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BRYOPHYTES OF THE EXPERIMENTAL AND TEACHING GARDEN OF THE FACULTY OF BIOLOGY AND ENVIRONMENTAL PROTECTION, UNIVERSITY OF ŁÓDŹ (POLAND)

Key words: bryophytes, species richness, ecologic analysis, Łódź, Central Poland

Abstract. The aim of the study was to determine the species composition, taxonomic and ecological diversity of bryophytes of the examined site and to determine their prevalence in the area.

During the research, there were showed the presence of 42 species of bryophytes (41 mosses and one liverworts) belonging to 15 families. The shown species represent 29 % of all the species identified in the city of Łódź and surrounding area. In this group there were 7 species not reported so far in this area. The research showed five types of habitats covered by bryophytes, they are: epigeic, epilithic, epiphytic, epixylic, and aquatic. Most species were found in the examined area, in epigeic habitats — 34 species, least were found in aquatic habitat — only one species.

A large number of identified species confirms that urban parks are characterized by a large diversity of species of bryophytes. The large number of species unlisted in this area so far confirms the validity of the green areas as the significant mainstays of briological diversity of a relatively floristically poor urban areas.

Introduction

Bryophytes (especially liverworts) are mostly characterized by narrow ranges of their ecological amplitudes. They exhibit a high sensitivity to changing habitat conditions, in both natural and anthropogenic habitats (Kłama, 2002, 2004; Żarnowiec, 2004; Stebel, 2006; Fojcik, 2011). Bryophytes are constant and integral components of almost all plant communities. In forest, non-forest, natural and anthropogenic plant communities, terrestrial species create the layer that can be easily distinguished; the others grow on the bark of trees, on wood or stone substrats (Kornaś, 1972; Mickiewicz, Sobotka, 1973; Kłama, 2003; Żarnowiec, 2003).

Urbanization alters natural habitats and causes the emergence of habitats of anthropogenic origin, which may be occupied by bryophytes. Despite the presence of different types of substrates, city centers are usually characterized by a low number of bryophytes appearing within such areas. This is due to adverse changes in environmental conditions, especially water or air pollution. Under the influence of anthropogenic changes, species richness of bryophytes in urban areas generally decreases. The

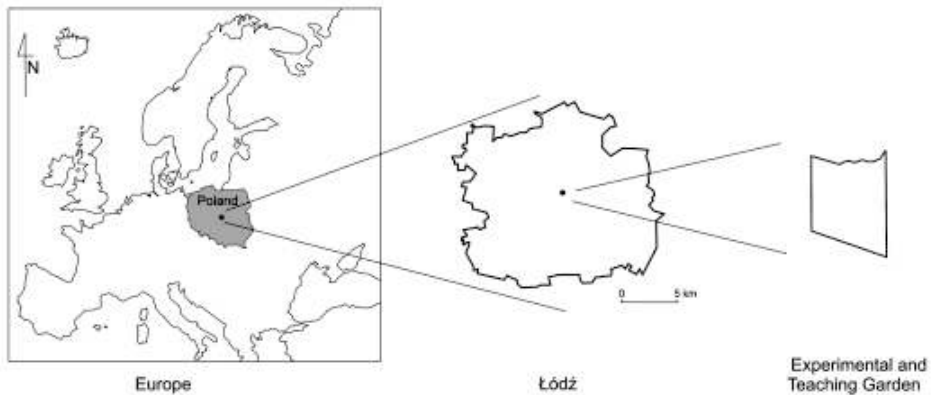


Fig. 1. Location of the Experimental Garden of the Faculty of Biology and Environmental Protection, University of Łódź

role of mainstay for species retreated from the city is adopted by the urban green areas. City parks, forests, and similar habitats play a key role in maintaining the diversity of bryophytes in urban floras. Within such areas, the habitats of many forest and grassland species of bryophytes occur; while in the past many of such species occurred throughout the entire area (Fudali, 2005, 2007).

First bryological data from the region of Łódź come from the district of Kutno and Łęczycza (Błoński, 1890), Piotrków Trybunalski (Kulesza, 1918-1919) and the village of Dobroń (Świtalska, 1936).

