DAUGAVPILS UNIVERSITY
INSTITUTE OF LIFE SCIENCES AND TECHNOLOGY
DEPARTMENT OF BIOSYSTEMATICS

ROLANDS MOISEJEVS

LICHENS AND ALLIED FUNGI IN LATVIA, WITH EMPHASIS ON DEAD WOOD-DWELLING SPECIES IN POST-HARVEST DRY PINE FORESTS

LATVIJAS ĶĒRPJU UN TIEM RADNIECĪGU SĒŅU BIOTAS IZPĒTE, AR EPIKSĪLO ĶĒRPJU PIEMĒRU SAUSU PRIEŽU MEŽU JAUNAUDZĒS

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Supervisor:
Dr. biol., Senior Researcher Jurga Motiejūnaitė
Co-supervisor:
PhD, Senior Researcher Piret Lõhmus

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Promocijas darba zinātniskais vadītājs/Supervisor and Co-supervisor:

Supervisor: Dr. Jurga Motiejūnaitė

Co-supervisor: PhD Piret Lõhmus

Darba recenzenti/Opponents:

prof., *Dr.biol*., Guntis Brūmelis (Latvijas Universitāte);
sekcijas vadītājs, *Dr.biol*., Volker Otte (Senckenberga Dabas vēstures muzejs, Vācija);
prof., *Dr.biol*., Arvīds Barševskis (Daugavpils Universitāte).

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Padomes sekretāre: Dr.biol. Jana Paidere, Daugavpils Universitātes pētniece.

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III. **Moisejevs R.** 2017. New lichens and allied fungi for Latvia. *Folia Cryptogamica Estonica* 54: 9–12.

IV. **Mosejevs R.** & Degtjarenko P. 2017. Four species of saxicolous lichens new for Latvia. *Botanica Lithuanica* 23 (1): 68-70.

V. **Moisejevs R.**, Degtjarenko P., Motiejūnaitė J., Piterāns A. and Stepanova D. 2019. New lichens and lichenicolous fungi of Latvia, including the first comprehensive list of lichenicolous fungi. *Lindbergia* 42: linbg.01119.

VI. Degtjarenko, P. & **Moisejevs, R**. 2020. Revision of the genus *Cetrelia* (Lichenized Ascomycota) in Latvia. *Botanica*. 26 (1): 88–94.

VII. **Moisejevs, R**. 2015. Some new to Latvia lichens and allied fungi. *Acta Biologica Universitatis Daugavpiliensis* 15 (2): 285 – 292.

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Data analysis / Datu analīze	50	10	100	75	75	40	100
Manuscript preparation / Manuskripta sagatavošana	50	10	100	75	75	30	100

The order of the authors' names doesn't reflect their involvement in the paper except papers IV and VI.
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2. Štikāne, K., Brūmelis, G., Piterāns, A., **Moisejevs R**. *9th International Conference on Biodiversity Research (ICBR).* 2017. Epiphytic lichen diversity in broad-leaved tree forests in Latvia. (Poster presentation).
3. **Moisejevs, R**., Balalaikins, M., Valainis, U. *9th International Conference on Biodiversity Research (ICBR)*. 2017. Transplantation of rare species from alleys – is it a compromise during road reconstruction activities? case study in Daugavpils, Latvia. (Poster presentation).
4. **Moisejevs, R**. *International Association for Lichenology Symposium (IAL 8),* Helsinki. 2016. Lichen conservation in Latvia: present state and problems. (Poster presentation).
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Yatsyna, A., **Moisejevs, R**., Degtjarenko, P. 2021. Lichens and allied fungi from the Gauja National Park (Latvia), including new records for the country. Folia Cryptogamica Estonica 58: 135–144.

Zolovs M., Jakubāne I., Kirilova J., Kivleniece I., **Moisejevs R**., Koļesnikova J., Pilāte D. 2020. The potential antifeedant activity of lichen-forming fungal extracts against the invasive Spanish slug (*Arion vulgaris*). *Canadian Journal of Zoology* 98: 195–201.

