica*, *Eucalyptus camaldulensis*, *Nerium oleander*, etc.

Methods

Altogether 145 trees – in 18 sampling points – were investigated for epiphytic mosses during the spring of 2016; 74 trees were sampled in the streets and green areas of the city, and 71 trees inside the Park's area (Fig. 1). Nomenclature of species follows Hill *et al*. (2006). Several indices have been taken into account

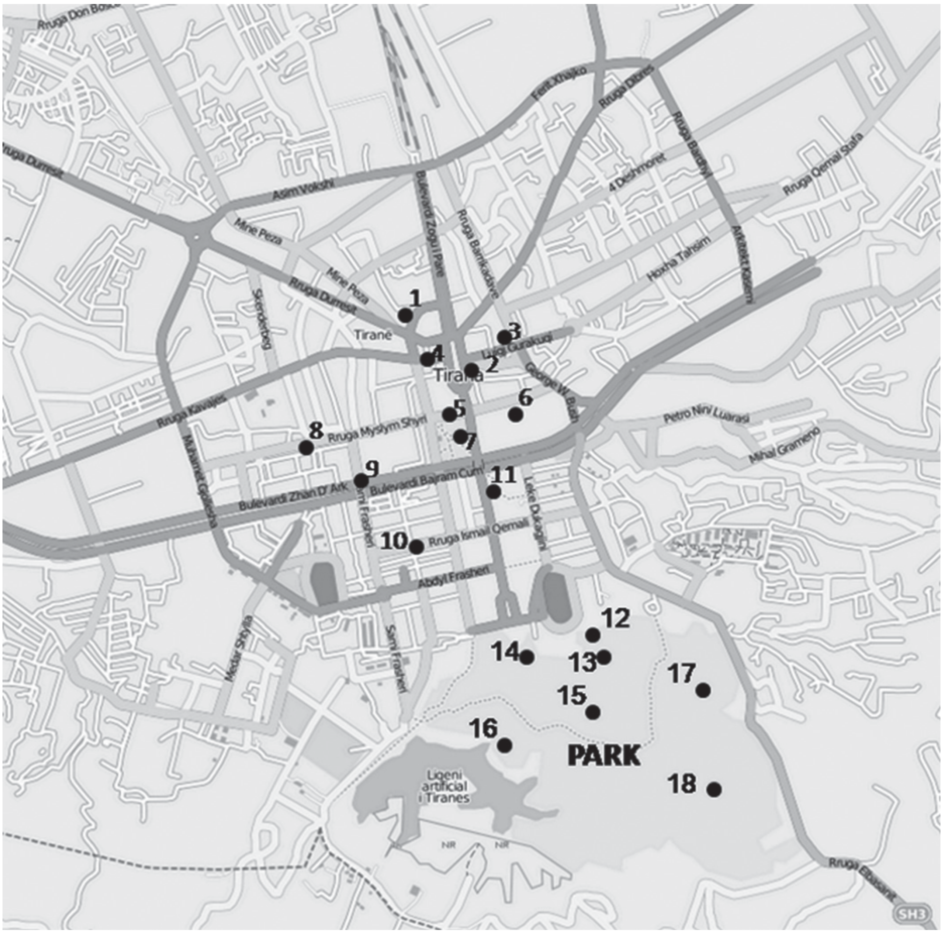

Fig. 1. Sampling points in the centre of Tirana city.

for analyses, e.g. Shannon–Weaver (H') and Simpson index (D) for biodiversity and Sørensen's Coefficient (CC) for community similarity (Anonymous s. d.). Furthermore, indicator values of mosses (Düll 1991) were used for ecological discussions. Moss specimens are deposited in the author's collection at the Department of Biology (Tirana University, Tirana).

RESULTS AND DISCUSSION

We have divided the data of this study into two groups, the first group from the streets and small green areas of the city, which we named as "strictly urban" and the second one from the city's Park. Altogether 553 moss samples were collected from 145 tree trunks, resulting in a total of 40 moss taxa, 19 taxa for strictly urban area and 39 for Park area, with 18 taxa shared by both communities (Table 1).

Table 1. Number of trees, moss samples and number of species for each sampling area. A = Sampling area code according to map (see Figure 1); B = Number of trees sampled; C = Number of moss samples; D = Number of moss species; TSUA = Total for the strictly urban area; TPA = Total for the park area.

