THE ECOLOGICAL STRUCTURE OF THE BRYOFLORA OF WROCLAW'S PARKS AND CEMETERIES IN RELATION TO THEIR LOCALIZATION AND ORIGIN

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ABSTRACT

The ecological structure of the flora of 81 bryophytes found in 22 town parks and 6 cemeteries situated within the borders of the Wrocław town has been analyzed in relation to the localization of objects (within the center of the town and its suburbs) and their origin (parks set up in the place of ruins, those built on the site of old cemeteries, objects established within former forests, and parks set up in open, previously rural areas, often as gardens of mansions). In general estimation, the bryoflora of parks and cemeteries appears to be rather ecologically highly specialized – more than 50% of species occurred only on one type of substratum. Epiphytes *s.s.* occurred rarely. More often bryophytes were noted at the bases and on the trunks of trees, up to 30 cm. Some of the mosses, described in literature as epiphytes, have adapted to terrestrial-epiphytic sites and have been found only at the base of trees. In parks, epigeits were found in abundance on the ground around the base of trees and in shaded lawns. The presence of specialized epixylics was insignificant, although some of the typical forest epixylics were noted, namely *Aulacomnium androgynum*, *Herzogiella seligeri* and *Dicranum scoparium*. However, only parks situated in the suburbs show a high ecological variety of bryoflora, while objects established within the center of the town do not differ in species composition of bryophytes from surrounding built-up areas, despite their origin. Only in the parks situated in the suburbs there was a pronounced presence of forest and meadow species. The factor of park's origin seems to influence the bryoflora's ecological structure and the species richness on objects situated in the suburbs. In the cemeteries a positive correlation between the high number of species, age of monuments and the dimensions of object areas was stated.

KEY WORDS: urban bryoflora, bryophyte ecology, flora of Wrocław.

INTRODUCTION

Bryological data have proved that urban areas can not be considered as „bryophyte deserts”. In scientific literature dealing with urban ecology a general opinion is fixed that towns are poor in bryophytes (Sukkop, Werner 1982, 1987; Gilbert 1991; Wittig 1991; Sudnik-Wójcikowska 1998). That statement is true only in the case of liverworts, while in relation to mosses it gives a false picture of their species diversity and distribution in towns (Schaepe 1986; Fudali 1996a-b, 1997a-b, 1998; Lo Giudice et al. 1997; Vanderpoorten 1997). Detailed bryological studies have shown a fair differentiation in species number and composition of mosses occurring in various parts of towns which differ in kind of use and density of buildings (Schaepe 1986; Filipiak, Sieradzki 1996; Fudali 1996b; Lo Giudice 1997). In densely built-up areas the total number of bryophytes was not more than 15, and the ecological spectrum of that bryoflora was poor – epixylics and epiphytes were absent, just as higrophilous epigeits. The so called

„bryophyte weeds” were dominating there. A higher number of species occurred in parks: the total of bryophytes found in 8 parks in the town of Szczecin amounted to 52 (Fudali 1996a), just as in 7 parks in Łódź (Filipiak, Sieradzki 1996), while in 34 objects in West Berlin – 87 (Schaepe 1986), and in one park in the town of Katowice – 32 (Jędrzejko 1981). In these urban biotopes the ecological spectrum of bryoflora was usually broader than in the previous ones and quite often contained epiphytes *sensu lato*, as well as some small quantities of epixylics and helophytes.

These data suggests that parks can be considered as isolated centers of floristic diversity for mosses in the surrounding homogenous bryological built-up areas of towns (Fudali 2000). Unfortunately, the above quoted statements are based on generalized data, which concerns all the objects studied in the above mentioned towns.

Furthermore, there is only little and varied information about bryofloristic diversity and ecological variety of town cemeteries. The number of mosses mentioned from the

cemeteries in the town of Lublin amounts to 7 species (Karczmarz, Szarowski 1998), from Bratislava – 34 (Janovicová 1998), from Szczecin – 64 (Fudali 1996a, 1997a, b) and from Berlin – 110 (Shaepe 1986).