Degtjarenko P., Mark K., **Moisejevs R**., Himelbrant D., Stepanchikova I., Tsurykau A., Randlane T., Scheidegger C. 2020. Low genetic differentiation between apotheciate *Usnea florida* and sorediate *Usnea subfloridana* (Parmeliaceae, Ascomycota) based on microsatellite data. *Fungal Biology* 124 (10): 892-902.

Štikāne K., Brūmelis G., Piterāns A., **Moisejevs R**. 2017. Epiphytic lichen diversity in broadleaved tree forests in Latvia. *Acta Biologica Universitatis Daugavpiliensis*, 17 (1): 123 – 132.

Popular science and educational literature / Mācību materiāli un populārzinātniskā literatūra:

Moisejevs R. 2016. Ķērpju indikatorsugu rokasgrāmata dabas pētniekiem. (red. Evarts-Bunders P.). SIA „Estonian, Latvian & Lithuanian Environment" un Daugavpils Universitāte. 70 lpp. ISBN 978-9934-14-779-1. https://www.daba.gov.lv/lv/media/1662/download

Supervision and consulting of students / Kursa darbu un bakalaura darbu vadīšana un konsultēšana:

1. Aizstāvēts maģistra darbs (Msc) - **Dace Stepanova**. 2022. Pirmais aizsardzības statusa novērtējums *Parmeliaceae* dzimtas Latvijas īpaši aizsargājamo ķērpju sugām, izmantojot IUCN sistēmas kritērijus / First assessment of the threat status of protected lichenized fungi from the family Parmeliaceae based on IUCN system in Latvia. Daugavpils Universitāte. (Maģistra darba vadītājs).
2. Aizstāvēts bakalaura darbs (Bsc) **- Inese Irbe**. 2020. Aizsargājamo ainavu apvidus "Augšdaugava" trīs upju epilītisko ķērpju biota. Bakalaura darbs. Daugavpils Universitāte. (Bakalaura darba vadītājs).
3. Aizstāvēts bakalaura darbs (Bsc) **- Dace Stepanova**. 2019. Epifītisko ķērpju sugu daudzveidība boreālos priežu sausieņu mežos. Degšanas ietekme. Bakalaura darbs. Daugavpils Universitāte. (Bakalaura darba vadītājs).
4. Aizstāvēts bakalaura darbs (Bsc) **- Samanta Incenberga**. 2018. *Cetrelia* ģints sistemātika un izplatība Latvijā. Bakalaura darbs. Daugavpils Universitāte. (Bakalaura darba vadītājs).

5. Aizstāvēts bakalaura darbs (Bsc) **- Žanna Brune**. 2018. Lihenizētu sēņu *Lobaria* (SCHREB.) Hoffm. ģints sistemātika, izplatība un ekoloģija Latvijā. Daugavpils Universitāte. (Bakalaura darba vadītājs).

6. Aizstāvēts bakalaura darbs (Bsc)– **Kristīne Štikāne. 2017.** Epifītisko ķērpju daudzveidība un tās ietekmējošie faktori platlapju koku mežos. Latvijas Universitāte. (Bakalaura darba konsultants).

CONTENTS

1. INTRODUCTION

Forests of Northern Europe have drastically changed in the past century due to intensive forest management (Esseen et al. 1997; Siitonen 2001). Young and mid-age forest stands have become more frequent in modern forest landscapes of Northern Europe (UNECE & FAO 2011, Vilén et al. 2012). Such forests differ from natural or old-growth forest ecosystems by having reduced quantity and variability of microhabitats (e.g. snags, logs, old trees etc.) (e.g. Lõhmus & Kraut 2010, Table 2), and by disturbed microclimatic conditions. In particular, the availability of dead wood (e.g., standing and downed coarse and fine woody debris) is reduced by logging and it is considered that in European production forests the current volumes of dead wood are less than 10% of what is found in natural forests (Stokland et al. 2012). Meanwhile species dependent on dead wood constitute 20–25% of all forest-dwelling species, as have been estimated for Fennoscandia (Siitonen 2001).

