Acta Biol. Univ. Daugavp., Suppl. 2, 2010
ISSN 1407 - 8953

EPIPHYTIC BRYOPHYTE AND LICHEN COMMUNITIES IN RELATION TO TREE AND FOREST STAND VARIABLES IN *POPULUS TREMULA* FORESTS OF SOUTH-EAST LATVIA

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Mežaka A., Brūmelis G., Piterāns A. 2010. Epiphytic bryophyte and lichen communities in relation to tree and forest stand variables in *Populus tremula* forests of south-east Latvia. *Acta Biol. Univ. Daugavp., Suppl. 2: 1 - 8.*

Epiphytic bryophyte and lichen species richness in relation to environmental variables at a tree scale (tree species, DBH, bark pH, inclination) and forest stand scale (forest stand age and area) were evaluated in three *Populus tremula* dominated forest stands in southeast Latvia. In total 71 epiphyte species were found, including four red-listed species and nine WKH indicator species. Forest stand age and area were the most important variables affecting epiphyte species richness. However, differences in the significance of the studied variables were found among total, bryophyte, lichen, signal and red-listed epiphyte species richness. Aspen forests have an important role in the conservation of biodiversity; epiphytic bryophytes and lichens including WKH indicator species and red-listed species.

Key words: epiphytes, bryophytes, lichens, *Populus tremula*, forest stand.

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Introduction

Epiphytic bryophytes and lichens of forest ecosystems are widely used as indicators of forest continuity and naturalness (Ek et al. 2002). They are also part of forest biodiversity, supporting existence of other forest dwelling species as well as ensuring moisture regime and forest ecosystem stability (Glime 2008).

Epiphytes have been much studied in the boreal forest landscape (Snäll et al. 2005, Löbel et al. 2006a, Jüriado 2007). *Populus tremula* is an important key element in the boreal forest and boreo-nemoral forest landscape supporting biodiversity (Hazell et al. 1998, Jüriado et al. 2003, Snäll et al. 2005, Hedenås, Hedström 2007).

Latvia is located in the boreo-nemoral vegetation zone, where nemoral broad leaved forests and boreal coniferous and deciduous forest elements are distributed together in relatively small areas. Epiphytes in broad leaved forests have been studied (Mežaka et al. 2008). However, epiphytes in other types of forests such as aspen *Populus tremula* forests have received little attention.

Aspen forest is one type of woodland key habitat (WKH) inventoried in Latvian state forests. WKH are areas that contain habitat specialists which cannot sustainably survive in forest stands managed for timber production. They are rather specialised species and their very existence shows a certain forest quality (Ek et al. 2002).

In total 2.7% of Latvian forests are aspen forests and 2025 ha of aspen forests are under WKH status. The southeastern part of Latvia is relatively rich in aspen WKH compared with other parts of Latvia (SFS 2003).

Tree species, DBH (diameter at breast height) and bark pH are the most significant factors affecting epiphytic species distribution in the boreo-nemoral landscape (Snäll et al. 2004, Löbel et al. 2006a, Mežaka et al. 2008). Bark roughness also has an impact on epiphyte species distribution (Barkman 1958, Snäll 2004).

The area and age of WKH are significant for red-listed and WKH indicator species existence (Hedenås, Ericson 2000, Gustafsson et al. 2004a). Tree inclination has also been shown to have a significant relationship with epiphytes. Inclination can support epiphyte establishment, up to a threshold where high inclination can decrease epiphyte establishment caused by a decrease in tree vitality or by affecting other epiphytes (Snäll et al. 2004).

The aim of the present study is to characterize epiphytic bryophyte and lichen communities depending on environmental variables in aspen forests of southeast Latvia.

Methods

Studied territories

All of the studied territories are located in southeast Latvia, where a continental climate prevails. The average precipitation in the studied forest stands is 540-560 mm per year.

Epiphytes were studied in three *Populus tremula* dominated forest stands (Tab. 1, Fig.1) – the Microreserve in Tadenava, Augšzeme Protected Landscape Area and Starinas mežs Nature Reserve. The studied territories were selected based on WKH inventory data and personal observations. All studied forest stands correspond to the WKH definition with live trees in different diameters, different tree species, course woody debris and epiphyte indicator species.