Research conducted by Urbanek (1959, 1961, 1962, 1962b, 1963b, 1964, 1965, 1966 b-d, 1967–1969); Filipiak (1981, 1986) and Łuczak and Filipiak (2001) undoubtedly contributed to the knowledge on the bryoflora of the region of Łódź, but were focused primarily on landscape parks, nature reserves, and other natural and semi-natural forest ecosystems of the region.

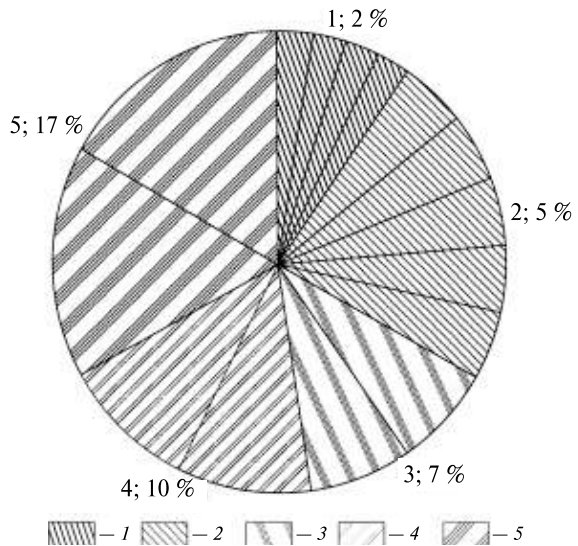
In many Polish cities, e.g. Katowice (Fojcik Stebel, 1999, 2001), Poznań (Fudali, 2002), Szczecin (Fudali, 1996a, b; 1997a, b; 2000), Warszawa (Fudali, 2003) and Wrocław (Fudali, 2000, 2001a, b), bryological studies covered the entire city and concerned many aspects of this group of plants. In Łódź, the bryological studies so far focused on the city center, green areas and its outskirts. During the research carried out in the 1960s and 1990s (Chmielewski, Urbanek, 1960, 1963a; Filipiak, 1996; Filipiak, Sieradzki, 1996) in the city of Łódź and the surrounding area, 143 species of bryophytes were found. They covered all the accessible surfaces, and were represented by many ecological groups, including epigeic, epixylic, epiphytic, epilithic and aquatic ones.

The main objective of the present study was to determine the species composition, taxonomic and ecological diversity of bryophytes of the examined site and to determine their prevalence in the area.

Materials and methods

The Educational and Experimental Garden of the Faculty of Biology and Environmental Protection, University of Łódź, is located in the center of Łódź (19°28'58" E 51°46'36"

Fig. 2. Families found in the Garden: 1 – *Cilmaciaceae*, *Ditrichaceae*, *Hylocomiaceae*, *Marchantiaceae*; 2 – *Dicranaceae*, *Funariaceae*, *Grimmiaceae*, *Orthotrichaceae*, *Polytrichaceae*; 3 – *Hypnaceae*, *Plagiomniaceae*; 4 – *Amblystegiaceae*, *Pottiaceae*; 5 – *Brachytheciaceae*, *Bryaceae*



N) (Fig. 1). It was established in 1985 and occupies at present about 1.02 hectares.

Within the area of the Garden, 793 taxa of plants occur; the total collection which consists of two separate collections, that of herbaceous plants and an arboretum. The first collection consists of 498 herba-

ceous taxa growing in the Garden, which belong to 58 families. The best represented families are: *Asteraceae* (76 species), *Lamiaceae* (42), *Ranunculaceae* (34) and *Liliaceae* s.l. (31). The arboretum collection contains 295 species of deciduous and coniferous trees. The best represented genera are: *Acer* (10 species), *Pinus* (9), *Prunus* (7) and *Salix* (6). In the Garden grow mostly species of forest trees and shrubs that are common in Poland, including *Abies alba* Mill., *Pinus sylvestris* L., *Carpinus betulus* L., *Fagus sylvatica* L., *Quercus robur* L., *Sorbus aucuparia* L. and *Frangula alnus* Mill. There are also species of foreign origin that are often planted in parks, such as *Acer saccharinum* L., *Physocarpus opulifolius* (L.) Maxim., *Philadelphus coronatus* L. and others. Moreover, indigenous fruit trees of the genera *Malus*, *Pyrus*, *Prunus*, *Cerasus* are grown in the Garden, as well as lesser-known species, such as *Cornus mas* L. and *Hippophaë rhamnoides* L. All these species compose the basis of teaching designed for students and employees of the University of Łódź (Kurzac, 2007; Stefaniak, 2008).