A	B	C	D
1	5	12	5
2	5	11	5
3	1	2	2
4	1	3	3
5	2	6	5
6	2	10	8
7	7	26	10
8	11	19	6
9	18	51	12
10	17	52	15
11	4	10	7
12	1	3	3
TSUA	**74**	**205**	**19**
13	2	12	11
14	10	51	20
15	12	71	20
16	19	87	16
17	23	111	27
18	5	16	13
TPA	**71**	**348**	**39**
TOTAL	**145**	**553**	**40**

Table 2. Moss taxa and their absolute frequency for each sampling area.

Moss taxa	**Absolute frequency for each sampling area (strictly urban area: 1–12; city's Park: 13–18)**																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Amblystegium serpens (Hedw.) Schimp.													1		2		2	
Brachythecium mildeanum (Schimp.) Schimp.																	1	
Bryum argenteum Hedw.		1			1		1		2	2							1	
Bryum capillare Hedw.				1	1	1	4		3	4				1	4		2	
Bryum moravicum Podp.	2					1		3		3	1							
Cinclidotus cf. fontinaloides (Hedw.) P. Beauv.																1		
Cryphaea heteromalla (Hedw.) D. Mohr										1						2	11	
Dialytrichia mucronata (Brid.) Broth.													1				1	
Dicranoweisia cirrata (Hedw.) Lindb.						1											1	
Fabronia pusilla Raddi	3	1				2	4	1	3	4	3		1		2	3	1	1
Fissidens taxifolius Hedw.													1		1			
Grimmia lisae De Not.															1		1	
Grimmia pulvinata (Hedw.) Sm.														1				
Habrodon perpusillus (De Not.) Lindb.										1				3	1	6	9	
Herzogiella seligeri (Brid.) Z. Iwats.																	1	
Homalothecium sericeum (Hedw.) Schimp.				1		2	3		11	3	1			2	10	6	10	2
Hypnum cupressiforme Hedw.					2	1	3	2	5	4	1		3	5	8	15	19	2
Leptodon smithii (Hedw.) F. Weber et D. Mohr										2				2	7	5	6	1
Leskea polycarpa Hedw.															1			
Leucodon sciuroides (Hedw.) Schwägr.							1			2				2	4	11	6	

Table 2. (continued).

Moss taxa	**Absolute frequency for each sampling area (strictly urban area: 1–12; city's Park: 13–18)**																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Neckera complanata (Hedw.) Huebener															1			
Orthotrichum affine Schrad. ex Brid.																	7	
Orthotrichum anomalum Hedw.														1				
Orthotrichum cf. *acuminatum* H. Philib.														1			1	
Orthotrichum diaphanum Schrad. ex Brid.	4	5	1				2	8	11	11	2	1	1	6	3	9	3	
Orthotrichum lyellii Hook. et Taylor														4	2	5	7	1
Orthotrichum sp.																1		1
Orthotrichum striatum Hedw.														1			1	
Orthotrichum tenellum Bruch ex Brid.									1	1		1	1	5	1	6	1	1
Oxyrrhynchium hians (Hedw.) Loeske														1				
Rhynchostegiella tenella (Dicks.) Limpr.																		1
Rhynchostegium confertum (Dicks.) Schimp.									1				1	1	3		4	1
Schistidium sp.																	1	
Scorpiurium circinatum (Bruch) M. Fleisch. et Loeske																		1
Sematophyllum substrumulosum (Hampe) E. Britton									1	4				1		1		1
Syntrichia laevipila Brid.		1		1	1	1	5		5	3	1	1		6	7	6	5	2
Syntrichia papillosa (Wilson) Jur.	2	3	1		1		2	3	5	7	1		1	8	7	9	4	1
Tortella cf. *humilis* (Hedw.) Jenn.															1			
Tortula muralis Hedw.	1							2									1	
Zygodon rupestris Schimp. ex Lorentz						1	1		3				1		5	1	4	

The full list of moss taxa recorded, including their absolute frequency, is given in Table 2. Furthermore, ranks of abundances are given for strictly urban and Park areas in Figures 2 and 3, respectively. For the strictly urban area the five most common species were *Orthotrichum diaphanum*, *Syntrichia papillosa*, *Fabronia pusilla*, *Homalothecium sericeum* and *Syntrichia laevipila*, with *O. diaphanum*, the only species having a frequency above 50% (61%). On the other hand, the five most common species of Park area are *Hypnum cupressiforme, Homalothecium sericeum*, *Syntrichia papillosa*, *S. laevipila* and *Leucodon sciuroides*, with *H. cupressiforme* the only species having a frequency above 50% (73%). Comparing moss diversity of these two communities, different indices were calculated, Shannon (H) and Simpson (D) indices for diversity, and Sørensen (CC) coefficient for community similarities. These simple calculations are summarized in Table 3.