To reduce negative impacts of logging on biodiversity loss and to ensure sustainable forest management policies, and comply with forest certification standard criteria like FSC (Forest Stewardship Council) and PEFC (Programme for the Endorsement of Forest Certification), different management practices have been applied. Retention of live trees (i.e. green tree retention) and dead wood structures in cut sites is one of the most frequently applied practices in northern Europe (Gustafsson et al. 2010; 2012). Recent studies have shown that retention of woody legacies (fine woody debris, snags and logs) can provide suitable microhabitats for species of various organism groups, like saproxylic beetles, polyporoid fungi and epixylic bryophytes (Hautala et al. 2011; Juutilainen et al. 2014; Floren et al. 2015), as well as for lichens (Lõhmus & Lõhmus 2010; Lundström et al. 2013; Runnel et al. 2013; Hämäläinen et al. 2014; Ranius et al. 2014).

It can be expected that dead wood legacies may provide species rich epixylic lichen assemblages during the first post-harvest decade both in boreal and hemiboreal regions of North-Europe (Caruso & Rudolphi 2009; Runnel et al. 2013). However, the difference in wood dwelling lichen assemblages and/or species composition between stands in boreal and hemiboreal regions may differ (e.g., for burned forests see Lõhmus et al. 2018). In the hemiboreal region, lichen assemblages on dead wood have been representatively studied only in Estonia (e.g., Lõhmus & Lõhmus 2001; Lõhmus & Lõhmus 2011; Runnel et al. 2013), so far.

Forest logging is one the biggest threats for biodiversity, and lately at least several publications address the ways how forest logging impact on lichens and other organisms could be mitigated including retentions of green trees and dead wood in post-logging area (Koivula & Vanha-Majamaa 2020). The biota of lichens and allied fungi of Latvia is one of the least studied among Northern European Countries, at the same time the pressure of forest management activities, such as logging, on wood dwelling lichen species has never been studied in Latvia. Therefore, neither true biodiversity of wood-inhabiting lichens is known, nor there is any data on what forest management measures in production forests would be best to maintain the diversity of lichen biota in Latvia.

1.1. Overview of lichen biota studies in Latvia

The first contributor to the knowledge of lichen biota in nowadays territory of Latvia was J. B. Fischer, the student of Carl Linnaeus, who mentioned seven lichen species in the first volume of "Versuch einer Naturgeschichte von Livland" (Fischer 1778). In the second volume, he already listed twenty-seven species of lichens (Fischer 1791). Later, D. H. Grindel, Latvian botanist, chemist and pharmacist, who had a professor and lecturer position in University of Tartu, reported 38 lichen taxa in "Botanisches Taschenbuch fur Liv-, Cur-und Ehstland'' including the species descriptions and some ecological data (Grindel 1803). Between 1846 and 1869, K. Millers and K. Heigels, the members of the Riga Naturalist Society (Naturforscher-Verein zu Rīga), recorded 157 lichen species (Heugel & Muller 1847; Heugel 1855; 1857). However, the main contributor to the knowledge on lichen biota of Latvia (and Estonia as well) in 19th century was A. Bruttan, the inspector and school teacher, who reported 362 lichen taxa from nowadays territory of Latvia (Bruttan 1869; 1870; 1889).

In the first part of 20th century K. S. Mereschkowski, profesor in Kazan University, published the list of lichen species for Baltic region (516 species), which also included information on species from nowadays territory of Latvia (Mereschkowski 1913). An outstanding German-Baltic botanist K. Kupfer formed plant herbarium of Baltic and other countries (including lichens, ca 400 specimens, in *Herbarium Balticum* and *Herbarium generale*), which is stored in herbarium of University of Latvia (RIG). Latvian botanist and mycologist K. Starcs also contributed to the collection of lichen herbaria, by collecting ca 1600 lichen specimens from different countries (650 specimens from Latvia). The publications of Latvian botanist and bryologist N. Malta, devoted to the studies of cryptogams, added new information about lichens on sandstones, with twelve species of lichens new for Latvian lichen biota (Malta 1925; 1926). Botanists H. Skuja and M. Ore (1935) investigated the biology and ecology of *Coenogonium nigrum* (at present *Cystocoleus ebeneus*), and in 1936, published a review of the lichens of Latvia. In 1939, K. Miške (1939) defended a dissertation of Candidate of Science on the *Cladonia* flora of the Riga area.