Field studies were conducted in 2009 and 2010. The bryological material was collected in all habitats. The occurrence of species on a particular type of substrate away from the other by one meter was considered as a position (or site). For each species, its occurrence frequency is given by the scale: 1–3 records – rare species (+), 4–10 records – frequent species (++) , more than 11 records – common species (+++). The nomenclature for mosses is based on Ochyra et al. (2003) and for liverworts, on Klama (2006). The species under legal protection were determined on the basis of the Decree of the Minister of Environment of 9 July 2004 on the species of wild plants to be protected. Herbarium materials were deposited in the Herbarium Universitatis Lodziensis (LOD) – *Bryophyta* Department of Geobotany and Plant Ecology, Faculty of Biology and Environmental Protection, University of Łódź.

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Occurrence of recorded bryophyte species on different types of substrates.

Species		Habitat										Frequency											
		Epigeic		Epixylic	Epiphytic	Epilithic	Aquatic	Substrate															
		Mineral Soil	Humus	Lawn	Litter	Stumps	Small Fragments Of Wood	<i>Acer-negundo</i>	<i>Betula pendula</i>	Concrete Structures	Stones		Pond										
1	<i>Amblystegium juratzkanum</i> Schimp.							+														+	
2	<i>A. serpens</i> (Hedw.) Schimp.							+	+			+											++
3	<i>Barbula unguiculata</i> Hedw.	+											+										++
4	<i>Brachythecium albicans</i> (Hedw.) Schimp.	+																					+
5	<i>B. rutabulum</i> (Hedw.) Schimp.			+																			+
6	<i>B. salebrosum</i> (Hoffm. ex F. Weber & D. Mohr)	+		+																			+
7	<i>Bryum argenteum</i> Hedw.	+											+										++
8	<i>B. bicolor</i> Dicks.	+																					+
9	<i>B. caespiticium</i> Hedw.	+											+										+
10	<i>B. klinggraeffii</i> Schimp.	+																					+
11	<i>B. rubens</i> Mitt.	+																					+
12	<i>Calliergonella cuspidata</i> (Hedw.) Loeske		+	+																			+++
13	<i>Ceratodon purpureus</i> (Hedw.) Brid.	+					+																+++
14	<i>Cirryphyllum piliferum</i> (Hedw.) Grout			+																			+++
15	<i>Climacium dendroides</i> (Hedw.) F. Weber & D. Mohr	+		+																			++
16	<i>Dicranella heteromalla</i> (Hedw.) Schimp.	+																					+
17	<i>Drepanocladus aduncus</i> (Hedw.) Warnst.																				+		+
18	<i>Dryptodon pulvinatus</i> (Hedw.) Brid.												+	+									++
19	<i>Funaria hygrometrica</i> Hedw.	+																					+++
20	<i>Hypnum cupressiforme</i> Hedw.		+				+			+			+	+									+++
21	<i>H. jutlandicum</i> Holmen & E. Warncke			+																			+

Species		Habitat										Frequency			
		Epigeic			Epixylic	Epiphytic	Epilithic	Aquatic	Substrate						
		Mineral Soil	Humus	Lawn	Litter	Stumps	Small Fragments Of Wood	<i>Acer negundo</i>	<i>Betula pendula</i>	Concrete Structures	Stones		Pond		
22	<i>Kindbergia praelonga</i> (Hedw.) Ochyra	+													+
23	<i>Marchantia polymorpha</i> L.	+		+								+	+		+++
24	<i>Orthodicranum montanum</i> (Hedw.) Loeske							+							++
25	<i>Orthotrichum affine</i> Schrad. ex Brid.							+							+
26	<i>O. diaphanum</i> Schrad. ex Brid.							+							+
27	<i>Oxyrrhynchium hians</i> (Hedw.) Loeske	+		+											+
28	<i>Physomitrium pyriforme</i> (Hedw.) Bruch & Schimp.	+													++
29	<i>Plagiomnium affine</i> (Blandow ex Funck) T.J. Kop.	+	+	+	+										+++
30	<i>P. cuspidatum</i> (Hedw.) T.J. Kop.		+												+
31	<i>P. undulatum</i> (Hedw.) T.J. Kop.	+		+											+
32	<i>Pohlia nutans</i> (Hedw.) Lindb	+													++
33	<i>Polytrichastrum formosum</i> (Hedw.) G.L. Sm.	+													++
34	<i>Polytrichum commune</i> Hedw.	+													+
35	<i>Pseudoscleropodium purum</i> (Hedw.) M. Fleisch. ex Broth.			+											++
36	<i>Rhytidiadelphus squarrosus</i> (Hedw.) Warnst.			+											+++
37	<i>Rosulabryum capillare</i> (Hedw.) J.R. Spence	+								+					+
38	<i>Schistidium apocarpum</i> (Hedw.) Bruch & Schimp.										+				+
39	<i>Sciuro-hypnum oedipodium</i> (Mitt.) Ignatov & Huttunen	+	+	+											++

