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Influence of city on the floristical and ecological diversity of Bryophytes in parks and cemeteries

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Abstract: This paper presents some of the results of studies on bryophyte species richness, diversity and ecology in the 94 parks and 51 cemeteries of six Polish cities: Warsaw, Cracow, Wrocław, Poznań, Lublin and Szczecin. The total number of species recorded in these 145 sites was 125; made up of 11 liverwort and 114 moss taxa. The number of species which occurred in individual sites was not significantly correlated with their area (R^2=22%) or biotope type (R^2=16%). The bryoflora of the parks and cemeteries studied appeared to be varied ecologically; only 30% of species were eurytopic. Both city ubiquists and bryophyte species, ecologically specialized, never recorded in densely built-up urban areas occurred in the sites studied. Most of the city centre parks studied were poorer in bryophyte species than those on the outskirts, although not all of the latter were necessarily species rich.

Key words: urban bryophytes, bryophyte ecology, city influence on floras, Polish cities

1. Introduction

Presently, there is no doubts that botanical research in urban areas is not only of scientific value but also has practical significance in the creation of, so called, cultural landscape and the preservation of biodiversity on a global scale (Goode 1998; Sukopp 1998; Wilke 2000). The conception of „sustainable city" demands knowledge of factors influencing plant species richness and their ecological diversity in towns and cities.

A review of the bryological literature dealing with urban areas shows some gaps in the field of city bryophyte biodiversity, distribution and ecology (Fudali 1998, 2000, 2005). For this reason I carried out comparative studies on bryophyte species richness and ecology in parks and cemeteries of six Polish cities. The paper presents some of the results obtained.

The principal aims of the research and analyses briefly presented here was to recognize, record and characterize the bryoflora occurring in the cities parks and cemeteries and to point out the factors influencing species richness and the ecological diversity of bryophytes in these types of biotope. In order to achieve these aims some detailed questions were identified. The paper provide answers to some of them. Namely: (*i*) is the bryoflora of parks and cemeteries ecologically and taxonomically different from that recorded in more intensively built-up areas? (*ii*) do bryophytes occurring in parks and cemeteries differ in their ecological requirements in relation to a degree of moisture, light and substrate type or are they mainly eurytopic? (*iii*) what are the relationships between the species and ecological diversity of the parks' bryophyte flora and the zonal structure of the cities as well as are there any relationships connecting the species present and the ecological diversity of the bryophyte flora in parks and cemeteries with their size and history?

2. Material and methods

The methodological approach applied here is based on the concept that towns constitute a mosaic of differently utilized biotope types. Town parks and cemeteries belong to the set of city biotopes which create conditions favouring bryophyte development and occur in every Central European town.

In each site (park or cemetery) every bryophyte turf was documented in accordance to a specially prepared procedure. For each appearance of a species the following were recorded and used in subsequent analyses as individual floristic-ecological data: (*i*) relative size of turf in relation to a square measuring 10×10 cm^2 (not

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larger or larger than 10×10 cm^2); (*ii*) type of substrate and microhabitat occupied according to a previously assigned classification (Fudali 2005); (*iii*) light intensity and water availability at the site according to three grades scales (full light, semi-shaded and shaded; waterlogged, well-drained to damp, dry). Turfs of the same species were recorded separately only when they were detached from one another and more than 1 m apart. If not they were regarded as one entity and their size was estimated in total.

Most field studies were made between 1999-2002. Unpublished bryological data from the parks and cemeteries in Szczecin collected by the author between 1991-1995 were also included in the analysis. In total 19912 floristic-ecological relevés were made.

The moss and liverwort nomenclature follows Ochyra *et al.* (1992) and Grolle & Long (2000) respectively.

The floristic-ecological data made in the field were systematically entered in specially prepared recording sheets. Thus every site studied acquired its own site field card containing a list of recorded species and information about species' microhabitat preferences. Rough estimates made in the field concerning light intensity and the degree of microhabitat's moisture were also recorded on specially designed cards. It was then possible to determine the ecological response of species with regard to light and moisture from consideration of the conditions under which they grew in the individual sites. In further analyses the synthetic data recorded on the field cards were used.

