

THE BRYOPHYTE FLORA OF THE SZENT ISTVÁN UNIVERSITY GÖDÖLLŐ BOTANICAL GARDEN

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Abstract: This is the first bryofloristic study in the Gödöllő Botanical Garden of Szent István University. The aim of the study was to determine the species composition, taxonomic and ecological diversity of bryophytes of the garden and to determine their prevalence in the area. Altogether 69 bryophyte taxa (3 liverworts and 66 mosses) were identified belonging to 24 families and 44 genera. Most species were found in the research area in epigeic habitats (26 taxa) and least were found in epixylic habitats (5 taxa). Most of them are considered to be common in Hungary, however, five species are listed as near threatened on the current Hungarian Red Data List: *Brachythecium glareosum*, *Dicranella howei*, *Didymodon insulanus*, *Fissidens viridulus*, *Nyholmia obtusifolia*.

Keywords: bryophyte diversity, life strategy, semi-natural habitats, comparison

INTRODUCTION

The first significant research into the bryoflora of Hungarian botanical gardens and arboretums was in 1954 of Vácrátót (Vajda 1954) and Szigliet (Vajda 1968). After the 2000s, the number of bryofloristical publications increased and to date 11 botanical gardens have been investigated in Hungary. In addition to the above, bryophyte surveys have been carried out in Zirc (Galambos 1992, Szűcs 2013), Agostyán (Szűcs 2009), Soroksár (Németh and Papp 2016), manor park of Martonvásár (Nagy *et al.* 2016), Eger (Szűcs and Péntesné-Kónya 2016, Szűcs *et al.* 2017), Sopron (Igmándy 1949, Szűcs 2017), Buda (Rigó *et al.* 2019), Erdőtelek (Szűcs and Fintha 2019) and Göd (Fintha *et al.* 2020).

The locations of the vascular plants in arboretums are consciously chosen by gardener, but mosses spontaneously select

the optimal habitats. They cover all accessible and favorable surfaces and are represented by many ecological groups, including epigeic, epixylic, epilithic, epiphytic and aquatic. The present research introduces the first bryofloristic study in the Szent István University Gödöllő Botanical Garden. The main objective of the study was to determine the species composition, taxonomic and ecological diversity of bryophytes of the garden and to determine their substrate prevalence in the area.

MATERIAL AND METHODS

Field studies were conducted between September and December 2020. The bryological material was collected in all habitats. Site details include data in the following order: habitats, GPS-coordinates and date of collection. Herbarium specimens were deposited in the Cryptogamic Herbarium of the Department of Botany and Plant Physiology at the Eszterházy Károly University, Eger (EGR). The evaluation of life strategies of bryophytes is according to Dierßen (2001). In order to characterise the conservation status of taxa, the Hungarian Red List was used (Papp *et al.* 2010). Nomenclature follows the classification of Király (2009) for the vascular plants. The nomenclature of mosses and liverworts follows Hodgetts *et al.* (2020). We used the Sørensen index (Sørensen 1948) for the comparison of the species composition of different localities.

Study area

The Gödöllő Botanical Garden of Szent István University was founded in 1959 after the University of Agricultural Sciences moved from Budapest to Gödöllő (S. Taba and Tuba 1999). In the next 3 years the first agrobotanical garden of Hungary was completed (Hortobágyi 1963). It is situated on the slopes of the Gödöllő Hills (GPS coordinates: 47.593027, 19.366136) at an altitude of 220 m above sea level (S. Taba and Tuba 1999). The Garden is located in the heart of the Gödöllő campus area of Szent István University, and occupies a 4.3 hectares site. It provides the teaching and research collection of living plants for the university, which counts over 1250 taxa. The botanical garden is a nature conservation area since 2008, and has over 110 protected higher plant species of the Hungarian Flora. After creating the necessary

infrastructure the garden has opened for visitors in 2011 (Szirmai *et al.* 2014).

Habitats and collections of the garden

Native and endangered open and closed sandy grassland communities have been created on a ca. 2500 m² area in 2009 (Czóbel *et al.* 2012), representing the once characteristic grassland vegetation of the Gödöllő Hills. More than a quarter of the garden is covered by a unique, natural forest stand, which belongs to a rare community "*Aceri campestri-Quercetum roboris*". These relict forest patches have national importance.

