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EPIPHYTIC BRYOPHYTES IN LATVIAN MANOR PARKS

ЭПИФИТНЫЕ МОХООБРАЗНЫЕ УСАДЕБНЫХ ПАРКОВ ЛАТВИИ

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Summary

The present study is a compilation of epiphytic bryophyte data in 20 Latvian manor parks with a focus on epiphytic bryophyte geographical distribution on trees. In total, we found 42 epiphytic bryophyte species on 16 tree taxa. Epiphytic bryophyte species composition was more similar between regions than between trees.

Резюме

Представлены результаты изучения видового состава эпифитных мхов и печеночников в 20 усадебных парках Латвии, расположенных в четырех географических регионах, отличающихся климатическими особенностями. Выявлено 42 видов мохообразных на деревьях 16 видов. Показано, что видовой состав эпифитов определяется региональными особенностями в большей степени, чем произрастанием на той или иной древесной породе.

KEYWORDS: biogeography, distribution, mosses, liverworts, trees

INTRODUCTION

As human population continues to increase in rural areas, it becomes more and more important to maintain the biodiversity of urban habitats (Fudali & Żołnierz, 2019; Großmann et al., 2020; Truchan & Sobisz, 2015). Manor parks belong to a group of urban habitats which are not only historically important as parks but which also play an important role in biodiversity maintanance and nature conservation (Liira et al., 2012; Truchan & Sobisz, 2015). One important biodiversity element in manor parks is the presence of different species of trees (Nutt et al., 2013) which are important hosts for epiphytes (Lõhmus & Liira, 2013; Liira et al., 2020). Epiphytic bryophytes significantly contribute to urban park epiphyte diversity (McDonald et al., 2017) and therefore are often used as urban area bioindicators (Oishi & Hiura, 2017).

Although urban habitats play an important role in epiphytic bryophyte conservation (Fudali & Żołnierz, 2019; Sabovljević & Grdović, 2009), knowledge about the importance of manor parks in epiphytic bryophyte conservation is limited (Popova, 2017; Popova, 2020).

In total 4806 dendrological plantings have been registered in Latvia, including also manor parks (Laiviņš, 2009). Manor parks are important rural landscape elements in Latvia, where they began to be created in the 16th century due to the development of manors (Janelis, 2010). The knowledge about epiphytic bryophytes in manor parks in Latvia is based mostly on general observation of bioindication (Āboliņa & Bambe, 2010) and research on epiphytes in Lūznava manor park (Mežaka & Kirillova, 2019), but studies on epiphytic bryophytes in general and in different geographical regions in Latvia, are missing.

Latvian flora has many biogeographical differences. Latvia is divided into eight geobotanical units based on the characteristics of regional vegetation shaped by various factors: soil, site geology, climate and human management activities (Kabucis, 1995). However, not all plant groups fit easily into the geobotanical units. For example, woody plant biogeographical distribution is found across western, central and eastern Latvian zones (Neilande, 1999), and differences exist in the geographical distribution of several bryophyte species in western and eastern parts of Latvia (Āboliņa, 1968). Still, there is a gap in research focused on the biogeographical aspects of bryophytes.

The aim of this study is to evaluate epiphytic bryophyte distribution in Latvian manor parks. The study objectives are: 1) to evaluate the overall number of epiphytic bryophyte species in Latvian manor parks; 2) to compare epiphytic bryophyte species composition dissimilarity between four geographical regions and host species; and 3) and to evaluate the importance of the region and host in epiphytic bryophyte distribution in Latvian manor parks.

MATERIALS AND METHODS

Study area

The average annual temperature in Latvia is +6.4 °C. The warmest month is July, with an average temperature

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Table 1. Climatic parameters in Latvia and in different regions.