The research results have been analysed through the application of some numerical and statistical methods which had been unconventionally combined and used previously for taxonomic research by Mitka (2002). The basic operational unit (OTU) was a site (park or cemetery) described by binary variables (species present in the site or not) and ordered variables (relative abundance of a species in every site). The statistical relationship between the number of species recorded in an individual site and the site size and city and biotope types was determined separately for every biotope types using the method of backward stepwise regression. Regression significance was tested at the level α=0.05.

3. Results

The total number of species recorded in these 145 sites was 125; 102 in parks and 105 in cemeteries, made up of 11 liverwort and 114 moss taxa. The bryoflora of the parks and cemeteries studied showed significant ecological diversity manifested by the incidence of species differing in their moisture and light requirements (Table 1). The presence of eurytopic species was no more than 30%. Most species occurred in no more than 3 microhabitat types of the 13 distinguished; these species made up 65% of the park bryoflora and 68% of that in cemeteries. Rock-like microhabitats were among the species richest both in parks and cemeteries; additionally tree bases, the ground under trees and shady grassland were also rich in parks and places devoid of vascular vegetation rich in cemeteries.

In relation to the sociological-ecological status of the bryophytes studied, forest species formed quite large group (36 species; 29%).

Most of the city centre parks studied were poorer in bryophyte species than those on the outskirts, although not all the latter were species rich (Fig. 1). Only in three of the cities studied (Wrocław, Poznań, Szczecin) were there statistically significant differences in their bryofloras (Fig. 2).

The number of species occurred in individual sites varied greatly, from 3 to 52 (Fig. 1), but it was not significantly correlated with their area (R^2=22%) or biotope type (R^2=16%).