Epiphytes were studied on seven deciduous tree species – *Populus tremula, Betula pendula,*

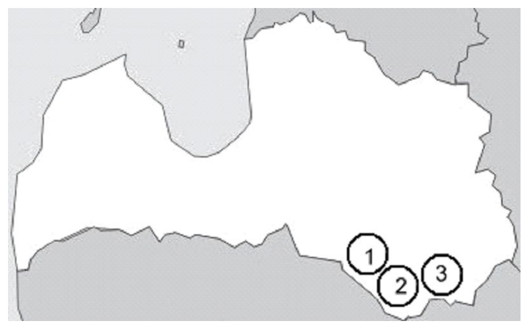

Figure 1. Studied territories. 1 – Microreserve in Tadenava, 2– Augšzeme Protected Landscape Area , 3 – Starinas mežs Nature Reserve.

Table 1. Characteristics of the studied territories

Studied territories	Geographic coordinates	Forest stand area	Forest stand age	Mean tree DBH	Studied tree species
Microreserve in Tadenava	56°11'8.8"N, 26°6'34"E	12.1	78	0.26	*Populus tremula, Tilia cordata, Ulmus glabra, Betula pendula*
Augšzeme protected landscape	55°52'15.4" N, 26°19'7.2"E	3	83	0.38	*Quercus robur, Populus tremula, Betula pendula, Acer platanoides, Sorbus aucuparia, Tilia cordata*
Starinas mežs Nature Reserve	55°49'41.2"N, 27°31'12.8" E	2.2	78	0.25	*Tilia cordata, Populus tremula, Ulmus glabra*

Explanations: DBH – diameter at breast height.

Acer platanoides, Sorbus aucuparia, Quercus robur, Tilia cordata and *Ulmus glabra*.

Field work

Sample plots (20x20m) were established randomly in each territory, with epiphytic bryophytes and lichens studied on 30 trees (DBH>0.1m). A second adjacent sample plot was made in Augšzeme Protected Landscape Area and Starinas mežs Nature Reserve due to an insufficient number of trees in the first sample plot.

Tree diameter, inclination (in degrees and direction of exposure) bark crevice depth (mm) and bark pH at 1.2 height on tree trunks were measured in a northerly direction of exposure for all studied trees. Epiphytic bryophyte and lichen species occurrence were evaluated up to 2m height on tree trunks. Unclear epiphyte species were collected for identification in the laboratory. The epiphytic bryophyte species nomenclature follows (Āboliņa 2001, Hallingbäck, Holmåsen 2000; Smith 1996a; Smith 1996b), and lichen species nomenclature after Piterāns (2001).

Bark pH measurements

Bark pH was measured for 90 samples. Bryophytes and lichens were removed from tree bark before the measurements due to possible influence of pH value. Tree bark samples were cut in pieces (average size of each piece 0.001 g). Each bark sample (0.50 g) was shaken in a 20-ml 1M KCl solution for one hour in 100-ml flasks and pH measurements were made using a pH-meter (GPH 014, Greisinger Electronic).

Data analysis

Data were analysed with Univariate GLM (General linear model) using SPSS Version 15. Response variables were as follows: total number of epiphytic species, number of epiphytic signal species (including WKH indicator species, and Latvian red-listed species), number of bryophyte species, number of bryophyte signal species, number of lichen species, and number of lichen signal species. Explanatory variables were tree species, tree bark depth, tree bark pH, tree inclination, tree height, tree diameter, forest stand age and forest stand area.

The HyperNiche programme was used to derive 3-dimensional nonparametric multiplicative regression models, Version 1.12) with epiphytic bryophyte species richness (response variable – epiphytic bryophyte species richness, predictor variables – tree bark crevice depth and pH).

Results

In total 71 epiphyte species (47 bryophyte species and 24 lichen species) were found. Four of the studied bryophyte species were red-listed in Latvia (Āboliņa 1994, Table 2). Nine bryophyte and four lichen species were WKH indicator species (Ek et al. 2002).

The highest total species richness (51 epiphytic species) and also epiphytic species richness in other species groups (Figure 2) were found in the Microreserve in Tadenava. Epiphytic lichen signal species richness (3 species) were similar in all studied territories.