In the second part of 20th century, botanist and bryologist A. Āboliņa and mycologist E. Vimba (University of Latvia) published first determination keys for forest lichens and bryophytes (Āboliņa & Vimba 1959). Later, A. Piterāns performed an extensive study on lichens in valley of Daugava river, as the part of this territory at that time was planned to flood by building the hydroelectric station. Alfons Piterāns, botany docent (associate professor) of University of Riga and the only active lichenologist at that time in Latvia, carried out an extensive research of lichen biota in different protected territories of Latvia. Other miscellaneous records of species new for territory of Latvia also were published during the whole period of scientific activity. During mentioned period of time lichenological collection (RIG) deposited in University of Latvia has been replenished on more than 10,000 lichen herbaria units. Also, lichen checklists for various protected territories of Latvia were made. In a year 1982 the first comprehensive checklist of lichens for Latvia was published, which included 464 lichen taxa (Piterāns 1982).

In the late 20th and early 21st century, the contributions to the Latvian lichens were made by visiting and local lichenologists (Motiejūnaite & Piterāns 1998; Piterāns 2001; Sundin & Thor 2001; Motiejūnaitė et al. 2006; Mežaka et al. 2008; Czarnota & Kukwa 2010; Mežaka et al. 2012(a;b); 2014; Jurciņš et al. 2014; Motiejūnaitė & Grochowski 2014; Moisejevs 2015; Mežaka 2015; Gerra-Inohosa & Laiviņš 2016; Mežaka et al. 2018; 2019). An updated checklist of lichens was published by A. Piterāns (2001), which contained 503 species, 5 subspecies and 8 varieties of lichens and allied fungi. In year 2015, the second checklist of lichens was published (Āboliņa et al. 2015), listing 588 taxa of lichens and allied fungi. However, total number of recorded lichen and allied fungi taxa still remains rather low in Latvia, comparing to the other Baltic states (Motiejūnaitė 2017; Randlane et al. 2019.). Such obvious dearth in knowledge on lichen biota, comparing with neighboring Baltic countries, can be explained by low activity of Latvian lichenologists in recent decades.

In year 2016, the report on Latvian forest lichens was published by Gerra-Inohosa & Laiviņš (2016), which was based on literature analysis of previously published papers. Authors concluded that approximately 300 species of lichens are related with forest habitats in Latvia.

At the same time, in neighboring Estonia, the meta-analysis of forest lichen biota, done in year 2003, showed that 481 species of lichens grow in forests. The Estonian study findings were based on 13 quantitative studies (with additional data from 4 studies) carried out in period between 1969-2000 (Lõhmus 2003). In case of Latvia, only seven quantitative studies devoted specifically to the forest lichen biota have been performed till year 2016. Most of these studies were carried out in broadleaved stands, and only epiphytic lichens on live broadleaved trees and aspen were studied (Mežaka et al. 2008; 2012(a); Štikāne et al. 2017). Few data on lichen species in boreal forest sites have been also reported (Mežaka et al. 2015; 2018; 2019). Meanwhile information of dead wood dwelling lichens and allied fungi in Latvia is even more sparse than for epiphytic lichens. Also, young and mid-age regenerated forest lichen biota in Latvia has never been studied systematically before.

1.2. Lichens as bioindicators

Lichens (including allied fungi) and their functional traits are widely used as sensitive indicators of climatic conditions, as their poikilohydric physiology depends on light conditions, water availability (Gauslaa 2014), surrounding temperature etc. (Green et al. 2008; Kranner et al. 2008; Giordani et al. 2012). Thus, they are related to environmental changes as land use (Pinho et al. 2012), forest disturbance (Nöske et al. 2008), forest management (Aragón et al. 2010; Nascimbene et al. 2013); fragmentation (Belinchón et al. 2007; Cardós et al. 2016), forest succession (Koch et al. 2013), air pollution and nitrogen deposition (Giordani et al. 2014; McMurray et al. 2015; Degtjarenko et al. 2018a) or climate change (Nascimbene et al. 2016).