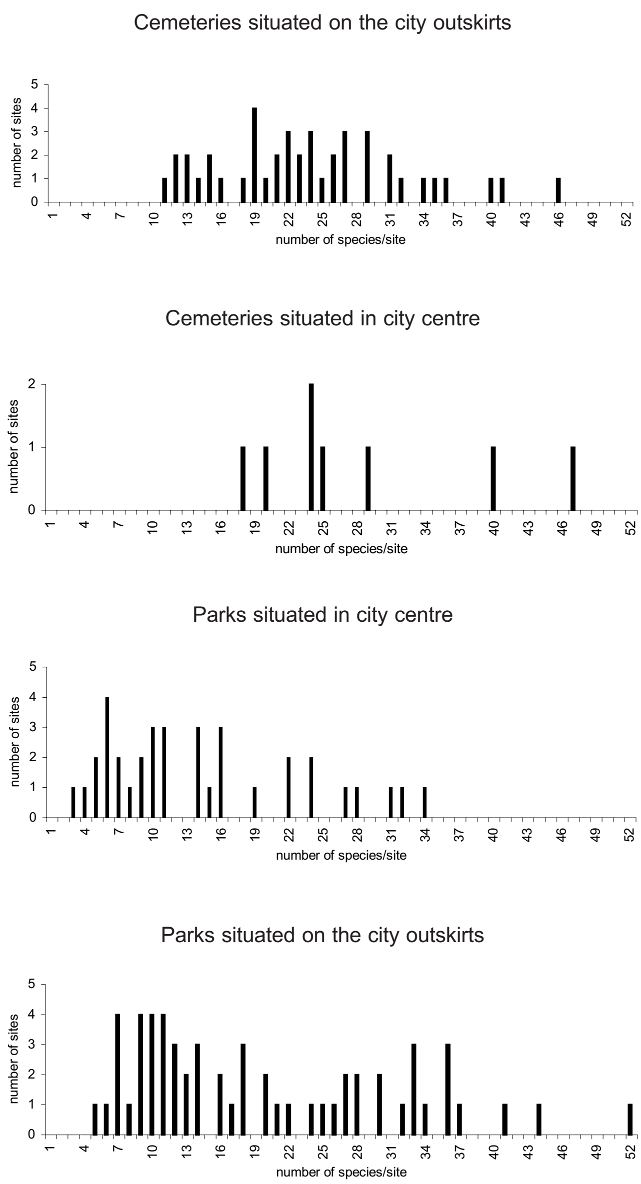

Fig. 1. Species richness of the sites in particular biotope types

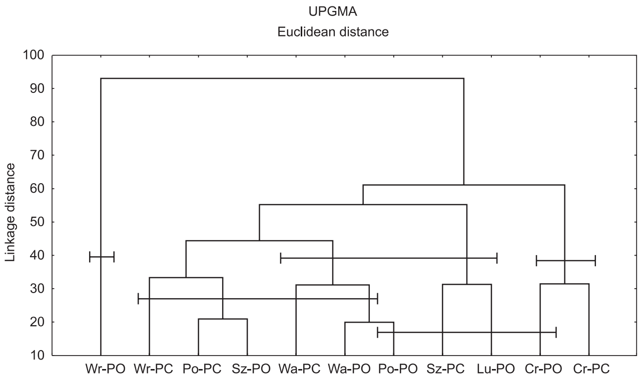

Fig. 2. UPGMA phenogram of numerical and statistical analyses of the bryofloristic similarity of the all centre parks (PC) and all parks on the outskirts (PO) situated in particular cities
Explanations: Cr – Cracow, Lu – Lublin, Po – Poznań, Sz – Szczecin, Wa – Warsaw, Wr – Wrocław; the horizontal line segments at the base of the diagram define subgroups containing objects not significantly statistically different ($p > 0.05$) with respect to mean score values on the CA axes

4. Discussion

Presented here studies showed that the presence of eurytopic species was no more than 30%. It proves that parks and cemeteries are sites of bryophyte ecological diversity within cities. This ecological diversity resulted mainly from the ecological specialization of the rare species, which formed more than the 70% of the studied bryoflora. Most of the more frequent, with the exception of obligatory epiliths, showed wide ranges of physiological response in relation to the degree of habitat moisture and exhibited wide microhabitat tolerance.

Rock-like microhabitats (both artificial containing cement and formed of natural rocky material) were among the most species rich in both parks and cemeteries. One of the city influence of bryophyte ecology is the widespread use of cement as a building material what promotes wide distribution in cities and towns of epilithic species, especially subneutral or basophilous ones which occurred rarely in the areas surrounding cities established on acid soils (Seaward 1979; Koperski 1986, 1996). Also using rock substrate as ornamental and building elements in the parks and cemeteries of the cities studied was responsible for the rather high species richness of the epilithic bryophyte flora. At the same time they have created the bryofloristic distinctness of the different sites and the incidence of some so called mountain species in cities situated in lowlands (e.g. *Brachythecium populeum, Leskella nervosa, Hygrohypnum luridum*).

The influence of the city on the epiphytic bryoflora of parks and cemeteries studied has been manifested by the small number of specialized epiphytes (5 species) and by the strengthening of epilithic tendencies in subneutral epiphytes as well as of epiphytic tendencies in some terrestrial and eurytopic species (e.g. *Bryum argenteum, Ceratodon purpureus, Bryum caespiticium*). The near absence of epiphytic bryophytes in city centers was pointed out in all former papers dealing with urban bryophytes (e.g. Barkman 1958; Seaward 1979; Nordhorn-Richter & Düll 1982; Wittig 1991; Fudali 1996; Vanderpoorten 1997; Hohenwallner 2000). In many cases only *Hypnum cupressiforme* appeared to be sustainable in city centre conditions, although other epiphytic bryophytes were noted sporadically. Similarly a phenomenon of epiphytic bryophytes extending from tree bark to cement walls has been reported in the bryological literature for years and interpreted as a bryophyte response to acid rain flow through bark causing transfer to less acid available habitats (e.g. Barkman 1958; Rao 1982).

Other bryophyte ecological group strongly affected and limited by man are obligate epixylics. Habitats associated with rotten wood were practically non-existent in parks and cemeteries because sawn or fallen branches were systematically removed. Only two specialized epixylics, *Aulacomnium androgynum* and *Herzogiella seligeri,* were reported from the sites studied, and only from sites situated on the outskirts.