Aquatic habitats consists of four ponds. The "central pond", the oldest of the aquatic habitats, was constructed in the 1960's and is located in the centre of the systematic beds. The "small pond" beside the entrance was completed in 2010. The "upper pond" was evolved in 2010 in order to enrich the landscape in the upper part of the garden. The fire water reservoir the largest of the aquatic habitats was established in 2015 and home of floating aquatic plants.

The tiny rock gardens display Hungarian native plants e.g. liverleaf (*Hepatica nobilis*) in addition those from mountainous parts of Europe and around the world (Szirmai *et al.* 2014).

Site details

The identifiers of the quadrates according to the Central European Flora Mapping System were indicated in square brackets (Király *et al.* 2003). Each collection point belongs to the 8482.1 square. The bryofloristic exploration was carried out by the authors in the whole area of the botanical garden, exploring the marked micro-habitats. The data of the indicated collection sites (*Figure 1*), provide the serial number of the collection site, the name of the habitat, the date of collection and the GPS coordinates.



Figure 1. The map of Szent István University Gödöllő Botanical Garden (OpenStreetMap and Google Earth contributors).

1. shady, sandy and gravelly soil, artificial stone, limestone, bark (07.09.2020., 04.12.2020.) N47°35'35.0" E19°21'58.6"
2. sandy soil, limestone (07.09.2020., 27.10.2020., 04.12.2020.) N47°35'34.8" E19°21'59.5"
3. shady limestone, gravelly soil (27.09.2020., 04.12.2020.) N47°35'34" E19°22'00"
4. sandy soil in the greenhouse (07.09.2020.) N47°35'35.0" E19°21'59.0"
5. lawn, shady soil, concrete (07.09.2020., 27.10.2020., 04.12.2020.) N47°35'36.8" E19°21'58.6"
6. lawn, shady soil (07.09.2020., 29.10.2020., 04.12.2020.) N47°35'34.8" E19°21'59.5"
7. wet soil (07.09.2020., 27.10.2020.) N47°35'37" E19°22'04"
8. shady artificial stone, lawn, concrete, bark (07.09.2020., 29.10.2020., 04.12.2020.) N47°35'36" E19°22'05.8"
9. dry sandy soil, artificial stone, concrete (07.09.2020., 04.12.2020.) N47°35'34" E19°22'06"
10. shady soil, artificial stone, decayed wood, bark (07.09.2020., 04.12.2020.) N47°35'34.8" E19°21'59.5"
11. shady soil, limestone, slate roof, decayed wood, bark (07.09.2020., 04.12.2020.) N47°35'32" E19°22'04"
12. shady soil, decayed wood, bark (07.09.2020., 29.10.2020., 04.12.2020.) N47°35'33" E19°22'02"

RESULTS AND DISCUSSION

List of species

Identified taxa are listed in alphabetical order with liverworts and mosses listed separately. The name of species and author is followed by the endangered status of the taxa, which categories are given on the basis of the current Hungarian Red List (Papp *et al.* 2010): LC – least concern; LC-att – least concern attention; NT – near threatened. This is followed by the locality of the species within the research area and the specification of the substrate.

Marchantiophyta

Frullania dilatata (L.) Dumort – LC – 1: bark of *Alnus glutinosa*

Porella platyphylla (L.) Pfeiff. – LC – 10: bark of *Acer platanoides*

Radula complanata (L.) Dumort – LC – 6: bark of *Acer platanoides*

Bryophyta

Abietinella abietina (Hedw.) M. Fleisch. – LC – 6: disturbed soil

Amblystegium serpens (Hedw.) Schimp. – LC – 1: wet rock, 2: bark of *Acer platanoides*, 3: limestone, 4: sandy soil in greenhouse, 7: wet soil, 9: bark of *Quercus petraea*, 10: artificial stone; 11, 12: soil

Atrichum undulatum (Hedw.) P. Beauv. – LC – 9, 10: soil

Barbula unguiculata Hedw. – LC – 1: artificial stone; 3: gravelly soil

Brachythecium albicans (Hedw.) Schimp. – LC-att – 7: wet soil

Brachythecium glareosum (Bruch ex Spruce) Schimp. – NT – 4: sandy soil in greenhouse