Climatic parameter	Latvia	Region			
		Kurzeme	Zemgale	Vidzeme	Latgale
Average annual temperature (°C)	+6.4	+6.5	+6.3	+5.7	+5.6
Average temperature in July (°C)	+17.4	+16.6	+17.4	+17.2	+17.2
Average temperature in February (°C)	-3.7	-3.3	-4.0	-5.4	-5.8
Annual rainfall (mm)	692	732	650	700	629

+17.4 °C, and the coolest month is February, with average temperature -3.7 °C. The annual rainfall in Latvia is 692 mm (Table 1). The climate differs by region. The highest average annual temperature of +6.5°C and highest amount of annual rainfall 732 mm were recorded in Kurzeme (Latvijas vides, ģeoloģijas un meteoroloģijas centrs. 2020. Latvijas klimats. https://www.meteo.lv/lapas/laiks/latvijas-klimats/latvijas-klimats?id=1199&nid=562).

The study was conducted in 20 Latvian manor parks (Figs. 1, 2) created from the 16th-19th century. The area of the studied manor parks varied from1.28 ha to 39.34 ha. All selected manor parks are open to the public and are maintained using traditional management activities (e.g. gardening). The selected manor parks are located far from active factory pollution (Latvijas piļu un muižu asociācija. 2014. Muižas un pilis. http://www.pilis.lv/lv/pilis-un-muizas), but we assume that traffic pollution is similar among the studied parks.

The manor parks were selected randomly to represent equally each of the four culturally and geographically different regions of Latvia (five manor parks in each region): Latgale (Eastern Latvia), Vidzeme (North-Central Latvia), Zemgale (South-Central Latvia) and Kurzeme (Western Latvia) (Fig. 1).

Field work

We studied epiphytic bryophytes until 2 m in height on 20 tree individuals (hosts) with a minimal DBH of more than 0.10 m in each manor park during May-August 2020. A sufficient number of hosts was selected for statistical analysis. The hosts were selected in 20x20 m sample plots, a plot size suggested for studies in forest habitats (Kent, 2012) which can also pertain to manor parks. We chose sample plots in the most typical parts of the parks, with big trees and less human influence. As most of Latvian manor parks are located in flat areas, we avoided ravines within manor parks for the purposes of comparing sample plots. If a sample plot contained less than 20 tree individuals, we made another sample plot nearby.

Epiphytic bryophyte and host taxa were identified to species or genus level. Bryophyte taxa names follow Hodgetts et al. (2020); woodland key habitat indicator species follow Ek et al. (2002); bryophyte red-list status follow Āboliņa (1994); protected species (legal conservation) status follow Latvijas Republikas Ministru kabinets. [2000. Noteikumi par īpaši aizsargājamo sugu un ierobežoti izmantojamo īpaši aizsargājamo sugu sarakstu. Noteikumi nr. 396. *Latvijas Vēstnesis.* 17.11.2000, 413/417: 4-6. (grozījumi 27.07.2004 not. nr. 627)]; and