Presently there is no doubt that ecological research in urban areas is not only of scientific but also practical significance in the creation of cultural landscapes and the preservation of biodiversity on a global scale. This approach is reflected in international research projects promoted by UNESCO, the Council of Europe and other international scientific societies (Sukopp 1990, 1992, 1998; Wittig 1998) as well as in numerous interdisciplinary conferences devoted to urban ecology (e.g. the recently organized „Natura Megapolis”, August 27 – September 1, 2000, in Prague).

The aim of this study on the diversity of species and the ecological varieties of mosses occurring in parks and cemeteries in some Polish towns, which was undertaken by the author was to define their possible roles in the maintenance of the floristic diversity of mosses and ecological variety in urban areas, and to formulate some suggestions addressed to green-management and urbanists concerning the planning and the conservation of these urban green areas which can preserve the still existing biodiversity in towns.

This paper presents the ecological structure of bryophytes in town parks and cemeteries of Wrocław, in relation to their localization, origin, area, and the intensity of use of these objects. Research was supported by Agricultural University of Wrocław.

MATERIALS AND METHODS

Bryological studies were carried out in the years 1999–2000 in all microhabitats of six cemeteries and 22 town parks. Objects situated in rural landscapes, on the outskirts, as well as the Botanical and the Zoological Gardens were excluded from the research, because they are not of town park's character. The research yielded 81 bryophytes collected from eight types of biotopes: the base of trees, the trunks of trees (up to 30 cm from the ground), decayed wood, concrete walls, and monuments, the surface of stone graves, open bare earth, and overgrown shaded and open earth (Fudali 2001, in press). Classes of frequency of occurrence were distinguished as follows: rare species – occurring on 1–27% of stations, quite frequent species – on 28–50% of stations, frequent species – on more than 50% of stations. Each object was treated as one station.

Wrocław is a good model for the studies of urban bryophytes because its localization, dimension, spatial structure and history of urbanization resemble other towns in Central and Western Europe. Wrocław is the biggest town on the Silesian plain and one of the biggest in Poland. It was established at the end of the 12th century and was in the past an administrative, political and industrial center in the region. Presently it occupies an area of 290 km² and has a population of almost 700 000. Through the town flows the river Odra with its four tributaries. The town is influenced by an oceanic climate and industrial pollution. The annual rainfall amounts to 585 mm, winters are short and mild (Kosiba 1948). The surrounding areas were for many centuries of rural character. In the north-western

parts there are sandy soils while in the southern part – humus and loessic ones. The potential vegetation of this region are deciduous mezophilous forests with a prevalence of oaks and hornbeams.

Within the town borders there are 29 parks (including the Botanical Garden and the Zoo) and 8 larger cemeteries scattered over the area of the town. There are 10 parks and one cemetery in the city center and 12 parks and 5 cemeteries in the suburbs (City plan 1999). The parks (including reforested squares), occupy an area of 690 ha, which equals 2.3% of the town's total area, and the cemeteries occupy 145 ha (Chudzyński et al. 1995). All the studied objects are historical sites and were established in the 19th century or at the beginning of the 20th century (Strojny 1975; Hryniewicz et al. 1986; Bińkowska, Ilkosz 1998a, b, 1999; Chudzyński 1995; Chudzyński et al. 1995; Ciesielski et al. 1984; Kaszewska 1996; Rybka-Ceglecka, Ornatek 1995). The origins of the studied parks are of four types: parks set up in the place of ruins (7 objects); parks established on areas of old parishes or municipal cemeteries (8 objects); parks within former forests (4 objects); and former mansions' parks set up in open and previously rural areas (4 objects). The objects situated within the city's center usually cover smaller areas (up to 6 ha), than the larger parks in the suburbs (from 7 to 100 ha), and they are more intensely disturbed by city inhabitants and their dogs. Among the cemeteries only the Jewish Cemetery is characterized by a low human interference. In the other cemeteries there is regular cleaning and maintenance of the graves, sometimes with industrial cleansers, and the paths and the rest of the grounds are also well maintained.