Brachythecium mildeanum (Schimp.) Schimp. – LC-att – 7: wet soil

Brachythecium rivulare Schimp. – LC-att – 1, 9: shady soil, 7: wet soil

Brachythecium rutabulum (Hedw.) Schimp. – LC – 1, 2, 5, 6, 8, 10, 11, 12: soil; 7: wet soil

Brachythecium salebrosum (Hoffm. ex F. Weber & D. Mohr) Schimp. – LC – 7: wet soil; 9: bark of *Quercus petraea*

Bryoerythrophyllum recurvirostrum (Hedw.) P.C. Chen – LC-att – 2: limestone

- Bryum argenteum** Hedw. – LC – 1, 8, 9, 11: artificial stone; 3: gravelly soil
- Bryum dichotomum** Hedw. – LC – 5: soil
- Calliergonella cuspidata** (Mitt.) Loeske – LC – 1: soil; 7: wet soil
- Ceratodon purpureus** (Hedw.) Brid. – LC – 1, 5, 10: soil and artificial stone
- Climacium dendroides** (Hedw.) F. Weber & D. Mohr – LC-att – 6: disturbed soil
- Dicranella howei** Renauld & Cardot – NT – 10: soil
- Dicranella varia** (Hedw.) Schimp. – LC – 1, 5, 8: soil
- Dicranum montanum** Hedw. – LC – 10: decayed *Quercus petraea*
- Dicranum tauricum** Sappegin – LC – 10: decayed *Quercus petraea*
- Didymodon acutus** (Brid.) K. Saito – LC-att – 2: limestone
- Didymodon insulanus** (De Not.) M.O. Hill – NT – 1: limestone
- Didymodon rigidulus** Hedw. – LC-att – 1, 2, 3: limestone
- Didymodon tophaceus** (Brid.) Lisa – LC-att – 1: soil; 3: gravelly soil
- Drepanocladus aduncus** (Hedw.) Warnst. – LC – 7: wet soil
- Fissidens taxifolius** Hedw. – LC – 1, 3: soil
- Fissidens viridulus** (Sw.) Wahlenb. – NT – 8: soil
- Grimmia pulvinata** (Hedw.) Sm. – LC – 1, 3: limestone; 5, 10: artificial stone
- Homalothecium lutescens** (Hedw.) H. Rob. – LC – 8: soil
- Homalothecium sericeum** (Hedw.) Schimp. – LC – 2, 3: limestone; 8: artificial stone
- Homomallium incurvatum** (Schrad. ex Brid.) Loeske – LC – 2, 3: limestone; 10: artificial stone
- Hygroamblystegium varium** (Hedw.) Mönk. – LC-att – 7: wet soil
- Hypnum cupressiforme** Hedw. – LC – 1: bark of *Magnolia x soulangeana*; 2, 3: limestone; 7: wet soil; 8,11: soil; 10: artificial
- Leptodictyum riparium** (Hedw.) Warnst. – LC – 1: soil, limestone
- Leskea polycarpa** Hedw. – LC – 1: bark of *Magnolia x soulangeana*; 6: bark of *Sophora japonica*
- Lewinskya affinis** (Schrad. ex Brid.) F. Lara, Garielleti & Goffinet – LC – 1: bark of *Magnolia x soulangeana*; 9: bark of *Quercus petraea*
- Lewinskya speciosa** (Nees) F. Lara, Garilleti & Goffinet – LC-att – 12: bark of *Quercus petraea*
- Nyholmiella obtusifolia** (Brid.) Holmen & E. Warncke – NT – 1: bark of *Magnolia x soulangeana*; 6: bark of *Acer platanoides*