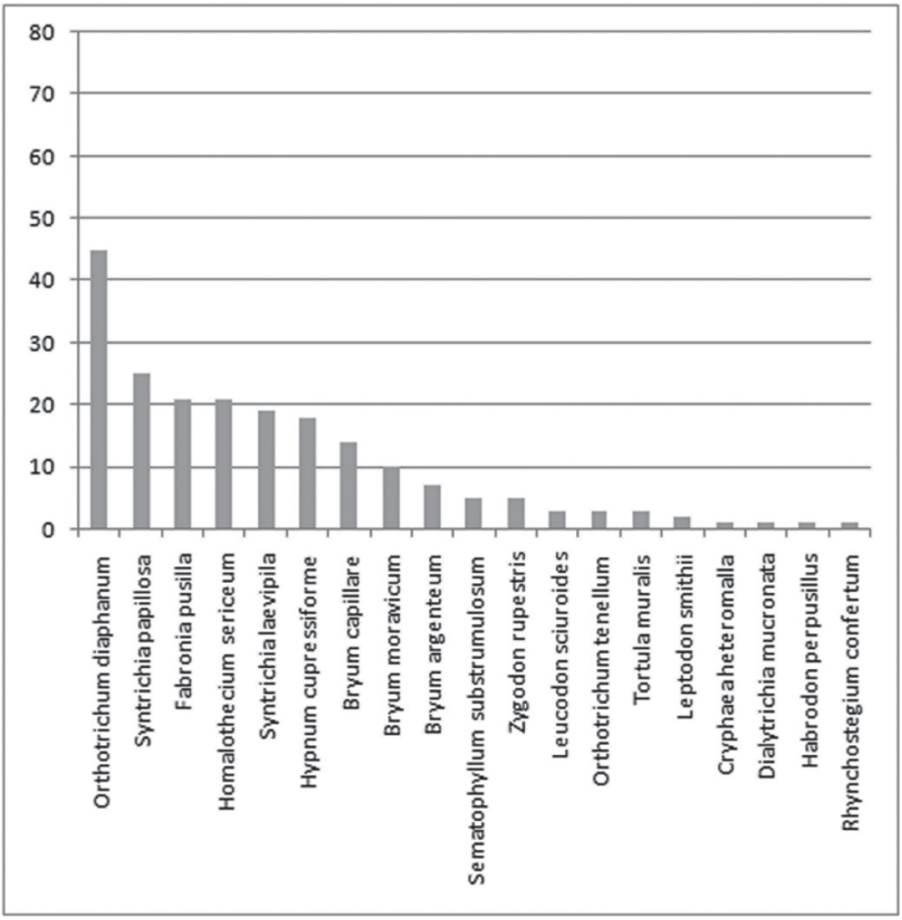

Fig. 2. Rank of species abundances for the strictly urban area.