The nomenclature of mosses follows Ochrya et al. (1992), liverworts Grolle (1983).

RESULTS AND DISCUSSION

Ecological structure of bryoflora

Parks: In 22 parks there occurred in total 73 species of bryophytes, 70 species of mosses and three species of liverworts. The majority of them, 51 species (70%), occurred rarely. The class of quite frequent species includes 6 species (8%) and the class of frequent species includes 16 (22%) (Fudali 2001, in press). The ecological spectrum of bryoflora contains six of the nine bryocoenological groups (according Gams 1932): epiphytes (*Epiphytia*), including species occurring on trunks above 30 cm (obligatory epiphytes) as well as those covering the bases and trunks up to 30 cm (facultative epiphytes), epixylics (obligatory and facultative) – *Epixylia*, epiliths (*Epilitia*) and epigeits occurring in mezophilous forests and meadows (*Bryochamaephytia*), on bare soil (*Xerogeophytia*) and on open banks of rivers (*Amphiphytia*). There are no aquatic species and helophytes (Table 1). Thus, in general, the synecological variety of park's bryoflora can be estimated to be rather rich.

In parks bryophytes colonized 11 types of microhabitats (Table 1). Epiphytes s.s. occur rarely and never abundantly. However, one should remember that densely built-up areas are quite devoid of bryophytes overgrowing tree-trunks (Fudali 1994). The most frequently occurring are *Hypnum cupressiforme*, *Amblystegium serpens*, *Ceratodon purpureus* and *Dicranoweisia cirrata*. Epiphytes were noted

TABLE 1. Comparison of the ecological spectrum of bryoflora occurring in cemeteries and various types of parks situated in inner town and in suburbs.

Key: **R** – parks set up on former ruderal sites, **L** – parks set up within former forest ecosystems, **O** – parks set up on the open areas previously disafforested, **P** – parks established on the area of transformed old cemeteries.

	PARKS								CEMETERIES
	In total	In inner town			In suburbs				
		In total	R	Others	In total	L	O	P	
Number of objects	22	10	7	3	12	4	3	5	6
Total area [ha]	428, 2	--	23, 8	28, 4	--	162	70	144	108, 5
Total number of species	73	29	23	28	71	60	44	49	63
Number of monosubstratum species	39-53%	9-31%	8-35%	5-18%	38-54%	27-45%	21-48%	20-41%	36-57%
Number of polysubstrate (3 and more) species	18-25%	10-35%	9-39%	8-29%	18-25%	18-30%	15-34%	17-35%	10-16%
EPIPHYTES – together, including:	23	3	0	3	23	14	8	18	14
– on trunks above 30 cm	9	0	0	0	9	5	2	7	5
– at base of trees and trunks up to 30 cm	22	3	0	3	21	14	7	17	12
EPIXYLICS – together, including:	28	5	2	5	20	19	10	12	19
– obligatory epixylics	3	0	0	0	3	1	2	0	4
EPILITHS – together, including:	34	13	12	6	33	30	13	16	34
– on concrete surfaces	28	13	12	6	27	23	9	17	23
– on stony surfaces	22	0	0	0	22	19	8	0	27
EPIGEITS – together, including	47	19	15	13	47	41	31	33	35
– on ground around trees	29	9	5	7	28	20	15	17	7
– on open lawns	19	8	8	3	19	10	6	13	15
– on shaded lawns	24	11	9	6	20	13	14	14	13
– on shaded area covered with perennials	16	2	0	2	16	14	0	11	13
– on naked earth	22	7	7	3	21	14	8	16	31
– banks of water reservoirs	16	0	0	0	16	16	2	0	0
Number of forest species	32	7	4	7	32	25	18	22	26
Number of meadow species	9	2	1	2	9	8	7	5	7
Number of hemerophilous species	25	15	14	15	24	20	12	16	24
Number of hemeroneutral species	7	5	4	7	7	7	6	12	6