- Orthotrichum anomalum*** Hedw. – LC – 2: limestone; 6: bark of *Acer platanoides*
- Orthotrichum cupulatum*** Brid. – LC-att – 2: limestone
- Orthotrichum diaphanum*** Brid. – LC – 1: limestone; 10: artificial stone
- Oxyrrhynchium hians*** (Hedw.) Loeske – LC – 1, 2, 11, 12: soil; 7: wet soil
- Plagiomnium cuspidatum*** (Hedw.) T.J. Kop. – LC – 1, 9: soil; 3: limestone; 9: bark of *Quercus petraea*
- Plagiomnium rostratum*** (Schrad.) T.J. Kop. – LC – 3: soil
- Plagiomnium undulatum*** (Hedw.) T.J. Kop. – LC – 1, 9, 10, 12: soil; 7: wet soil
- Platygyrium repens*** (Brid.) Schimp. – LC – 1: bark of *Magnolia x soulangeana*; 9: bark of *Quercus petraea*
- Pseudanomodon attenuatus*** (Limpr.) Ignatov & Fedosov – LC – 12: decayed *Quercus petraea*
- Pseudocrossidium hornschuchianum*** (Schultz) R.H. Zander – LC – 3: soil
- Pseudoleskeella nervosa*** (Brid.) Nyholm – LC – 1: bark of *Alnus glutinosa*
- Ptychostomum capillare*** (Hedw.) Holyoak & N. Pedersen – LC – 1: bark of *Alnus glutinosa*
- Ptychostomum imbricatum*** (Müll.Hal.) Holyoak & N. Pedersen – LC – 1: soil
- Ptychostomum moravicum*** (Podp.) Ros & Mazimpaka – LC – 2: bark of *Acer platanoides*
- Pulvigerella lyellii*** (Hook. & Taylor) Plášek, Sawicki & Ochyra – LC – 1: bark of *Magnolia x soulangeana*; 2: bark of *Paulownia tomentosa*; 6: bark of *Sophora japonica*
- Pylaisia polyantha*** (Hedw.) Schimp. – LC – 2: bark of *Paulownia tomentosa*; 6: bark of *Sophora japonica*
- Rhytidiadelphus squarrosus*** (Hedw.) Warnst. – LC – 1, 5: soil
- Schistidium crassipilum*** H. H. Blom – LC – 2: limestone; 10: artificial stone
- Schistidium elegantulum*** H. H. Blom – LC-att – 2, 11: limestone
- Sciuro-hypnum populeum*** (Hedw.) Ignatov & Huttunen – LC – 1: soil; 11: limestone
- Syntrichia papillosa*** (Wilson) Jur. – LC-att – 1: bark of *Magnolia x soulangeana*

Syntrichia ruralis (Hedw.) F. Weber & D. Mohr – LC – 1: bark of *Magnolia x soulangeana*; 2: bark of *Paulownia tomentosa*; 5, 10: artificial stone

Syntrichia virescens (De Not.) Ochyra – LC-att – 2: bark of *Paulownia tomentosa*; 6: bark of *Sophora japonica*

Thuidium assimile (Mitt.) A.Jaeger – LC – 8, 9: soil

Tortella squarrosa (Brid.) Limpr. – LC – 6, 8: lawn

Tortula acaulon (With.) R.H.Zander – LC – 6, 8: disturbed soil

Tortula caucasica Broth. – LC-att – 8: soil

Tortula muralis Hedw. – LC – 1, 2, 3: limestone; 5, 10: artificial stone

Bryophyte diversity

During the research, 69 species of bryophytes (3 species of liverworts and 66 mosses) were found. These species belong to 24 families and 44 genera (Figure 2). Among the reported families the most numerous in terms of the species number were *Pottiaceae* (14 taxa) and *Brachytheciaceae* (10 taxa).

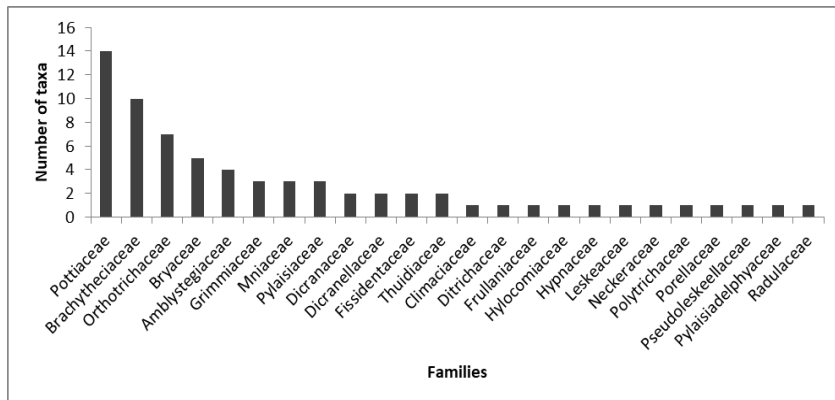


Figure 2. Distribution of bryophyte species found in the Gödöllő Botanical Garden among families (Taxonomy follows Hodgetts *et al.* 2020).