The most common bryophyte species on trees were *Hypnum cupressiforme* and *Radula*

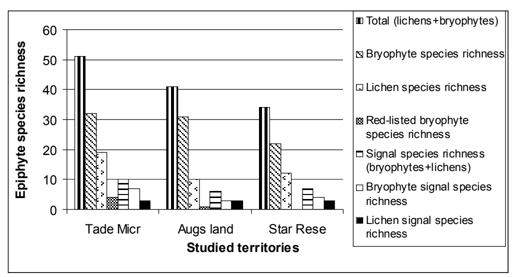

Figure 2. Epiphytic bryophyte and lichen species in the studied territories. Tade Micr – Microreserve in Tadenava, Augs land – Augšzeme Protected Landscape Area, Star Rese – Starinas mežs Nature Reserve. Signal species include all WKH indicator species and red-listed species.

Table 2. Epiphyte species on studied tree species. Number of trees on which species were found are given.

Epiphytes	*Populus tremula (45)*	*Tilia cordata (32)*	*Betula pendula (5)*	*Acer platanoides (4)*	*Ulmus glabra (2)*	*Qurcus robur (1)*	*Sorbus aucuparia (1)*
Bryophytes							
Amblystegium serpens	30	7	1	3	-	-	-
Amblystegium subtile	1	-	-	-	-	-	-
Anomodon longifolius [1]	1	-	-	-	-	-	-
Brachythecium rutabulum	19	10	1	1	-	-	-
Brachythecium oedipopodium	8	6	-	-	-	-	1
Brachythecium populeum	13	2	-	1	-	-	-
Brachythecium salebrosum	8	3	-	-	-	-	1
Brachythecium velutinum	1	-	-	-	-	-	-
Cirriphyllum piliferum	8	3	1	-	-	-	-
Climacium dendroides	1	-	-	-	-	-	-
Dicranum montanum	6	13	4	-	-	-	-
Dicranum scoparium	5	9	1	-	1	-	-
Eurhynchium angusturete	12	15	-	-	1	-	-
Eurhynchium hians	1	-	-	-	-	-	-
Eurhynchium pulchellum	2	-	-	-	-	-	-
Fissidens taxifolius	5	-	-	-	-	-	-
Frullania dilatata	2	-	-	-	-	-	-
Herzogiella seligeri	-	2	-	-	-	-	-
Homalia trichomanoides [1]	31	16	-	1	1	-	-
Hypnum cupressiforme	28	26	3	3	1	1	1
Isothecium alopecuroides [1]	2	-	-	-	-	-	-
Jamesoniella autumnalis [1,2]	-	3	-	-	-	-	-
Jungermannia leiantha [1]	-	7	-	-	-	-	-
Lejeunea cavifolia [1,2]	4	-	-	-	1	-	-
Leucodon sciuroides	-	1	-	-	-	-	-
Lophocolea heterophylla	3	-	1	-	-	-	-
Mnium stellare	2	3	-	-	-	-	-
Neckera complanata [1,2]	1	1	-	-	-	-	-
Neckera pennata [1,2]	12	-	-	-	1	-	-
Orthotrichum affine	24	-	-	1	1	-	-
Plagiochila asplenioides	10	-	-	1	-	-	-
Plagiomnium affine	9	4	-	-	-	-	-
Plagiothecium cavifolium	3	2	-	-	-	-	-
Plagiomnium cuspidatum	7	6	-	1	1	-	-
Plagiothecium denticulatum	1	-	1	-	-	-	-
Plagiochila porelloides	6	5	3	-	1	-	-
Plagiomnium undulatum	4	-	-	-	-	-	-
Plagiothecium laetum	14	8	1	-	-	-	-
Platygyrium repens	16	8	-	-	1	-	-
Pseudoleskeella nervosa	4	1	1	-	-	-	-
Ptilidium pulcherrimum	3	4	-	-	-	-	-
Pylaisia polyantha	4	2	-	-	-	-	-
Radula complanata	36	7	1	4	1	1	1
Rhytidiadelphus triquetrus	3	-	-	-	-	-	-
Rhodobryum roseum	4	1	-	-	1	-	-
Sanionia uncinata	2	-	-	-	-	-	-
Ulota crispa [1]	3	2	-	1	-	-	-