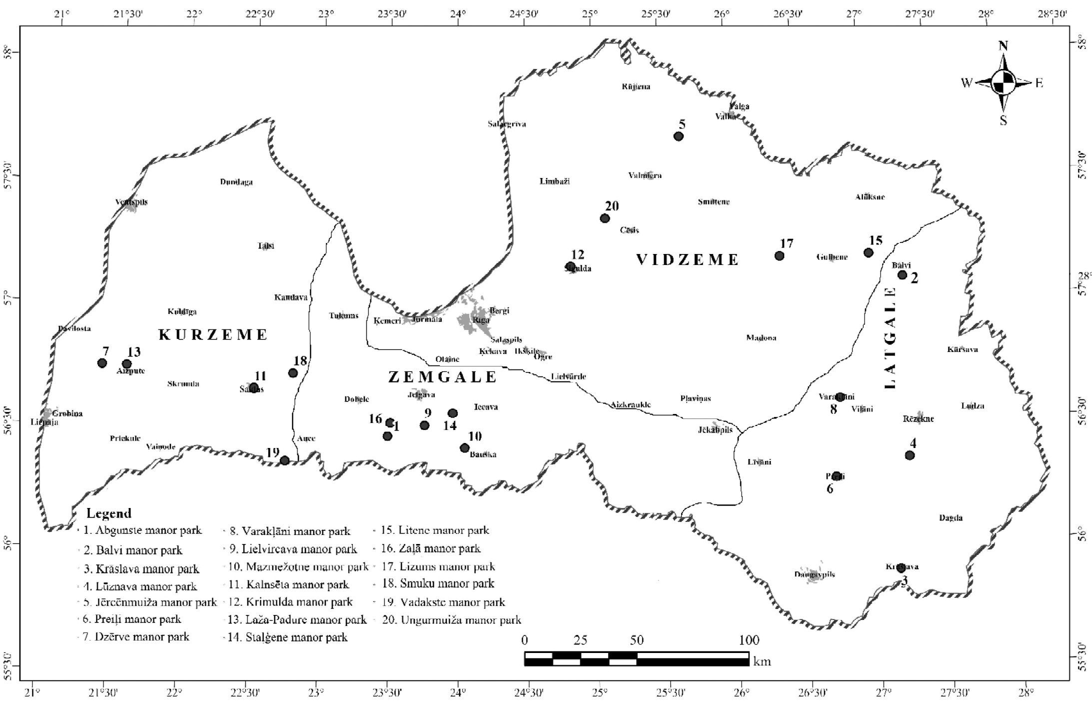

Fig. 1. Studied manor parks. Each numbered point denotes a particular manor park. Titles indicate the biggest cities and the four regions (Latgale, Vidzeme, Zemgale, Kurzeme).

Fig. 2. Studied site in Litene manor park (Photo: A. Mežaka).

tree taxa follow Laiviņš (2009). Rare species in this article are defined as all bryophyte species with conservation status in one of the following categories: woodland key habitat (WKH) indicator species; red-listed species; and specially protected species.

Data analysis

In our analysis, because bryophytes were absent on only three trees, we used epiphytic bryophyte presence/absence data on 397 trees. To evaluate the dissimilarity of epiphytic bryophyte species composition (beta diversity) between four studied regions and host individuals, we used dissimilarity analysis (Baselga et al., 2020).

To understand how the region and host species are shaping total and rare epiphytic bryophyte number of species, we applied generalized linear mixed model (GLMM) with poisson family. In GLMM, the region and tree species were fixed effects while the site (20 manor parks) was a random effect.

Dissimilarity analysis was conducted using Betapart package (Baselga et al., 2020), GLMM was applied with a lme4 package (Bates et al., 2015) and significance of each variable was calculated with the ANOVA function using 'car' package (Fox & Weisberg, 2019) in R programme 4.0.3 (https://www.R-project.org/).

RESULTS

In total, we identified 42 epiphytic bryophyte taxa on 16 host taxa (Table 2). Most tree species overlap across regions. The most common host taxa was *Tilia cordata*, whereas the most common epiphytic bryophyte species were mosses *Hypnum cupressiforme, Leucodon sciuroides* and liverwort *Radula complanata*. Nine of the bryophyte taxa were rare species, including seven WKH indicator species, five red-listed species and three specially protected species. *Anomodon longifolius* was the most common WKH indicator species. Four of the red-listed species (*Metzgeria furcata, Neckera complanata, Neckera pennata, Pulvigera lyellii*) belong to the vulnerable (2nd) category, while one *Porella platyphylla* belongs to the rare (3rd) category of the red-listed species of Latvia. Specially protected species (*Neckera complanata, Porella platyphylla*, *Pulvigera lyellii*) were few in number and found only in eastern and western part of Latvia.

Dissimilarity analysis showed that epiphytic bryophyte species composition is more similar between regions (total dissimilarity 0.24±0.03) than between host individuals (total dissimilarity 0.59±0.20). However, we found some epiphytic bryophyte species preference for a particular region. For example, *Pulvigera lyellii* was found in western and eastern part of Latvia, while *Orthotrichum diaphanum* was found in south-central and southwestern parts of Latvia. The liverworts *Frullania dilatata* and *Porella platyphylla* were found only in western part of Latvia.