more often on bases and trunks of trees, up to 30 cm. This group was rather rich in species, 23 were noted. Some of the mosses described in bryological literature as epiphytes, adapted to terrestrial-epiphytic sites and occurred only on bases of trees: *Amblystegium juratzkanum*, *Bryum capillare*, *Isoetecium myosuroides*, *Leskea polycarpa* and *Pylaisia polyantha*. A similar phenomenon has been reported on polluted European countries for over twenty years and interpreted as a bryophytic response to air pollution and the decrease of air humidity (Gilbert 1971; Rao 1982; Vanderpoorten 1997).

The occurrence of specialized epixylics was insignificant. However on some objects noted were *Aulacomnium androgynum*, *Herzogiella seligeri* and *Orthodicranum montanum*.

Epigeits abundantly appeared on the ground around the bases of trees. In that biotope mainly forest species were found, which are typical for the *Quercus-Fagetum* class: *Atrichum undulatum*, *Brachythecium velutinum*, *Dicranella heteromalla*, *Fissidens taxifolius*, *Hypnum cupressiforme*, *Kindbergia praelonga*, *Polytrichastrum formosum* and *Pohlia nutans*. Also, shaded lawns were rich in terrestrial species and overgrown with forest and meadow species, such as: *Atrichum undulatum*, *Brachythecium rutabulum*, *Cirriphyllum piliferum*, *Eurhynchium hians*, *Plagiomnium rostratum*, *P. undulatum*, *Rhytidiadelphus squarrosus*, *Pseudoscleropodium purum* and *Kindbergia praelonga*. The presence of forest and meadow species was well pronounced in parks situated in the suburbs. This suggests that the current present spores pool contains the remains of bryoflora from the pre-urbanized period. It also suggests that these parks play an essential role in the maintenance of floristic diversity in urban areas.

Bryophytes show various degrees of attachment to specific types of substrata. The ratio of obligatory to facultative species indicates a specialization of bryoflora and the quality of the ecosystem. A high share of polysubstrate species shows an advancing process of trivialization of bryoflora and its ecological degradation (Fudali 1996c). Exclusive occurrence on only one type of substratum was noted for 39 species (53% of total number) (Table 1). This is more than in the case of the flora of built-up areas, but much lower than in forest ecosystems (e.g. in the nature reserves of Beech Forest, the participation of obligatory species amounts to 72% (Fudali 1999). On two types of substrata 16 species (22%), and on 3 or more 18 species (25%) were found. Within the obligatory group, the richest are epigets with 19 species and epiliths with 11 species; the number of epiphytes *s.l.* amounts to 6 species, while epixylics 3 species only.

The proportions of obligatory, bisubstrate, and polysubstrate species differ distinctly between groups of rare and frequent species, and appear as follows: rare species – 64: 20: 16 [%], and frequent species – 25: 19: 56 [%], respectively.

Considering the optimal occurrence and distribution of recorded species they can be separated into four groups: (1) hemerophilous species – taxa distinctly related to anthropogenic sites, which are all epiliths (there are no natural rocky substrata in the town area), mosses growing on arable fields, such as *Pottia truncata*, and overgrowing ruderal sites as *Brachythecium albicans*, *Bryum argenteum*, *B. bicolor*, *B. caespitium*, *B. violaceum*, *Ceratodon pur-*

pureus, *Funaria hygrometrica*, *Physcomitrium pyriforme* and *Streblotrichum convolutum*; (2) species related to deciduous mesophilous forests; (3) taxa related to meadows; and (4) hemeroneutral species – polysubstrate species occurring with similar frequency and abundance, both in anthropogenic and semi-natural habitats (Nyholm 1954-1969; Szafran 1957-1961; Smith 1982; Frahm, Frey 1990).