Many of the common mosses of the Gödöllő Botanical Garden can be found in the most Hungarian botanical gardens, for example: *Amblystegium serpens*, *Barbula unguiculata*, *Brachythecium rutabulum*, *B. salebrosum*, *Bryum argenteum*, *Calliergonella cuspidata*, *Ceratodon purpureus*, *Fissidens taxifolius*, *Grimmia pulvinata*, *Homalothecium lutescens*, *H. sericeum*, *Hypnum*

cupressiforme, *Leskea polycarpa*, *Lewinskya affinis*, *Orthotrichum diaphanum*, *Oxyrrhynchium hians*, *Plagiomnium cuspidatum*, *Syntrichia ruralis*, *Tortula muralis*.

There are 5 taxa in Gödöllő Botanical Garden, which are not known from other botanical gardens in Hungary: *Brachythecium mildeanum*, *Dicranum montanum*, *D. tauricum*, *Didymodon tophaceus*, *Fissidens viridulus*.

Compared to the studied areas, this research area shows the least common species with the Arboretum of Agostyán (20 taxa), while the most with the Arboretum of Vácrátót (54 taxa) bryophyte flora. The Arboretum of Erdőtelek shows the greatest similarity in species composition with this research area (highest Sørensen index of 0,6).

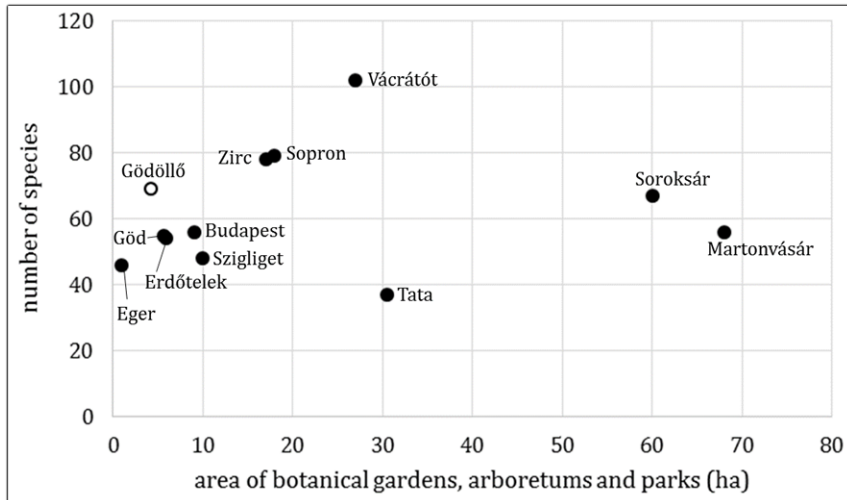


Figure 3. Comparison of arboretums, botanical gardens and manor parks by species number in Hungary. Comparative data were obtained from the following sources: Martonvásár (Nagy *et al.* 2016), Soroksár (Németh and Papp 2016), Agostyán (Tata) (Szűcs 2009), Vácrátót (Vajda 1954, Palotai 2018), Zirc (Galambos 1992, Szűcs 2013), Sopron (Szűcs 2017), Szigliget (Vajda 1968), Budapest (Rigó *et al.* 2019), Eger (Szűcs *et al.* 2017), Erdőtelek (Szűcs and Fintha 2019), Göd (Fintha *et al.* 2020).

It is a typical trend that the larger the garden, the greater the number of species. The deviation from this is remarkable in Soroksár and Martonvásár characterized by large area and low number of species as well as in Tata (Agostyán). However the latter

is also due to the fact that the entire bryophyte flora the Agostyán Arboretum has not yet been studied. The Gödöllő Botanical Garden, with its 4.3 hectares and 69 bryophytes, also differs from the trend, because the number of bryoflora species is outstandingly high compared to other gardens of similar size (Figure 3).

Life strategies

There is a remarkable difference between Gödöllő Botanical Garden and the Arboretum of Erdőtelek concerning the percentage of species in each of the life strategy categories (Dierßen 2001). Gödöllő Botanical Garden is more abundant in colonists and perennials, and less abundant in annual shuttle and long-lived shuttle species. None of the bryophytes in Gödöllő Botanical Garden belong to the fugitive category (Figure 4).