The total number of bryophytes reported from densely built-up parts of Central European cities is rather small and has never exceeded 40; on average no more than 20 taxa have been noted in an individual city (Schaepe 1986; Filipiak & Sieradzki 1996; Fojcik & Stebel 2001; Fudali 1996; Vanderpoorten 1997; Hohenwallner 2000; Janovicová *et al.* 2003). One of the most characteristic features of the bryoflora in the densely built-up parts of cities has been the almost complete absence of liverworts, represented by just one species, *Marchantia polymorpha.* In all the compared cities the following moss species occurred frequently: the eurytopic and polyhabitat *Amblystegium serpens, Bryum argenteum, B. caespiticium, Ceratodon purpureus* and *Funaria hygrometrica*; the exclusively epilithic, on subneutral and xerophitic places, *Barbula unguiculata, Bryum capillare*, *Grimmia pulvinata, Orthotrichum diaphanum, Schistidium apocarpum* and *Tortula muralis*; as well as the mainly terrestrial eurytopic *Brachythecium rutabulum, Eurhynchium hians* and *Streblotrichum convolutum.*

The species listed above have also been reported from parks and cemeteries studied where they usually occurred with high frequency. In contrast, the bryoflora of parks and cemeteries studied was richer in both liverwort and moss species – in total 125 bryophyte species was found of which 11 were liverworts. It also appeared more sociologically-ecologically diverse, containing not only ubiquitous hemerophilous urban taxa but forest and meadow bryophytes as well. Typical forest bryophytes made up 30% of the total. In city centre