The average number of rare and total number of epiphytic bryophytes per host individual did not differ significantly among studied regions (Fig. 3, Table 3). Host species significantly affected the total number of epiphytic bryophyte species (Table. 3).

Table 2. Epiphytic bryophytes on trees in four studied regions. Numbers are tree individuals.

Bryophyte taxa	Region				Tree taxa															
	L	V	Z	K	Ag	Ap	Bp	Cb	Fe	Fg	Ld	Ps	Qr	Tc	To	Tp	Ts	Tv	Ug	Ul
Amblystegium serpens	60	32	12	25	0	34	0	0	10	3	0	2	9	50	0	2	0	0	14	5
Anomodon attenuatus[1]	0	1	0	7	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Anomodon longifolius[1]	6	6	5	17	0	11	1	0	1	0	0	1	1	16	0	0	0	0	1	2
Anomodon viticulosus[1]	0	6	7	11	0	9	1	0	1	0	0	0	1	12	0	0	0	0	0	0
Brachytheciastrum velutinum	1	1	2	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1
Brachythecium rutabulum	24	5	6	27	0	14	0	0	5	1	0	0	5	18	1	3	0	0	8	7
Brachythecium salebrosum	7	4	5	5	0	8	0	0	2	0	0	0	1	9	0	0	0	0	1	0
Dicranum montanum	3	5	0	1	0	0	1	0	1	0	2	1	2	2	0	0	0	0	0	0
Frullania dilatata	0	0	0	13	0	2	0	0	1	1	0	0	0	9	0	0	0	0	0	0
Homalothecium sericeum	0	3	3	15	0	3	0	0	1	1	0	2	0	11	0	2	0	0	0	1
Homalia trichomanoides[1]	12	6	3	1	0	5	0	0	2	0	0	1	3	9	0	0	0	0	0	2
Hygroamblystegium varium	3	0	0	2	0	2	0	0	0	1	0	0	0	0	0	1	0	0	1	0
Hypnum cupressiforme	64	97	62	87	2	65	2	4	17	4	5	7	35	138	1	5	2	0	14	9
Leskea polycarpa	0	0	37	15	0	17	0	3	8	0	0	1	0	21	0	0	0	0	1	1
Leucodon sciuroides	61	65	66	91	2	89	2	0	22	4	0	7	18	108	0	5	2	0	15	9
Metzgeria furcata[1, 2]	3	0	0	15	0	3	0	0	0	3	0	1	0	8	0	2	0	0	0	1
Neckera complanata[1, 2, P]	0	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Neckera pennata[1, 2]	8	2	0	1	0	4	0	0	0	0	0	0	0	5	0	0	0	0	1	1
Nyholmiella obtusifolia	4	0	10	3	0	8	0	0	4	0	0	1	0	1	2	0	0	1	0	0
Orthotrichum affine	16	6	44	25	1	34	0	2	13	3	0	4	5	23	1	3	0	1	1	0
Orthotrichum diaphanum	0	0	7	1	0	1	0	0	1	0	0	0	0	2	3	0	0	1	0	0
Orthotrichum pallens	28	0	0	0	0	4	0	0	5	0	0	0	0	7	0	0	1	0	7	4
Orthotrichum speciosum	17	10	6	22	0	20	1	0	6	1	0	0	6	17	1	0	0	0	2	1
Orthotrichum sp.	6	0	0	1	1	1	0	0	1	0	0	0	0	2	0	0	1	0	1	0
Oxyrrhynchium hians	1	0	6	6	0	7	0	0	2	0	0	0	0	3	0	0	0	0	1	0
Plagiomnium cuspidatum	2	1	2	5	0	6	0	0	1	0	0	0	0	3	0	0	0	0	0	0
Plagiomnium undulatum	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Platygyrium repens	9	18	3	3	1	4	0	0	1	0	3	1	13	9	0	0	0	0	0	1
Pleurozium schreberi	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Porella platyphylla[3, P]	0	0	0	4	0	0	0	1	0	0	0	0	0	2	0	1	0	0	0	0
Pseudoamblystegium subtile	16	3	13	15	0	24	0	0	4	0	0	3	1	13	0	0	0	0	1	1
Pseudoleskeella nervosa	56	53	27	16	0	44	1	1	10	0	0	2	17	56	3	1	2	0	12	3
Ptychostomum moravicum	7	2	4	2	0	1	0	0	4	1	0	1	2	5	0	0	1	0	0	0
Pulvigera lyellii[2, P]	1	0	0	2	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Pylaisia polyantha	67	18	59	30	0	54	1	2	19	0	0	8	5	62	3	2	1	0	12	5
Sanionia uncinata	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Sciuro-hypnum oedipodium	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Sciuro-hypnum populeum	26	9	0	2	0	8	0	0	2	0	0	0	5	10	0	0	0	0	6	6
Sciuro-hypnum reflexum	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Syntrichia ruralis	0	0	0	3	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Syntrichia virescens	0	4	23	8	0	13	0	0	7	0	0	2	3	8	2	0	0	0	0	0
Radula complanata	75	54	57	62	2	56	1	1	19	4	0	7	6	121	0	5	2	0	16	8
Total number of species	29	27	24	37	6	33	9	8	29	12	3	18	21	38	9	13	8	3	19	20