A possible explanation for this rate is the existence of constant and optimal conditions in the garden and plenty of natural rock surfaces, tree bark and open grassland are available for bryophytes, but disturbed substrates are rare in the study area.

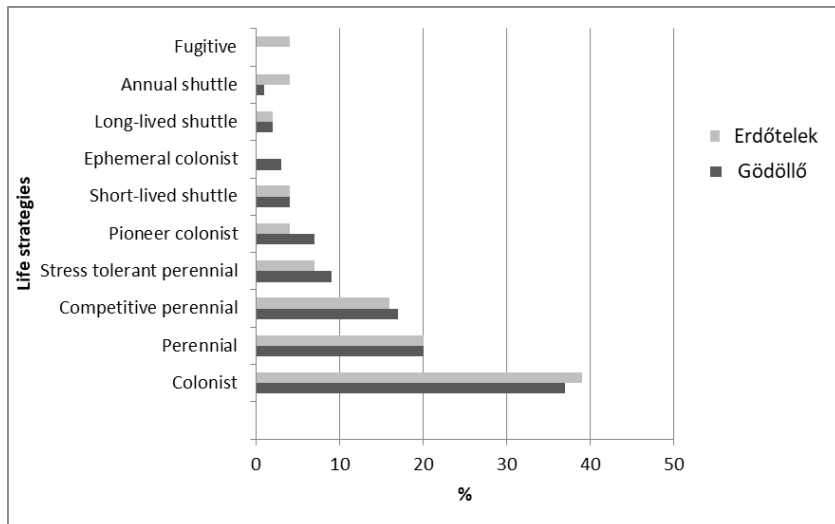


Figure 4. Comparison of the life strategies of bryophytes in Arboretum of Erdőtelek (Szúcs and Fintha 2019) and Gödöllő Botanical Garden (present study).

Types of habitats

During the research we distinguished five types of habitats covered by bryophytes: epigeic, epilithic, epiphytic, epixylic and aquatic.

Most species were found on epigeic (44%) and epilithic habitats. Due to four artificially created wetlands, 25% of the species identified in the area were also found in aquatic habitats: *Amblystegium serpens*, *Brachythecium albicans*, *B. mildeanum*, *B. rivulare*, *B. rutabulum*, *B. salebrosum*, *Calliergonella cuspidata*, *Drepanocladus aduncus*, *Hygroamblystegium varium*, *Hypnum cupressiforme*, *Leptodictyum riparium*, *Oxyrrhynchium hians*, *Plagiomnium cuspidatum*, *P. undulatum*.

Due to the fact that many tree species occur in the garden most diverse habitat types among the reported ones was the epiphytic one, this type includes: *Acer platanoides*, *Quercus petraea*, *Magnolia* sp., *Paulownia tomentosa*, *Sophora japonica*, *Alnus glutinosa*. Bryophytes that prefer these substrates can be classified into the following families: *Frullaniaceae*, *Leskeaceae*, *Orthotrichaceae*, *Pottiaceae*, *Radulaceae*.

Despite the occurrence of many stumps and decaying wood lying in the relict forest stand, the smallest number of species was found here: *Dicranum montanum*, *D. tauricum*, *Lewinskya affinis*, *Orthotrichum anomalum*, *Plagiomnium cuspidatum*.

Most species are found on multiple substrates within the same habitat, but some taxa occur in only one place in the garden. Species registered from only one place are: *Atrichum undulatum* in the education trail, *Drepanocladus aduncus* in the upper pond and *Plagiomnium rostratum* on soil near the entrance, *Pseudanomodon attenuatus*, *Dicranum montanum* and *D. tauricum* in decayed *Quercus petraea*.

The species that occupy the largest space in the garden are non-specialist terricolous taxa: *Abietinella abietina*, *Atrichum undulatum*, *Calliergonella cuspidata*, *Plagiomnium cuspidatum*, *P. undulatum*, *Rhytidiadelphus squarrosus* and *Thuidium assimile*.

CONCLUSIONS

Despite of the small size this garden has a remarkable bryophyte diversity. The rich bryophyte flora can be partly explained by the presence of different habitats, the abundance of old and diverse deciduous trees and the presence of artificially created wetlands. Consequently, in semi-urban ecosystems, this botanical garden like green areas, is an important refuge for bryological diversity.

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