The ecological analysis of the group of rare species shows that it contains 85% of all obligatory species (41% occurred sporadically), particularly, all epiphytes and epixylics, almost all epiliths (with exception of *Tortula muralis*), and 85% of epigeits. These are mostly forest species. The group of frequent species contains 11 forest or meadow moss species: terrestrial – *Atrichum undulatum* (13 stations), *Brachythecium albicans* (18 stations), *B. rutabulum* (19 stations), *Eurhynchium hians* (21 stations), *Plagiomnium rostratum* (16 stations), *P. undulatum* (13 stations) and *Rhytidiadelphus squarrosus* (12 stations); related to the base of trees and pieces of decayed wood *Brachythecium salebrosum* (13 stations), *B. velutinum* (16 stations), *Hypnum cupressiforme* (16 stations) and *Pohlia nutans* (15 stations), as well as, five moss species called „Bryophyte weeds”: *Amblystegium serpens* (18 stations), *Bryum argenteum* (16 stations), *Ceratodon purpureus* (22 stations), *Streblotrichum convolutum* (14 stations) and *Tortula muralis* (16 stations). The phenomenon of presence of forest species in town parks was also noted in other towns (Schaepe 1986; Fudali 1994; Filipiak, Sieradzki 1996) and in relation to the vascular plants (Sukopp, Werner 1982, 1987).

According to Düll and Wielgolaski (Sukopp, Werner 1982) *Plagiomnium undulatum* can occur in polluted towns only in high and unmowed grass. However, the observations taken in the Wrocław parks do not confirm that opinion. In all the studied objects, where this species was found, the grass is regularly mowed. The factor which seems to promote the occurrence of this species is shade.

Cemeteries: The bryoflora of 6 cemeteries contains in total 63 species of bryophytes, 60 species of mosses and three species of liverworts. More than half of all species, 33 (52%), belong to the class of rare species in the cemeteries of Wrocław. The class of quite frequent species includes 7 taxa (12%), and the class of frequent species includes 23 (36%).

The 10 types of microhabitats in cemeteries were colonized by bryophytes (Table 1).

The ecological spectrum contains 5 bryocoenological groups (Gams 1932): *Epiphytia*, *Epixylia*, *Epilithia*, *Bryochamaephytia* and *Xerogeophytia*. The ratio of obligatory to facultative species amounts to 57: 43, including 10 polysubstrate taxa (16%). Among obligatory species the richest in number are the groups of epigets (15 species) and epiliths (14 species), while the poorest are the groups of epixylics (4 species) and epiphytes (3 species).

Proportions of obligatory, bisubstrate and polysubstrate taxa differ between groups of rare and frequent species: within the first – 76: 34: 0, within the latter – 32: 32: 36. The ecological analysis of the group of rare species shows that it contains 69% of all obligatory species, including all epiphytes and epixylics, a half of the epiliths (7:14) and the majority of epigeits (11:17).

The group of frequent species contains 19 epiliths, including 6 obligatory ones: *Grimmia pulvinata*, *Orthotri-*

chum anomalum, *O. diaphanum*, *Rhynchostegium murale*, *Schistidium apocarpum* and *Tortula muralis*, and such „Bryophyte weeds”, that are also found in parks.

The occurrence of forest species in cemeteries seems to be insignificant, despite their localization in suburbs. Only seven species, generally known as „forest bryophytes”, were found in more than a half of the objects and never abundantly: *Atrichum undulatum*, *Brachythecium rutabulum*, *B. salebrosum*, *B. velutinum*, *Eurhynchium hians*, *Hypnum cupressiforme* and *Pohlia nutans*. Epiphytes occurred sporadically and individually, what can be explained by the low air humidity.