In many Northern European countries, as well as in central part of Europe, lichens are widely employed in woodland key habitat evaluation for conservation purposes (Ek et al. 2002; Gustafsson et al. 2004; Motiejūnaitė et al. 2004). Moreover, the indicator species and their values differ among countries where such evaluations are applied, due to different climatic and vegetation conditions and the distributions of individual lichen species (Ek et al. 2002, Motiejūnaitė et al. 2004). For example: *Evernia mesomorpha* and *Mycoblastus sanguinarius* are habitat specialists in Lithuania (at present absent in NE Poland), *Lobaria virens* is an old growth forest indicator in NE Poland (absent in Baltic States), *Calicium trabinellum* is considered as habitat specialist in Lithuania, but not in Estonia and Latvia (Ek et al. 2002; Motiejūnaitė et al. 2004; Āboliņa et al. 2015; Randlane et al. 2019).

Lichens and allied fungi are good model organisms for evaluation of forest ecological functioning and the effectiveness of conservation measures in forest ecosystems (Tibell 1992;

Wolseley et al. 1994; Brunialti et al. 2010; Miller et al. 2020, etc.). However, as it is expected, the ecological preferences and traits of species and their assemblages differ in wide geographical scales (Stofer et al. 2006; Spribile et al. 2008). For instance, recently it was shown the difference between wood dwelling lichen assemblages and/or species composition in burned forests, between stands in European middle-boreal and hemiboreal region (Lõhmus et al. 2018). However, such studies are few and dearth of general information on lichen distribution applicable to a specific region hinders the application of lichens in monitoring systems.

1.3. Functional traits as the measure of diversity

Traditionally the effect of ecological factors on species diversity is measured by changes in species richness, however, such measure might not reflect the function (viability) of assemblages in studied treatment groups nor general forces driving community assembly (Bässler et al. 2016). Functional traits refer to characteristics of the organisms (such as physiological and/or morphological attributes) thought to be relevant to ecosystem functioning and/or its response to the environment (Díaz and Cabido 2001). Lichen species traits (e.g. photobiont type, growth form, reproduction type, etc.) could indicate lichen community adaptation to environmental conditions (Diaz and Cabido 2001; Giordani et al. 2012; Degtjarenko et al. 2018a). For example, photobiont type, growth form, reproductive structure and presence of lichen substances are showed to be directly related to microclimatic factors (e.g. canopy cover and tree age) and abiotic factors, such as humidity, light availability and temperature (Ellis and Coppins 2006; Pinho et al. 2012; Li et al. 2013; Bässler et al. 2016; Prieto et al. 2017,). Moreover, recently was found, that changes in the environment caused by climate warming and eutrophication can shift the composition and functional diversity of lichens in primeval forests (Łubek et al. 2021b). The importance of the flexibility in the photobiont choice was demonstrated by Ertz et al. (2018), as it enables particular species to use a larger range of tree hosts. Such strategies potentially help lichens to withstand changes of environmental conditions, to widen distribution range and to increase the size of population (Kranner et al. 2008; Marini et al. 2011; Hauck et al. 2013). It is also known that different reproductive modes (e.g. type of vegetative propagules, apotecia/peritecia, pycnidia) are responsible for species' spatial pattern in fragmented forest landscapes (Löbel et al., 2006).

Previously it was shown by Giordani et al. (2012) that forest type and light conditions influence the composition of lichen functional traits; the latter is among the main factors shaping lichen communities, as shown in previous studies done by Humphrey et al. (2002) and Moning et al. (2009). For example, it was also found that fruticose lichens are clearly ecologically separated from other growth forms, requiring higher light availability (Giordani et al. 2012; Gauslaa 2014). In many forest ecosystems, this growth form is known to be restricted to the higher part of the canopy or to open stands, which provide well-lit conditions (Barkman 1958; Aragón et al. 2016). The studies of Łubek et al. (2021a) demonstrated that different types of substrates can affect the grouping of lichens with similar functional traits. At the same time, authors conclude that not forest community itself, but the availability of specific phorophytes and substrates influences the lichen functional traits' composition in different forest communities.

Forest logging (particularly clearcutting) affects several microclimatic conditions, mostly related to light, temperature and moisture (Heithecker & Halpern 2006; 2007). Thus, different logging activities (including preservation of ecological structures) can have different effect on the lichen assemblages, which is related to the availability or absence of particular environmental conditions that were preserved during the process of logging. Moreover, the effect of different forest management activities on lichen functional traits' composition in various forest communities needs to be studied yet.