Species		Habitat										Frequency	
		Epigeic		Epixylic	Epiphytic	Epilithic	Aquatic	Substrate					
		Mineral Soil	Humus	Lawn	Litter	Stumps	Small Fragments Of Wood	<i>Acer negundo</i>	<i>Betula pendula</i>	Concrete Structures	Stones		Pond
41	<i>Syntrychia ruralis</i> (Hedw.) F. Weber & D. Mohr	+								+			++
41	<i>Tortula acaulon</i> (With.) R.H. Zander	+											++
42	<i>T. muralis</i> Hedw.	+								+			++

Results

During the research, 42 species of bryophytes (41 mosses and one species of liverworts) were revealed (Table). These species belong to 15 families. Among the reported families, the most numerous in terms of the species number were *Brachytheciaceae* and *Bryaceae* (7 species each) (Fig. 2). The species registered during the research represent 29 % of all species identified so far in the city and surroundings of Łódź.. Thirty-five of them were previously reported in this region, while seven species were recorded for the first time for the region: *Bryum bicolor* Dicks., *B. klinggraeffii* Schimp., *B. rubens* Mitt., *Drepanocladus aduncus* (Hedw.) Warnst., *Hypnum jutlandicum* Holmen & E. Warncke, *Orthotrichum diaphanum* Schrad. ex Brid., and *Rosulabryum capillare* (Hedw.) J.R. Spence.

During the research we distinguished five types of habitats covered by bryophytes: epigeic, epilithic, epiphytic, epixylic, and aquatic. Most species were found on epigeic habitats – 34 species, least of all occurred in aquatic habitats – *Drepanocladus aduncus* (Fig. 3).

The most diverse habitat type among the reported ones was the epigeic one. This type include: mineral soil, humus, lawn, and litter. In the group of epilithic habitats, there were recorded: stones and concrete structures (walls and curbs). Although, despite the occurrence of many species of trees in the garden, only two species of trees were overgrown by mosses: *Acer negundo* and *Betula pendula* (up to 50 cm high). The stumps and small pieces of wood lying on the ground were numbered among the epixylic habitats, whereas the most undifferentiated one was the aquatic habitat, a small pond located in the Garden (Table).

Thirty-two species (76 % of all identified species) occurred only in one type of habitat. Only two species were registered in more than two types of habitat. *Hypnum*

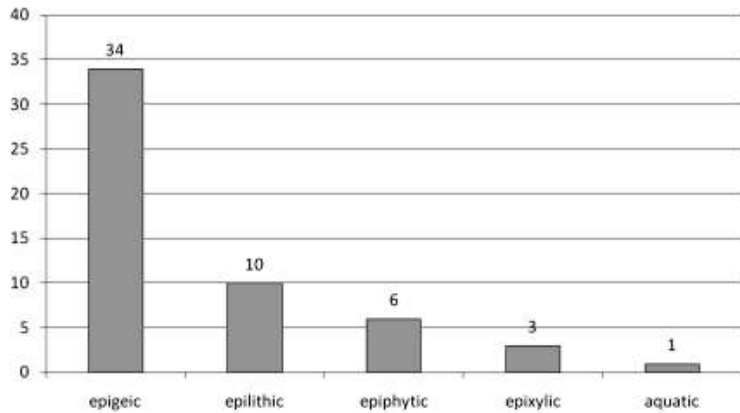


Fig. 3. Total number of bryophyte species recorded in different types of habitats

cupressiforme was recorded in epigeic (humus), epilithic (stones and concrete structures), epixylic (stumps) and epiphytic (bark of *Acer negundo*) habitats. *Amblystegium serpens* occurred in epilithic (concrete structures), epixylic (small pieces of wood) and epiphytic (bark of *Acer negundo*) habitats (Table).