Comparison of objects

Parks: The low number of species (3 to 14) and impoverishment of ecological spectrum of bryoflora are characteristic of all objects situated within the center, despite their origin (Table 1). In total 29 species were noted, but only in three parks more than 10 species were found. The common features of these objects are the rather small areas (on average no more than 6 ha) and surroundings (densely built and main streets) as well as the frequent disturbances by the city inhabitants and their dogs. The ecological specialization of bryoflora occurring in these parks is low, only 31% of obligatory species, while in parks situated in suburbs 54% of obligatory species were found (Table 1).

Considering species composition and ecological variety of the bryoflora a group consisting of 6 parks, set up on former ruderal sites, can be distinguished from the other parks in the center. In total 23 moss species were found, but their species composition resembles, in 82% to 100%, the bryoflora of surrounding built-up areas. The only microhabitats in which mosses grew more abundantly were concrete walls (12 species) and lawns (9 species). In these parks epiphytes and epixylics were absent, while forest and meadow epigeits, such as *Atrichum undulatum*, *Brachythecium rutabulum*, *B. velutinum*, *Cirriphyllum piliferum* and *Plagiomnium rostratum*, occurred sporadically.

Three other parks situated within the center were richer in species (10 to 14 species in each) and differed slightly in ecological structure of bryoflora from the latter – the share of polysubstrate species was lower; the sporadic occurrence of facultative epiphytes *Hypnum cupressiforme* and *Amblystegium serpens* was noted, and the forest species *Plagiomnium undulatum*, *Pohlia nutans* and *Brachythecium velutinum* were found on the ground around the base of trees.

In objects situated in suburbs there appeared a higher level of species diversity (from 16 to 55 species). The total number amounts to 71 species (Table 1). Only the suburban parks form a species richness and ecological variety of bryoflora in the parks of Wrocław, which were described above. Three „genetic” groups of parks occur in the suburbs: (1) parks set up within former forest ecosystems; (2) parks established on open rural areas; (3) parks established on sites of former old cemeteries. Among them, the first group of 4 parks appeared to be richer, 26 to 55 species were found in the particular objects and, on average, more than 30 species in each park. The total number of taxa found in the parks amounts to 60 species. The share of polysubstrate species was the lowest (30%) and the number of epixylics was the highest, 19 species – 32% of the flora in the park. Surprisingly, a high number of epiliths were

noted, 30 species (50%). In these parks, eight moss species occurred exclusively, but only two forest species: *Isoetecium myosuroides* and *Plagiothecium denticulatum*. Other „genetic” groups of parks had similar numbers of species in objects, diversity of moss flora, and participation of polysubstrate taxa. However, they differ slightly in ecological structure of the bryoflora. Parks set up on areas of former cemeteries were richer in obligatory and facultative epiphytes, 18 species (37% of all species in these group) and in participation of hemerophilous species (33%) than those established on previously rural areas, which appeared richer in meadow species.

Unfortunately, there are no comparative data from other towns to define the relations between ecological specialization of parks' bryoflora and their origin. Research carried out in 7 parks in Łódź (Filipiak, Sieradzki 1996) showed also that the richness of their bryoflora depends on size of the park, its localization, and its origin. A higher floristic diversity was noted in large parks situated in suburbs and set up within former forest ecosystems. However, the differences in ecological structure of bryoflora were not studied.

Cemeteries: The objects differ in the number of species found (from 18 to 42), and the number of biotopes (from 3 to 9), (Fudali 2001, in press). There is a positive correlation between the high number of species, age of monuments and areas of the objects. However, in the latter case the intensity of human disturbances can alter that relation. For example, in the rather small and old Jewish Cemetery (10 ha), which is rarely visited and maintained by mourners, 40 species were noted, while in the largest municipal, equally old cemetery (55 ha) only 42 species were found.