Table 1. Ecological diversity of the bryophytes studied

Name of species	Ecological response to degree of moisture observed in		Ecological response to light intensity observed in		Microhabitat types occupied by species in	
	Parks	Cemeteries	Parks	Cemeteries	Parks	Cemeteries
Abietinella abietina	.	Mw	.	Ml	.	7
Amblystegium juratzkanum	K-Mw	K-M	Ml	Ml	1,3,5,13	1,2,9,12,13
*Amblystegium serpens**	W-K	W-K	S-L	S-L	without 8	1-5,9,10,12,13
Atrichum undulatum	Mw	Mw	S-Ml	S-Ml	4-6,8,9	4-11,13
Aulacomnium androgynum	Mw	Mw	S	S	4	4
Barbula unguiculata	K-Mw	K-Mw	L	L	10,12,13	10,12,13
*Brachythecium albicans**	K-Mw	K-Mw	L	L	2,4,7,10,12,13	4,6,7,9,10,12,13
Brachythecium oedipodium	Mw	Mw	Ml-L	Ml-L	6-8	6-8
Brachythecium populeum	K-Mw	K-Mw	Ml-S	Ml-S	12,13	12,13
Brachythecium reflexum	Mw	.	Ml	.	1,2	.
Brachythecium rivulare	W	.	S	.	8	.
*Brachythecium rutabulum**	W-Mw	W-Mw	S-L	S-L	1-13	without 1
*Brachythecium salebrosum**	Mw	Mw	S-Ml	S-L	1-6,8,9,12-13	2-6,9,12-13
Brachythecium velutinum	Mw	Mw	S-Ml	S-Ml	1-6, 8,9,12-13	2-6,8,9,13
Bryoerythrophyllum recurvirostre	K	K	Ml-L	Ml-L	12,13	9,10,12,13
*Bryum argenteum**	K	K	L	L	1,4-7,10,12-13	1,5,7,10,12,13
Bryum bicolor	K-Mw	K	Ml-L	L	5,10,12	10,12
*Bryum caespiticium**	K-Mw	K	L	L	2-5,7,10,12,13	1,3-5,9,10,12,13
Bryum capillare	K-Mw	K-Mw	Ml-L	S-L	1-4,12,13	1,3,5,10,12,13
Bryum flaccidum	K-Mw	K-Mw	S	S	1,2,12,13	1-4,12,13
Bryum rubens	Mw		Ml	.	9	.
Bryum subapiculatum	.	Mw	.	Ml	.	5
Bryum violaceum	Mw	.	Ml	.	5	.
Callicladium haldanianum	.	Mw	.	Ml	.	9,13
Calliergonella cuspidata	W-Mw	Mw	S-L	S-L	4,6,7,9,11-13	6,7,9,10,12,13
Camptothecium lutescens	K	K	Ml-L	L	7	7
Cephalozia bicuspidata	.	Mw	.	Ml	.	4,8
*Ceratodon purpureus**	K-Mw	K-Mw	Ml-L	Ml-L	without 7,11	without 11
Chiloscyphus pallescens	.	Mw	.	S	.	8
Cirriphyllum piliferum	Mw	Mw	S-Ml	S-Ml	3,5-9	5,6,8,9
Climacium dendroides	W-Mw	Mw	Ml	Ml	5,6,8,9,11	6,7,9
Cratoneuron filicinum	Mw	.	Ml	.	8,9,11	.
Dicranella heteromalla	Mw	Mw	S-Ml	S-Ml	2,5,9	2,4,5,9,12
Dicranella staphylina	W	W-Mw	L	L	11	10,11
Dicranoweisia cirrata	K-Mw	K-Mw	Ml-L	Ml-L	1-2	1-3,13
Dicranum polysetum	.	Mw	.	Ml	.	8-9
Dicranum scoparium	K-Mw	K-Mw	Ml-L	S-L	1	1,4,8-10,13
Didymodon rigidulus	K	K	Ml-L	L	13	12,13
Drepanocladus aduncus	W	.	L	.	11	.
Drepanocladus polycarpos	.	Mw	.	Ml	.	9
Encalypta streptocarpa	K	.	Ml-L	.	12,13	.
Eurhynchium angustirete	.	Mw	.	Ml	.	9
*Eurhynchium hians**	K-Mw	K-Mw	Ml	Ml-L	2-10	5-11,13
Eurhynchium pulchellum	K	.	L	.	13	.
Eurhynchium striatum	Mw	Mw	Ml	Ml	6	8
Fissidens bryoides	.	K	.	L	.	10
Fissidens cristatus var. *mucronatus*	Mw	.	Ml	.	8,13	.
Fissidens taxifolius	Mw	Mw	S-Ml	S-Ml	5-11	9,10
Funaria hygrometrica	Mw	Mw	L	L	4,6,8,9-13	5,9,10,12,13
Grimmia pulvinata	K	K	Ml-L	L	12,13	12,13
Herzogiella seligeri	Mw	Mw	Ml	Ml	4	4
Homalia trichomanoides	.	Mw	.	S	.	13
Homalothecium sericeum	K	K	Ml-L	Ml-L	4,13	1,12,13
Hygroamblystegium varium	W	.	S	.	11	.
Hygrohypnum luridum	.	W	.	S	.	13
*Hypnum cupressiforme**	K-Mw	K-Mw	S-L	S-L	1-5,7,9,12,13	without 11
Hypnum pallescens	Mw	.	Ml	.	1,2	.
Hypnum pratense	Mw	.	L	.	6	.
Isothecium alopecuroides	Mw	.	Ml	.	2	.
Kindbergia praelonga	W-Mw	W-Mw	S-Ml	S-Ml	4-9	5,6,9
Leptobryum pyriforme	W-Mw	Mw	Ml-L	Ml-L	7,10,11	9,10
Leptodictyum riparium	W-Mw	Mw	S-L	S-L	1-4,6,11-13	1,2,10,12,13