1.4. Lichens in forest ecosystems

Forest ecosystems contain up to half of total species richness of lichens and allied fungi known in Baltic region. The most species-rich groups of lichens in lowland forest ecosystems of hemiboreal vegetation region are epiphytic and epixylic lichens (Lõhmus 2003; Gerra-Inohosa & Laiviņš 2016). Lichens are considered a valuable component of forest ecosystems, making important part in nutrient turnover, as well as inproviding food and habitat for various organisms, etc. (Ellis 2012; Asplund & Wardle 2017). At the same time, lichens are highly sensitive to environmental changes (Kranner et al. 2008; Pinho et al. 2012) because their physiology is strongly coupled to solar radiation, humidity and temperature conditions (Green et al. 2008; Honegger 2009). Old-growth forest ecosystems, with long ecological continuity, hold the unique and species-rich lichen assemblages, that are documented on old trees and dead wood substrates (particularly on coarse woody debris – e.g. logs and snags) in various studies (e.g. Kuusinen and Siitonen 1998; Lie et al. 2009; Moning et al. 2009; Lõhmus and Lõhmus 2011).

Many studies have shown that various stand-scale and particular structure-scale factors are affecting lichen assemblages and species richness in different old-growth and near natural forest ecosystems (Siitonen 2001; Jüriado et al. 2003; Löbel et al. 2006; Jüriado 2009; Mežaka et al. 2012; Lõhmus & Lõhmus 2011; Asplund et al. 2014, etc). Structure-scale factors affecting lichen richens and assemblages are related with microclimatic conditions and physical properties of substrates. It is known that lichen richness and assemblages on living trees in forest ecosystems are driven by following characteristics of phorophytes: physical characteristics of bark (Barkman 1958; Löbel et al. 2006), bark pH (Barkman 1958; Löbel et al. 2006), age of substrate (Ranius et al. 2008; Caruso & Rudolphi 2009). Also, the particular tree species present in a stand constitute an important factor influencing epiphytic lichen assemblages and total stand-scale species richness (Barkman 1958; Jüriado et al. 2003; Mežaka et al. 2008; Mežaka et al. 2012).

A large proportion of forest-dwelling lichens in boreal forests use dead wood as the main or facultative substrate (Spribille et al. 2008). For example, many wood-dependent lichens in boreal pine forests are confined to old hard wood, such as snags, low natural stumps and logs (Lõhmus & Lõhmus 2011; Santaniello et al. 2017). For dead wood dwelling species, structure-scale characteristics such as fraction of dead wood – e.g. coarse woody debris (CWD) or fine woody debris (hereafter FWD) (Hämäläinen et al. 2015), the decay class of wood (Kruys et al. 1999; Humphrey et al. 2002; Caruso & Rudolphi 2009), standing/lying wood (Hämäläinen et al. 2014) are factors affecting lichen assemblages and species richness. The occurrence of additional natural structures in a forest site, such as stones/cliffs, root plates, substrates submerged in the water also support species richness in forests (Ek et al. 2002; Andersson et al. 2005; Lõhmus et al. 2010; Lõhmus & Lõhmus 2011).

The stand scale characteristics, such as stand age and ecological continuity (Jüriado et al 2003; Mežaka et al. 2012), canopy cover (Esseen et al. 1997), humidity (Gauslaa 2014), light conditions (Trest et al. 2015), topography (Sevgi et al. 2019) also affect positively the formation of lichen communities and species richness in forests. TMain human-induced factrors that adversely influence lichen diversity in forests are intensive forest management (Thor 1998; Lõhmus et al. 2019), air pollution (Giordani et al. 2014; Degtjarenko et al. 2016;) and climate change (Moning et al. 2009; Ellis 2012; Nascimbene et al. 2013).

1.4.1. Lichens in post-harvest forest sites

The commercial forestry has been proposed as the most important threat causing the decline of many lichen species (Thor 1998; Nascimbene et al. 2013; Lõhmus et al. 2019). It has been shown that intensive forest management methods, such as clear-cut harvesting, cause drastic changes in forests, resulting in modified and impoverished communities of forest biota (Pawson et al. 2006). As a result, silvicultural alternatives have received more and more attention globally (Puettmann et al. 2015) and sustainable management of production forests has been one of the major goals of modern forestry (MCPFE 2020).