There is also a difference in ecological spectra among objects. Most epiphytes and forest bryophyte species were noted on the largest object set up within a former oak forest, while most epixylics were noted in the Jewish Cemetery, where fallen trees and leaves are not removed. The number of epiliths was clearly related to the age of the graves, the older graves had more epilithic species.

CONCLUSIONS

1. Parks situated within the center and those in the suburbs differ distinctly in ecological structure of their bryoflora because of absence of epiphytes, epixylics, and the infrequency of forest epigeits, which occur frequently in the suburbs. The ratio of monosubstrate species is also lower.
2. The ecological spectrum of parks situated in the center is similar to that of densely built-up areas.
3. In general, the origin of the object seems to be the main factor generating the bryological richness and ecological variety of bryoflora in parks situated in suburbs. In parks set up within former forest ecosystems the share of polysubstrate species was the lowest and all ecological groups were represented. These parks were also the richest in number of forest's moss species.
4. In total, the bryoflora of town parks and cemeteries reveals a rather high ecological specialization – more than 50% of species occurred on only one type of substratum (53%, 57% respectively). Unfortunately, most obligatory species belong to the group of rare species which indicates a strong threat for the still existing ecological varieties of bryoflora in urban areas.

5. It was found that 68% of the bryoflora in the parks and cemeteries under study was the same, but the ecological specialization of bryophytes varies. In cemeteries, man-made rock-like habitats, such as graves, walls and monuments, as well as open bare and unstable earth, were the richest in species and most abundantly covered with mosses. In parks the ground around trees, shaded lawns, tree trunks (up to 30 cm), and concrete surfaces were the richest in species, and were abundantly overgrown with mosses.

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STRUKTURA EKOLOGICZNA BRIOFLORY
MIEJSKICH PARKÓW I CMENTARZY WROCŁAWIA
W ODNIESIENIU DO ICH LOKALIZACJI I POCHODZENIA

STRESZCZENIE

W pracy omówiono strukturę ekologiczną flory 81 gatunków mszaków znalezionych w 22 miejskich parkach i na 6 cmentarzach Wrocławia. Stwierdzono, że parki zlokalizowane w centrum miasta wyraźnie odróżniają się strukturą ekologiczną od parków usytuowanych na peryferiach. Udział gatunków obligatoryjnych jest w nich niższy, nie występują epifity, epiksyle oraz leśne epigeity. Brioflora tych parków nie różni się istotnie od flory mszaków terenów zabudowanych. Parki na peryferiach wykazują dość wysoką ekologiczną specjalizację – więcej niż 50% gatunków wystąpiło tylko na 1 typie podłoża. Obserwowano w nich obecność epifitów (obligatoryjnych i fakultatywnych), epiksyli, epilitów oraz epigeitów. Większość gatunków obligatoryjnych należy do klasy rzadkich, co wskazuje na silne zagrożenie istniejącego jeszcze na terenach zurbanizowanych ekologicznego zróżnicowania brioflory. Geneza parków zaznacza się w strukturze ich brioflory – obiekty założone w obrębie dawnych ekosystemów leśnych odznaczają się największą liczbą gatunków leśnych, w tym epiksyli; parki założone na terenie dawnych cmentarzy wyróżniają się wysoką liczbą epifitów *s.l.* i najwyższym procentowym udziałem gatunków hemerofilnych i hemeroneutralnych; parki utworzone na terenach porolniczych – największym udziałem mszaków łąkowych.

Brioflora parków i cmentarzy jest w 68% identyczna, ale zaznaczają się różnice w strukturze ekologicznej. Na cmentarzach dominują epifity i gatunki naziemne zasiedlające nagą glebę, natomiast w parkach – leśne epigeity występujące u podstawy drzew i na zacienionych trawnikach oraz epifity *s.l.* porastające pnie drzew do 30 cm i stopy drzew, a także epifity na betonowych murkach.

SŁOWA KLUCZOWE: brioflora miast, ekologia mszaków, flora Wrocławia.