Leskea polycarpa	Mw	Mw	Ml	Ml	1-3	1-3,13
Leskella nervosa	.	Mw	.	Ml	.	13
Leucobryum glaucum	.	K	.	L	.	10
Lophocolea bidentata	W-Mw	Mw	S-Ml	S-Ml	6,8,13	6,9,12
Lophocolea heterophylla	Mw	Mw	Ml	Ml	1-5	1-6,12,13
Lunularia cruciata	Mw	Mw	Ml-L	Ml	7	9
Marchantia polymorpha	Mw	Mw	Ml-L	Ml-L	7,9-11	6,9
Mnium hornum	W-Mw	Mw	Ml	Ml	5,8,11	5
Mnium stellare	W	.	S	.	13	.
Orthodicranum montanum	K-Mw	K-Mw	S-L	S-L	1,2,4	1,4
Orthotrichum affine	K	K	Ml	Ml	1	1,2
*Orthotrichum anomalum**	K	K	Ml-L	Ml-L	3,12,13	12,13
Orthotrichum diaphanum	K	K	L	Ml-L	1,3,12,13	1,12,13
Orthotrichum pallens	K-Mw	K-Mw	Ml-L	L	1-3,12	1,2,12,13
Orthotrichum pumilum	K	K	L	L	1,13	1,13
Orthotrichum rupestre	.	K	.	L	.	12,13
Orthotrichum speciosum	.	K-Mw	.	L	.	1
Pellia endiviifolia	Mw	.	Ml	.	6	.
Pellia epiphylla	W-Mw	Mw	Ml-L	Ml-L	6,9,11	6,9
Phascum cuspidatum	K-Mw	K-Mw	L	L	10	10
Physcomitrella patens	W	.	L	.	11	.
Physcomitrium pyriforme	W-Mw	W-Mw	Ml-L	Ml-L	4,7-11	9-11
Plagiomnium affine	Mw	Mw	S-Ml	Ml	5-11	5,6,8-10,12
Plagiomnium cuspidatum	Mw	Mw	S-Ml	S-Ml	without 11	3,5-7,9,10,12,13
Plagiomnium elatum	Mw	Mw	S-Ml	S-Ml	6-8	6,8,9
Plagiomnium medium	.	Mw	.	Ml	.	8
Plagiomnium rostratum	Mw	Mw	S	S	9,13	9
*Plagiomnium undulatum**	W-Mw	Mw	S-Ml	S-Ml	5-9,11	5-9
Plagiothecium cavifolium	Mw	.	S	.	7	.
Plagiothecium curvifolium	Mw	Mw	Ml	Ml	2-5	2,5
Plagiothecium denticulatum	Mw	Mw	S-Ml	Ml	2-5	2,5,13
Plagiothecium laetum	Mw	Mw	Ml	Ml	2,5	2,4
Plagiothecium nemorale	Mw	Mw	Ml	Ml	2,5	2
Platygyrium repens	.	Mw	.	Ml	.	4
Pleurozium schreberi	.	Mw	.	Ml	.	5,8
Pohlia nutans	K-Mw	K-Mw	Ml	Ml	1-5,9	2,4,5,9,10
Pohlia wahlenbergii	W-Mw	Mw	Ml-L	L	6,7,11	9
Polytrichastrum formosum	Mw	Mw	S-Ml	S	5,6,8	8
Polytrichum juniperinum	K-Mw	K-Mw	Ml	Ml-L	4,5	4,8,10,13
Polytrichum piliferum	.	K	.	L	.	10
Pottia intermedia	K	K	L	L	10,13	10
Pottia truncata	Mw	Mw	L	L	6,7,10,12	8,10
Pseudoscleropodium purum	Mw	Mw	Ml-L	Ml-L	6-8	6-9
Pterigynandrum filiforme	Mw	Mw	Ml	Ml	1,12	1,12
Ptilidium pulcherrimum	Mw	.	Ml	.	4	.
Pylaisia polyantha	Mw	Mw	Ml-L	Ml-L	1-3,12	1,2,12,13
Racomitrium canescens	.	K	.	L	.	10
Racomitrium elongatum	.	K	.	L	.	10
Rhizomnium punctatum	Mw	W-Mw	S	S	12,13	12,13
Rhynchostegium murale	Mw	W-Mw	S-Ml	S-Ml	12,13	12,13
Rhytidiadelphus squarrosus	Mw	Mw	Ml-L	Ml-L	6-8	6-8
Riccia fluitans	W-Mw	.	L	.	11	.
Riccia glaca	.	K	.	L	.	10
Sanionia uncinata	K-Mw	K-Mw	Ml-L	S-L	1,2,13	1,2,13
*Schistidium apocarpum**	K-Mw	K-Mw	Ml-L	S-L	12,13	12,13
*Streblotrichum convolutum**	K-Mw	K-Mw	L	L	2,7,9,10,12,13	5,7,9,10,12,13
Syntrichia latifolia	.	Mw	.	S	.	13
Syntrichia ruralis	K	K	L	L	7,10,12,13	5,7,10,12,13
Syntrichia virescens	K	K	S-L	Ml-L	2,12,13	1,12,13
Thuidium erectum	Mw	Mw	Ml	Ml	6,7	6
Thuidium philibertii	Mw	.	L	.	6	.
*Tortula muralis**	K-Mw	K-Mw	Ml-L	S-L	12,13	12,13
Tortula subulata	K	K	L	L	12,13	12,13