Among the reported types of substrates, most of species were found at mineral soil (26 species), lawn (13), concrete structures (10), and on the bark of *Acer negundo* and humus (five species). Lesser numbers of species were found on stones (4 species), stumps (2), and the least on the litter, small fragments of wood, bark of *Betula pendula* and in the pond sites (only one species in each). Twenty-four species (57 % of all species reported) were found only on one type of substrate. Only *Hypnum cupressiforme* was recorded on five different types of substrates (see Table).

The analysis of the frequency level has shown that common species comprised the smallest group (8 species). Next was the group of frequent species (14) and the most numerous group was that of rare species (32) (see Table).

Five of the reported species (*Calliergonella cuspidata*, *Climacium dendroides*, *Polytrichum commune*, *Pseudoscleropodium purum* and *Rhytidiadelphus squarrosus*) are under legal protection in Poland (Act 2004...). Two of them, *Polytrichum commune* and *Pseudoscleropodium purum*, are forest species, while others (*Calliergonella cuspidata*, *Climacium dendroides*, *Rhytidiadelphus squarrosus*) are grassland species. These species prefer moist habitats. Within the garden they are located in its southern part. In this part one can find moist lawns, which provide conditions for the development of these species (Fig. 4).

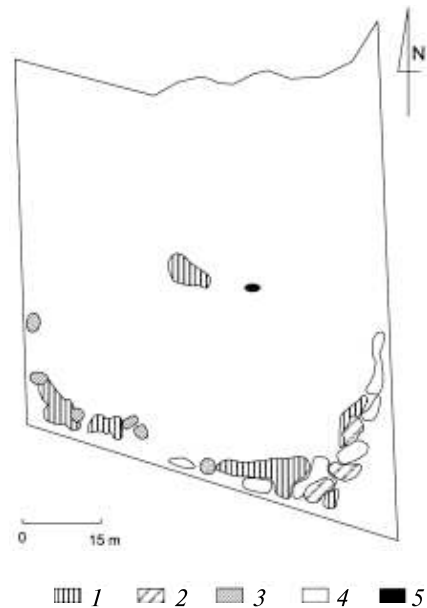


Fig. 4. Occurrence of the protected species. 1 – *Calliergonella cuspidata*, 2 – *Pseudoscleropodium purum*, 3 – *Climacium dendroides*, 4 – *Rhytidiadelphus squarrosus*, 5 – *Polytrichum commune*

Discussion

A large number of species reported on the area of the Garden supports the research published in the area of other Polish cities (Fudali, 1996a), that city parks have a wide variety of species of bryophytes. A great number of unlisted species from the city and surroundings of Łódź confirms the validity of urban parks and other green areas which are significant enclaves to maintain the bryological diversity of urban ecosystems (Fudali, 1996a).

While the research was conducted, there were recorded only one species of liverworts. This illustrates the vulnerability of this group of plants to anthropopressure and a lack of suitable substrates (Fudali, 2000).

Epigeic species dominate at the test site, as in other Polish cities (Fudali, 1996b, 2000, 2001a, b, 2002). This is because the epigeic substrate is the most common in the city and thus the most accessible substrate for bryophytes. In the city, epilithic habitats are mainly concrete structures or other man-made structures (Fudali, 1996b). Despite the large number of species of trees available to be colonized within the area of the Garden, only two species, *Acer negundo* and *Betula pendula*, were overgrown by bryophytes. Among the proper epiphytes that can be found in the Garden, there were recorded only two species of the genus *Orthotrichum*. Research studies confirmed that *Acer negundo* is a tree species mostly covered by bryophytes in the urban environment (Filipiak, Sieradzki, 1996; Fudali, 1996a). The previous studies conducted in Łódź (Filipiak, Sieradzki, 1996; Filipiak, 1996) and in other Polish cities (Fudali, 1996a, b; 2002, 2003) demonstrated that species from epixylic habitats comprise a small group. This is mostly due to the lack of available substrates. Other studies conducted in several Polish cities (Fudala, 1996b) had presented that the group of species associated with aquatic habitats was found to be the smallest of all groups identified in the examined area. In the area of urban parks (Fudali, 2002) and in the Garden, most species were associated with one type of substrate.