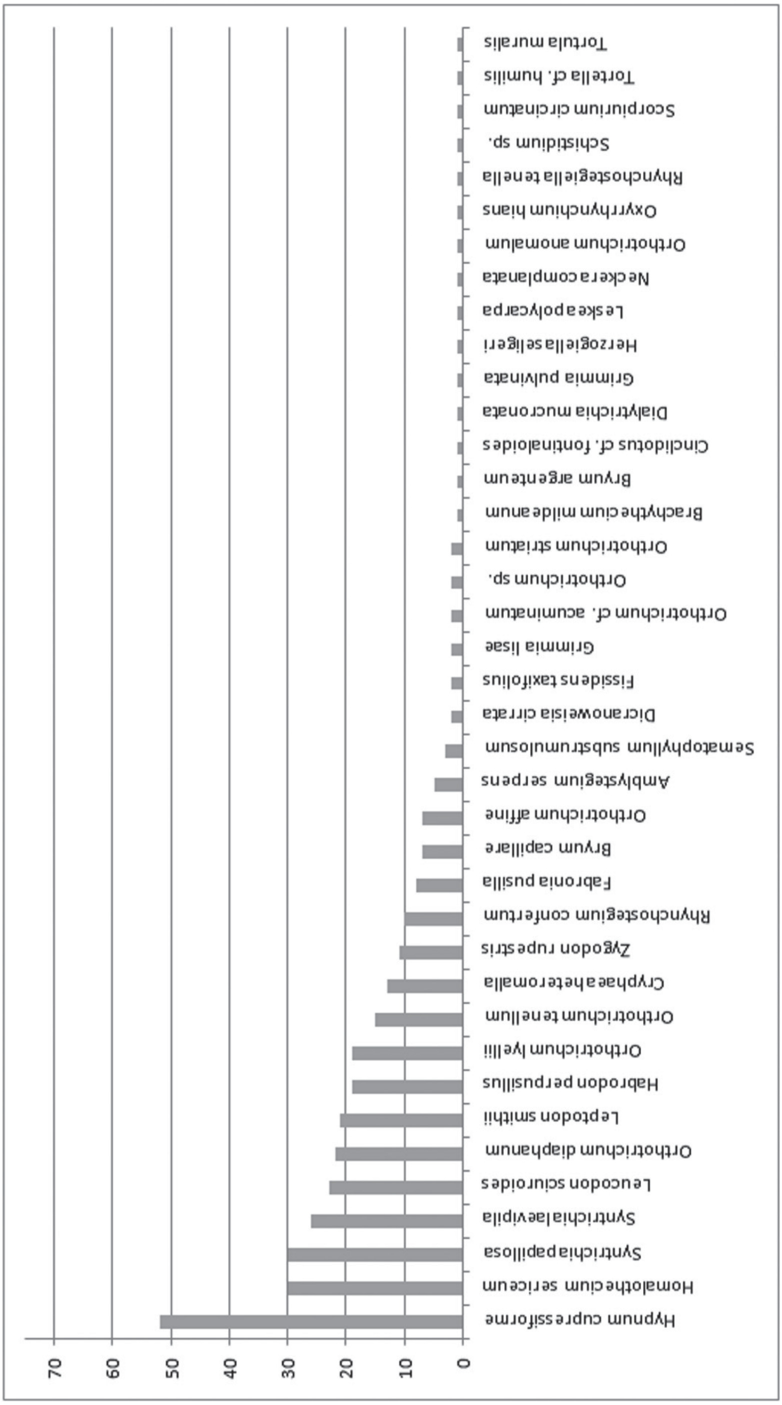

Fig. 3. Rank of species abundances for the park area.

Table 3. Diversity indices and coefficient for community similarities.

Biodiversity indices	Strictly Urban	Park
Shannon (H)	2.45	2.99
Simpson (D)	9.04	14.76
Similarity coefficient		
Sørensen (CC)	0.63	

As it was empirically expected the values of biodiversity indices are higher for the Park area, and the similarity of these two communities is of average degree. The question may arise which are the causes of these differences in communities? Are these differences resulted mainly from microclimatic changes or other factors are contributing as well? As it has already been mentioned in the introduction this study may contribute only as a starting point of future investigations which may give more accurate answers. However, at this phase we have calculated the ecological values of moss species (Düll 1991) for some parameters (light, temperature, humidity and reaction) to check if there are differences in the mean values of the two communities. Indeed, mean values of these ecological indices are slightly different in the two communities compared (Table 4).

For example, values for light, temperature and humidity confirm that in the strictly urban area the species dominates which prefer more light, higher temperature and drought than those of the Park's area. On the other hand the richness of an epiphytic moss community is also affected by pH and nutrition level of tree bark, where usually neutral and basic substrates (e.g. elders, elms, willows, etc.) shelter more species compared to acid ones (e.g. pines, birches, beeches, etc.) (Vanderpoorten and Goffinet 2009).

In Table 4 we see that the taxa growing in strictly urban area have a lower pH value than those of the Park's area. Is this ecological difference only related to the type of the host tree as discussed above, or it may also be influenced by air pollution which is known for increasing acidity through precipitation? Furthermore, recent reports from the National Environmental Agency show that levels of SO_2 and NO_2 for the year 2015 – compared to EU standards – are within the standards, although very close to the upper limit (AKM 2016). However, we do not know if these levels were within these EU standards for earlier periods.

Table 4. Average values for ecological indicators of mosses.