Post-harvest sites usually hold large amounts of coarse dead wood (e.g. logs, snags and stumps), in contrast to managed production forests, where such substrates are rather rare (Siitonen 2001). Also, compared to bark on living tree trunks, with a pH from acid to around neutral, decorticated dead wood is generally an acid substrate, and hosts many specialized lichen species (Crites & Dale 1998; Lõhmus and Lõhmus 2001; Humphrey et al. 2002), indicating its importance for conservation of overall lichen diversity.

Retention forestry – one of the tools of sustainable forest management - was first introduced in the Pacific Northwest (USA) in the 1990s and has since become a widely applied practice, particularly in northern Europe and North America (Gustafsson et al. 2012). It refers to the retention of part of the living trees or dead wood on the harvested site (Gustafsson et al. 2012) in order to provide structural legacies similar to those that occur after natural forest disturbances. These legacies increase the structural variability of the sites (Gustafsson et al. 2010; Kruys et al. 2013; Lõhmus et al. 2013; Rudolphi et al. 2014) and enhance habitat connectivity at a landscape scale (Franklin et al. 1997). Sites with retention trees have been shown to maintain higher levels of species richness and abundance of forest-dwelling species than clear-cut sites with no retained trees (Fedrowitz et al. 2014). Various studies have shown that retention of biological legacies, like living and dead trees, during the process of logging, can provide habitats for specialized epiphytic and epixylic lichens (Lõhmus et al. 2006; Rosenvald and Lõhmus 2008; Lohmus & Lohmus 2010; Caruso et al. 2011; Gustafsson et al. 2013; Lundström et al. 2013; Runnel et al. 2013; Hämäläinen et al. 2014; Ranius et al. 2014; Rudolphi et al. 2014).

The retention of dead wood legacies can support the existence of lichen meta populations, providing substrates for colonization and dispersal sources in the regenerating post-harvest stands (Sillett and Goslin 1999; Hedenås and Hedström 2007; Lõhmus and Lõhmus 2010). In previous studies it was found that level/volume of retention trees can affect the species richness (Hämäläinen et al. 2015) and composition in post-harvest sites. The volume of retained CWD structures in cut-over sites is also meaningful factor for conservation of epixylic lichens (Caruso et al. 2008). However, there are only few studies dealing with the stand scale factors on lichen assemblages in post-harvest sites (Hämäläinen et al. 2014; 2015; Lõhmus et al. 2018). In case of hemiboreal vegetation region, studies devoted to the lichen assemblages in post-harvest sites lack.

1.4.2. The importance of dead wood structure for lichens conservation in boreal post-harvest sites

The dead wood legacies (e.g. snags, logs, stumps and FWD) and retention trees are the main source of substrata for epixylic and epiphytic lichens in young regenerated post-harvest sites of boreal forest types (Caruso 2008; Hämäläinen 2016; Santaniello et al. 2017). The dynamic process of substrate decay and overgrowing by vascular plants and bryophytes provides suitable microhabitat conditions for different lichen assemblages over the course of time (Fałtynowicz 1986, Lõhmus & Lõhmus 2001; Blasy & Ellis 2014).

In the post-harvest ecosystem, stumps are most abundant woody structure, except the cases when stump harvesting is performed. More-over, stumps, similar substrate as snags in old-growth forest ecosystems, can support lichen species rich microhabitats in first decades after felling in Fennoscandia (Hämäläinen et al. 2014; Santaniello et al. 2017), particularly stumps of Norway spruce (*Picea abies* (L.) Karst.; hereafter “spruce”) and pine (Caruso et al. 2008; Svensson et al. 2013; Hämäläinen et al. 2015). Thus stumps provide “buffering” substrata to maintain populations of dead wood lichens in the managed forests at the landscape scale.