Conclusion

1. During the study, 42 species of bryophytes (41 mosses and one liverworts) were found. Seven of these species have not been reported before for the city of Łódź and its surroundings. *Bryaceae* and *Brachytheciaceae* were found to be most species-rich families.

2. Within the area of the Garden, there were recorded five types of habitats: epigeic, epilithic, epiphytic, epixylic, and aquatic ones. Most species (34) were found in epigeic habitats. Thirty-two species (76 % of all identified species) occurred only in one type of habitat. Twenty-four species (57 %) occurred on only one type of substrate.

3. Epigeic habitats (especially the mineral soil) create the essential base that determines the occurrence of many species of bryophytes.

4. Analysis of the frequency of the species showed that the study area is dominated by rare species (32 species). Among all reported species, five were covered by legal protection in Poland. Consequently, in urban ecosystems the green areas are important refuges of bryological diversity.

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БРИОФИТЫ ЭКСПЕРИМЕНТАЛЬНОГО ТА УЧБОВОГО САДУ ФАКУЛЬТЕТУ БИОЛОГІЇ І ЗАХИСТУ СЕРЕДОВИЩА ЛОДЗЬКОГО УНІВЕРСИТЕТУ (ПОЛЬЩА)

Мета дослідження — визначення видового складу таксономічного та екологічного різноманіття мохоподібних на обстежуваній території і з'ясування питання щодо їхнього поширення в регіоні.

Під час дослідження виявлено 42 види мохів (41 вид — зелені мохи, 1 — печіночник), які належать до 15 родин. Вони становлять 29 % усіх бриофітів, знайдених у м. Лодзь та його околицях. Серед знайдених мохів сім видів, які для цієї території досі не вказувалися. Під час досліджень відзначено п'ять типів місцезростань, покритих мохами, а саме: епігейні, епілітні, епіфітні, епіксилітні та водні. Більшість видів (34) були знайдені в епігейних місцях, значно менше — в інших; у водному середовищі — лише один вид.

Виявлення великої кількості видів мохів свідчить про те, що в міських парках зростає багато різноманітних бриофітів. Той факт, що знайдено велику кількість видів, не відзначених на цій території дотепер, переконує в тому, що зелені насадження є значним осередком біологічного різноманіття порівняно з флористично бідними міськими територіями.

К л ю ч о в і с л о в а: бриофіти, видове багатство, екологічний аналіз, Лодзь, Центральна Польща.

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БРИОФИТЫ ЭКСПЕРИМЕНТАЛЬНОГО И УЧЕБНОГО САДА ФАКУЛЬТЕТА БИОЛОГИИ И ЗАЩИТЫ СРЕДЫ ЛОДЗСКОГО УНИВЕРСИТЕТА (ПОЛЬША)

Цель исследований — определение видового состава, таксономического и экологического разнообразия мохообразных на обследуемой территории и выяснение их распространения в регионе.

Во время исследования выявлено 42 вида мхов (41 вид — зеленые мхи, 1 — печеночник), которые относятся к 15 семействам. Эти виды составляют 29 % всех криофитов, отмеченных в г. Лодзь и его окрестностях. Среди найденных мхов семь видов, которые до последнего времени не указывались на данной территории. Во время исследований отмечено пять типов местообитаний, покрытых мхами, а именно: эпигейные, эпилитные, эпифитные, эпиксилитные и водные. Большинство видов (34), найденных на исследуемой территории, были отмечены в эпигейных местах, значительно меньше — в других местах, в водной среде — только один вид.

Большое количество выявленных видов свидетельствует о том, что городские парки характеризуются высоким разнообразием мхов, а также о том, что зеленые насаждения являются существенным очагом бриологического разнообразия в сравнении с флористически бедными городскими территориями.

К л ю ч е в ы е с л о в а: бриофиты, видовое богатство, экологический анализ, Лодзь, Центральная Польша.