Explanations: Mw – species of well–drained sites, W – hygrophyte, K – xerophyte, L – photophyte, Ml – species of semi-shaded sites, S – sciophyte, 1 – tree trunks at heights between 0.3 and 2.5 m above ground level, 2 – tree bases and trunks up to 30 cm above ground level, 3 – protruding roots of living trees, 4 – decaying tree stumps, 5 – ground around trees, 6 – shady grassy areas, 7 – unshaded grassy areas, 8 – shady places with herb vegetation, 9 – shady places devoid of vascular plants, 10 – unshaded places devoid of vascular plants, 11 – banks of streams and ponds, 12 – walls and other elements made of concrete, 13 – rock or stone elements, * – species occurring frequently in parks and/or cemeteries (in more than 50% of sites) parks just 69 species were reported, including 6 liverworts; the proportion of forest bryophytes was 36%.

It is worth pointing out that densely built-up areas supported only xerophytic epiliths such as *Tortula muralis, Grimmia pulvinata,* and *Schistidium apocarpum*, whereas in shady parks and ancient cemeteries hygrophilous epiliths were found too, such as *Rhynchostegium murale, Rhizomnium punctatum, Syntrichia latifolia* and *Hygrohypnum luridum*.

The obtained data allows us to regard parks and cemeteries as environmental islands of higher moss biodiversity (in floristic, taxonomical and ecological aspects) in the urban landscape. However, not every park or cemetery supports a high bryophyte biodiversity in cities. In many sites the bryoflora was poor and was formed exclusively by ubiquitous urban taxa. Such sites were mainly small parks situated in city centres and established on the ruins of former buildings or fortifications; cemeteries devoid of old trees and with a plethora of modern tombstones; and green recreational areas situated on the outskirts and established on former arable fields or degraded sites. The most rich in species were old landscape parks set up within former forest phytocoenoses.

Most of the city centre parks studied were poorer in bryophyte species than those on the outskirts. However, among the latter green recreational areas were always poor in bryophytes (no more than 10 species per site). Thus the position of parks did not always influence their bryofloristic richness, as well as their bryofloristic dissimilarity – statistically significant differences in the bryofloras, resulting probably from the sites differing locations in relation to the city center, were only in three cities. However it was noted that epiphytes and forest species occurred more frequently in parks on the outskirts than in those of the city centres.

The number of species which occurred in individual sites varied greatly (from 3 to 52) but it was not significantly correlated with their area (R^2=22%) or biotope type (R^2=16%). But the species richness of many sites was associated with the large number of microhabitat types colonized by bryophytes in them. Bryophytes did not colonize all of the microhabitat types present in individual sites, often being absent from tree trunks, protruding tree roots and shady places devoid of vascular vegetation. It was impossible to identify the factors influencing bryophyte settlement in the different microhabitat types. This phenomenon was observed to a similar extent in both city centre parks and those on the outskirts which suggests that bryophyte colonization of the different microhabitat types does not depend strictly on a park's position in the city.

5. Conclusions

City as a special type of ecosystem influences strongly the urban bryophyte species richness and ecological diversity due to its spatial structure. The unequal distribution of rock-like microhabitats was responsible for the higher frequency of epiliths in cemeteries than in parks, while the dominance of shady terrestrial microhabitats in parks was accompanied by a higher frequency of forest species in them.

Parks and cemeteries can play a special role as environmental islands of higher bryophyte biodiversity in the urban landscape. However the species richness of their bryoflora depends, among others, on the number of microhabitat types but the inner microhabitat variety in parks and cemeteries is strongly influenced by human activity.

It seems that the bryophyte species richness of the parks studied was determined, to some extent, by local environmental features (e.g. location beside a river, the presence of rocky outcrops, hilly terrain) and phytocoenotic specificity (e.g. established on the site of eutrophic deciduous forest or riverside willow-poplar brushwood). Other significant factors were, for example, lack of disturbance and the type of park. With reference to cemeteries, the main factors determining their bryophyte species richness seemed to be their age, presence of ancient tombstones and old trees as well as an unkempt state (e.g. old Jewish cemeteries).

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