Continuation of Table 2

Epiphytes	*Populus tremula* (45)	*Tilia cordata* (32)	*Betula pendula* (5)	*Acer platanoides* (4)	*Ulmus glabra* (2)	*Qurcus robur* (1)	*Sorbus aucuparia* (1)
Lichens							
Acrocordia gemmata [1]	3	-	-	-	-	-	-
Arthothelium ruanum	-	1	-	-	-	-	-
Arthonia spadicea [1]	1	1	-	-	-	-	-
Arthonia vinosa [1]	-	1	-	-	-	-	-
Bacidia rubella [1]	8	1	-	-	-	-	-
Buellia griseovirens	-	1	-	-	-	-	-
Cladonia coniocraea	16	16	4	-	-	-	1
Graphis scripta [1]	3	31	1	-	-	-	1
Hypogymnia physodes	-	6	1	-	-	1	-
Lecidella euphorea	3	-	-	-	1	-	-
Lecanora carpinea	5	-	-	-	-	-	-
Lecidella elaeochroma	18	27	4	-	1	1	-
Lepraria incana	-	4	-	-	-	-	-
Lecanora subrugosa	1	-	-	-	1	-	-
Melanelia glabratula	2	9	-	1	-	-	-
Melanelia olivacea	-	1	-	-	-	-	-
Opegrapha rufescens	-	2	-	-	-	-	-
Parmelia sulcata	-	1	-	-	-	-	-
Peltigera canina	1	-	-	-	1	-	-
Peltigera praetextata	1	-	-	-	-	-	-
Pertusaria amara	2	13	-	-	-	-	-
Pertusaria leioplaca	-	1	-	-	-	-	-
Phlyctis agelaea [1]	1	-	-	-	-	-	-
Phlyctis argena	35	19	-	4	1	1	1

Explanations: 1 – WKH indicator species, 2 – Latvian red-listed species.

Table 3. Differences in epiphyte species richness depending on studied environmental variables.

Epiphyte species groups	Tree level				Forest stand level	
	DBH	pH	BCD	Tree species	Forest stand age	Forest stand area
Total species richness (bryophytes+lichens)	x	-	-	-	-	x
Signal species richness (bryophytes+lichens)	-	-	-	-	x	x
Bryophyte species richness	-	x	x	-	x	x
Lichen species richness	-	-	-	-	-	x
Lichen signal species richness	-	-	-	x	x	x
Bryophyte signal species richness	-	-	-	-	x	-

Explanations: DBH – tree diameter at breast height, pH – tree bark pH, BCD – tree bark crevice depth. x- factor is significant (Sig.<0.05), - – factor insignificant (Sig.>0.05) Univariate GLM.

complanata, and the most distributed lichen species was *Phlyctis argena* (Table 2). The most common bryophyte signal species was *Homalia trichomanoides*, and lichen species – *Graphis scripta.*

Differences between the studied environmental variables in epiphytic species richness were found. Tree trunk diameter showed a significant relationship only with total epiphytic species richness (Table 3). Tree bark pH and bark crevice depth were significant only for

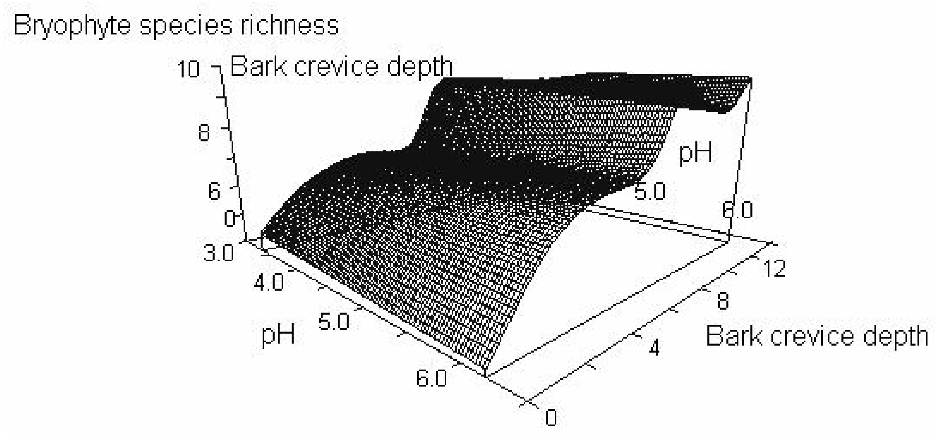

Figure 3. Bryophyte species richness depending on tree bark pH and bark crevice depth (non parametric multiplicative regression model).