Explanations: L: Latgale; V: Vidzeme; Z: Zemgale; K: Kurzeme; Tree taxa (number of individuals and regions; host found in brackets) Ag: *Alnus glutinosa* (2, K), Ap: *Acer platanodes* (107, K, Z, V, L); Bp: *Betula pendula* (2, K); Cp: *Carpinus betulus* (5, Z, K); Fe:*Fraxinus excelsior* (28, K, Z, L); Fg: *Fagus grandifolia* (4, K); Ld: *Larix decidua* (5, K, Z, V); Ps: *Populus* sp. (9, L, Z); Qr: *Quercus robur* (35, K, V, L); Tc: *Tilia cordata* (158, K, Z, V, L); To: *Thuja occidentalis* (5, Z); Tp: *Tilia platyphyllos* (5, K); Ts: *Tilia* sp. (2, L); T: *Tilia* x *vulgaris* (1, Z); Ug: *Ulmus glabra* (20, K, Z, L); Ul: *Ulmus laevis* (9, K, L); I: woodland key habitat indicator species: 2 (vulnerable), 3 (rare), red-listed species in Latvia; P: specially protected species in Latvia.

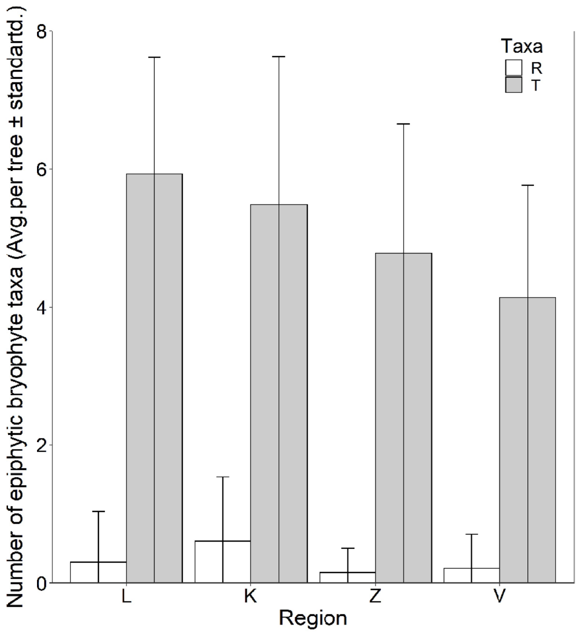

Fig. 3. The number of epiphytic bryophyte taxa in studied regions. L: Latgale, K: Kurzeme, Z: Zemgale, V: Vidzeme. R: rare bryophyte taxa (woodland key habitat indicator species, specially protected species and Red-listed species in Latvia); T: all bryophyte taxa.