	Ecological indicators			
	Light	**Temperature**	**Moisture**	**Reaction**
Average values for Park area	6.6	5.2	4	6.4
Average values for strictly urban area	7	6	3.5	6

From the floristic point of view the species recorded are all known in Albania. However, it is worth mentioning that *Dicranoweisia cirrata* is a confirmation of an old and single report from Shkodra (Baumgartner 1915). Meanwhile, *Fabronia pusilla* was included in the preliminary red list of Albania (Marka *et al.* 2012), and this was based indirectly on other regional red lists (Natcheva *et al.* 2006, Ştefănuţ and Goia 2012), but these recent data suggest that this species has frequent occurrence in urban areas, and with abundant cover density, mostly in old *Platanus* trees. Another interesting record is *Cryphaea heteromalla*, which was recently reported for Albania (Marka *et al.* 2013), and it is also red listed in Montenegro and Romania (Sabovljević *et al.* 2004, Ştefănuţ and Goia 2012).

For many species that were recorded in our study some literature data are related to air quality, e.g. some species are reported as resistant to pollution and others are sensitive to it. Based on this, we can divide our species into several groups. For example, species which are widespread like *Orthotrichum diaphanum*, *Syntrichia laevipila*, *Bryum capillare*, *Hypnum cupressiforme*, *Homalothecium sericeum*, *Rhynchostegium confertum*, and other species which are less widespread like *Amblystegium serpens* and *Dicranoweisia cirrata*, but in literature these are mentioned as resistant to pollution (Duckett and Pressel 2009, Govindapyari *et al.* 2010). Another group of species are *Cryphaea heteromalla*, *Habrodon perpusillus*, *Leucodon sciuroides*, *Syntrichia papillosa* and *Orthotrichum lyellii*, which are reported as sensitive to air pollution (Smith 2004, Duckett and Pressel 2009). In the third group there are species which based on their primary substrate are not epiphytic like *Bryum argenteum*, *Tortula muralis*, *Grimmia pulvinata*, *Orthotrichum anomalum*, *Schistidum* sp., and their presence on trees is explained with high level of dust in the air (Dymytrova 2009, Fudali 2012).

CONCLUSIONS

Among the epiphytic moss taxa recorded in Tirana's city centre some are known as resistant to air pollution and others are sensitive to it. Furthermore, the data show differences in epiphytic moss communities when the strictly urban area is compared with the Park's area. Are these differences only a consequence of microclimatic conditions, or other factors – like air pollution – might influence it? At present, this remains an open question as the long term monitoring of biodiversity dynamics will be needed on the one hand and a standardized method to check for correlations between biological parameters and chemical-physical parameters on the other hand.

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Összefoglaló: Tanulmányunk áttekintést nyújt a fán lakó mohaközösségek összetételéről Tirana (Albánia) belvárosában és a közeli parkban. 2016 tavaszán összesen 145 fát vizsgáltunk meg és 553 mohamintát gyűjtöttünk, melyek 40 fajhoz tartoznak. Közülük 19 fordul elő a belvárosi környezetben és 39 a vizsgált parkban; 18 faj közös a két terület mohaflórájában. A belvárosi területen az öt leggyakoribb mohafaj az *Orthotrichum diaphanum*, *Syntrichia papillosa*, *Fabronia pusilla*, *Homalothecium sericeum* és a *Syntrichia laevipila*; a parkban pedig a *Hypnum cupressiforme*, *Homalothecium sericeum*, *Syntrichia papillosa*, *S. laevipila* és *Leucodon sciuroides*. A diverzitási indexek a parkban magasabbnak mutatkoztak. A kimutatott mohák közül egyesek jól tűrik a légszennyezést, mások érzékenyek rá. A fajok ökológiai mutatói alapján megállapítottuk, hogy a belvárosi környezetben a fény- és hőigényesebb, szárazságtűrő fajok domináltak a parkkal szemben és ugyanitt az alacsonyabb pH-értékeket igénylő fajok aránya nagyobb. Annak megválaszolása, hogy a két terület között kimutatott mohaflórabeli különbségek kizárólag azok mikroklimatikus különbségeire vagy egyéb okokra is visszavezethetők, további vizsgálatokat igényel. A vizsgálataink során kimutatott *Dicranoweisia cirrata* a faj egyetlen régi, Shkodrából származó albániai adatának megerősítése, míg a *Fabronia pusilla* szerepel Albánia előzetes moha-vöröslistájában.

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