epiphytic bryophyte species richness (Table 3, Figure 3). Tree species was a significant variable for epiphytic lichen species richness. Forest stand age and forest stand area were significant factors for most of the epiphyte species richness groups (Table 3).

Discussion

The Microreserve in Tadenava, which was also the largest area, supported the highest epiphytic species richness compared with the two other studied territories. The forest stand size could be one of the reasons for the higher richness, as it would be expected to have more suitable structures, substrates and microclimatic conditions for epiphyte species' long-term existence (Gustafsson et al. 2004b). A strong relationship between species richness and forest stand area could also be explained by metapopulation dynamics (Löbel et al. 2006a).

Total species richness was also affected significantly by DBH. Literature about the significance of DBH on epiphytic species distribution is contradictory. Some studies assign a great role to DBH in epiphyte distribution (Barkman 1958, Hazell et al. 1998, Johansson et al. 2007), while others refute this (Löbel et al. 2006a). DBH is probably significant for more common epiphyte species as there is more space for colonizing on the tree stem, while red-listed species prefer more specific microclimatic conditions. Forest stand area was also a significant factor for red-listed bryophyte and lichen species distribution in boreal Swedish forests (Gustafsson et al. 2004b).

Forest stand age and forest stand area were significant for epiphytic signal species, bryophyte species and lichen signal species richness. Bryophyte signal species richness was affected significantly only by forest stand age in the present study. Signal species richness was more affected by forest stand characteristics, but not by tree parameters. Signal species richness was high in all of the forest stands, which indicates their naturalness (Hedenås, Ericson 2000) and quality (Johansson, Ehrlén 2003). Jüriado et al. (2003) found forest stand age is a significant factor in explaining epiphytic and epixylic lichen species diversity. Epiphytic lichen species richness showed a significant relationship with forest stand area but not with the other studied variables.

Tree species only significantly affected epiphytic lichen signal species richness. However, tree species was found to have a major role in the epiphyte species distribution in other studies (Barkman 1958, Löbel et al. 2006b, Mežaka et al. 2008). Data about the seven tree species is probably not sufficiently replicated in this study to indicate the importance of tree species.

Epiphytic bryophyte species richness were affected significantly by tree bark pH, bark crevice depth, forest stand age and forest stand area. Tree bark pH was also significant for epiphytic bryophyte distribution in forests of slopes, screes and ravines in northwest Latvia (Mežaka, Znotiņa 2006). A similar trend in bark crevice depth and epiphytic bryophyte *Neckera pennata* was found by Snäll et al. (2004), who found that bark crevice depth supports epiphyte establishment on tree trunks.

Conclusions

Aspen forests have an important role in the conservation of biodiversity; epiphytic bryophytes and lichens including WKH indicator species and red-listed species. Differences in factor significance showed that it is important to know the epiphyte ecology of each group before planning nature conservation or long-term forestry in the boreo-nemoral forest landscape. The high importance of stand level characteristics indicates that landscape level planning is necessary in the future.

Acknowledgements

This study was financially supported by the European Social Fund ESF 2004/0001/VPD1/ESF/PIAA/04/NP/3.2.3.1/0001/0001/0063, the Latvian Academy of Science Z-821-090, and the University of Latvia Y2-ZP08-090.

Thank you to A. Āboliņa , B. Bambe and L. Liepiņa for help in identification of unclear bryophyte samples. We are also grateful to Dienvidlatgale and Sēlija regional forest district ecologists, district foresters and forest rangers for their assistance with transport, maps and housing.

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Received: 01.12.2008.
Accepted: 20.09.2009.