Discussion

We found similar epiphytic bryophyte species composition (at least half of the total number of bryophyte species in Latvian manor parks) as in manor parks of Belgorod (Popova, 2017), Saratov (Popova, 2020), Tambov (Popova, 2019) and in Voronezh oblast in Russia (Popova, 2018).

However, we found relatively more epiphytic bryophyte species in Latvian manor parks compared to other regions studied in Russia. We found 42 epiphytic bryophyte species compared to Popova (2017), who found 32 in Belgorod oblast, 35 epiphytic bryophyte species in 50 manor parks in Voronezh oblast (Popova, 2018), 28 epiphytic bryophyte species in 36 manor parks in Tambov oblast (Popova, 2019) and only 24 epiphytic bryophyte species in 24 Saratov manor parks (Popova, 2020). We likely found more bryophyte species because annual rainfall (692 mm) is higher in Latvia than in Belgorod (572 mm Belgorod climate. https://en.climate-data.org/asia/russian-federation/belgorod-oblast/belgorod-927919/), Saratov (430 mm, Saratov climate. https://en.climate-data.org/asia/russian-federation/saratov-oblast/saratov-467/), Tambov (540 mm, Tambov climate. https://en.climate-data.org/asia/russian-federation/tambov-oblast/tambov-1815/) and Voronezh oblast (567 mm, Voronezh climate. https://en.climate-data.org/asia/russian-federation/voronezh-oblast/voronezh-468/) in Russia. Therefore, humidity is among the main factors which shapes epiphytic bryophyte distribution (Barkman, 1958).

Similar to our study, *Leucodon sciuroides* and *Radula complanata* were also among the most common bryophytes found in rural parks in Estonia (Lõhmus & Liira, 2013).

We found small epiphytic bryophyte species composition dissimilarity between the studied regions. With few exceptions, most of the studied species were found in all study regions. Previously, *Pulvigera lyellii* was found only in western part of Latvia (Āboliņa, 1968), but we also found this species in eastern part of Latvia, possibly indicating that *Pulvigera lyelii* shows higher affinity to the microclimate of a particular site than to a particular region. *Orthotrichum diaphanum* was noted before as a rare species in Latvia, found only in the Zemgale region (Āboliņa, 1968), but we found it also in Kurzeme. The liverworts *Frullania dilatata* and *Porella platyphylla* were found only in western part of Latvia, but this might be explained by greater precipitation in Kurzeme than in other regions (Avotniece et al., 2017). More precipitation ensures longer periods of humidity in manor parks. *Frullania dilatata* is widespread in semi-natural deciduous forests in Latvia (Gerra-Inohosa, 2018), where we assume that there is more consistent air humidity than in more open spaces such as manor parks.

Total epiphytic species dissimilarity was found to be rather high between hosts, likely related to different host species composition in a particular manor park. However, each manor park has some host species in common with other manor parks. At a regional level, these differences decrease because most of the host species are the same in all four regions. The importance of host species in epiphytic bryophyte distribution is well established (Barkman, 1958).

The present study adds to our knowledge about epiphytic bryophyte distribution in Latvian manor parks. We assume that similar epiphytic bryophyte communities are also distributed in manor parks of other parts of Europe. We recommend future studies of epiphyte dependence on microclimatic conditions in different manor parks.

Table 3. Evaluation of the effects of (1) region and (2) host tree species on the total number of bryophyte species and number of rare bryophyte species according to generalized linear mixed model, applied to the data from 20 manor parks in four regions of Latvia. Chi-square test value (Chisq) and Significance (P) shows that host species influence total number of bryophyte species significantly.

	Chisq	P
Total		
Region	8.03	0.05
Host species	27.94	0.02*
Rare		
Region	0.92	0.82
Host species	9.95	0.82

CONCLUSIONS

The study results show that manor parks in Latvia ensure rather high epiphytic bryophyte species diversity and also play an important role in rare bryophyte conservation. We found that the particular region is not significant for overall epiphytic bryophyte distribution but that regional differences play a role in particular species occurrence. In Latvian manor parks, host species are, in fact, more important than region in epiphytic bryophyte composition.

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