Another specific dead wood substrate created during the felling is cutting residues (i.e. alternative for FWD in old stands). For example, in managed boreal spruce forest, lichen species richness is higher on FWD when equal volumes of coarse woody debris (CWD) and FWD are compared (Kruys & Jonsson 1999). Attached dead branches make a significant proportion of all available dead wood in boreal forests, nevertheless such types of substrata mainly support generalist lichen species (Svensson et al. 2014). Downed fine woody debris (including slash) also can provide suitable microhabitats for a relatively large biomass of dead wood dwelling lichens (Kruys & Jonsson 1999; Svensson et al. 2014; Hämäläinen et al. 2015); though several studies have shown that only few species are present on such substrata (Caruso et al. 2008; Svensson et al. 2016). Nevertheless, there is a lack of studies devoted to the green tree retention effect on lichen species assemblages on FWD.

1.5. Actuality, novelty and aims of the study

Compared to the neighboring countries (see 1.1), the diversity of lichens and allied fungi in Latvia is understudied. Therefore, the **first aim** was to increase the general knowledge about the assemblages of lichens and allied fungi in Latvia (**II–VII**), especially the knowledge on wood-inhabiting species (**I–III,** pro parte).

Standardized methodology of thin layer chromatography (TLC) procedure for detecting and comparing lichen metabolites was elaborated by C.F. Culberson already half centure back (Culberson 1972) and have been widely used for lichen species delimitation and determination nowadays (Nash III 2008; Smith et al. 2009). But TLC method was not used during revision of materials in Latvian herbarium before. Therefore, based on TLC method, the **second aim** was to revise genus *Cetrelia* in Latvia, because it includes species having similar morphology, but form chemotypically diverse and difficult complex (**VI**). The determination of secondary metabolite complex in lichen thalli can be used for species identification in genus *Cetrelia*, as it was approved by Mark et al. (2019). The genus has high conservation importance in Latvia and Northern Europe, as all *Cetrelia* species are known to be rare and threatened in all Northern European countries where the species are found.

The **third aim** of the study was to explore the effects of sustainable activities in forest management system (i.e. green tree retention) on lichen species assemblages and species richness in various habitat types (**I**). More specifically, the aim was to describe lichen assemblages on pine dead wood structures (stumps, FWD, snags and logs) in post-harvest 4–6 and 9–11 yr. old dry boreal pine stands in Latvia (**I**) and to find, a) what type of substrata and stand-scale characters (e.g., decay stage and proportion of exposed wood of the substrata, green tree retention level, time since harvest, volume of dead wood) are related to the lichen species richness and composition on pine dead wood legacies (**I**), and b) whether the functional traits of lichens and allied fungi on stumps in post-harvest 4–6 and 9–11 yr. old dry boreal pine stands differ (**in current thesis**).

Statements to be defended:

- Lichen diversity of Latvia requires modern treatment and data supplementation;
- Green tree retention level and age since cut in cut-over sites have impact on stump-dwelling and fine woody debris inhabiting lichen species richness;
- Particular lichen functional trait composition on stumps is changing along the time during the first decade after forest harvest.

Tasks of the study:

- Targeted lichen species diversity research in pre-selected areas to reveal existing lichen data deficiency;
- The revision of the lichen genus *Cetrelia* in Latvia;
- The lichen data collection in post-harvest 4–6 and 9–11 yr. old dry boreal pine stands in Latvia;
- The description of lichen assemblages on pine dead wood structures (stumps, FWD, snags and logs) in post-harvest 4–6 and 9–11 yr. old dry boreal pine stands in Latvia;
- The determination of the collected specimens using adequate lichenological methods applied for species determination.

2. MATERIALS AND METHODS

2.1. Background study of lichen diversity

In order to establish general knowledge level of the diversity of lichen and allied fungi diversity and to check the frequency of forest species, several types of habitats (forests, rocks and outcrops, wooded meadows, tree alleys and parks, mires, etc.) were studied in preselected sites (see Fig. 1 and Fig. 2 (black dots)). In every studied habitat lichens and allied fungi were recorded on all substrata up to 2 meters above the ground. All noteworthy (e.g. Red-listed, protected, rare, and previously unknown from Latvia) lichen species were recorded. For species which can not be determined in field, herbaria material was also collected. All lichen records collected by non-professional lichenologists were verified by author of thesis via visiting locations, and/or identification of colleted herbaria material (Fig. 2 (white dots)). All noteworthy lichen records are stored in The Nature Data Management System called "OZOLS", maintained by Nature Conservation Agency (under Ministry of Environmental Protection and Regional Development of the Republic of Latvia).

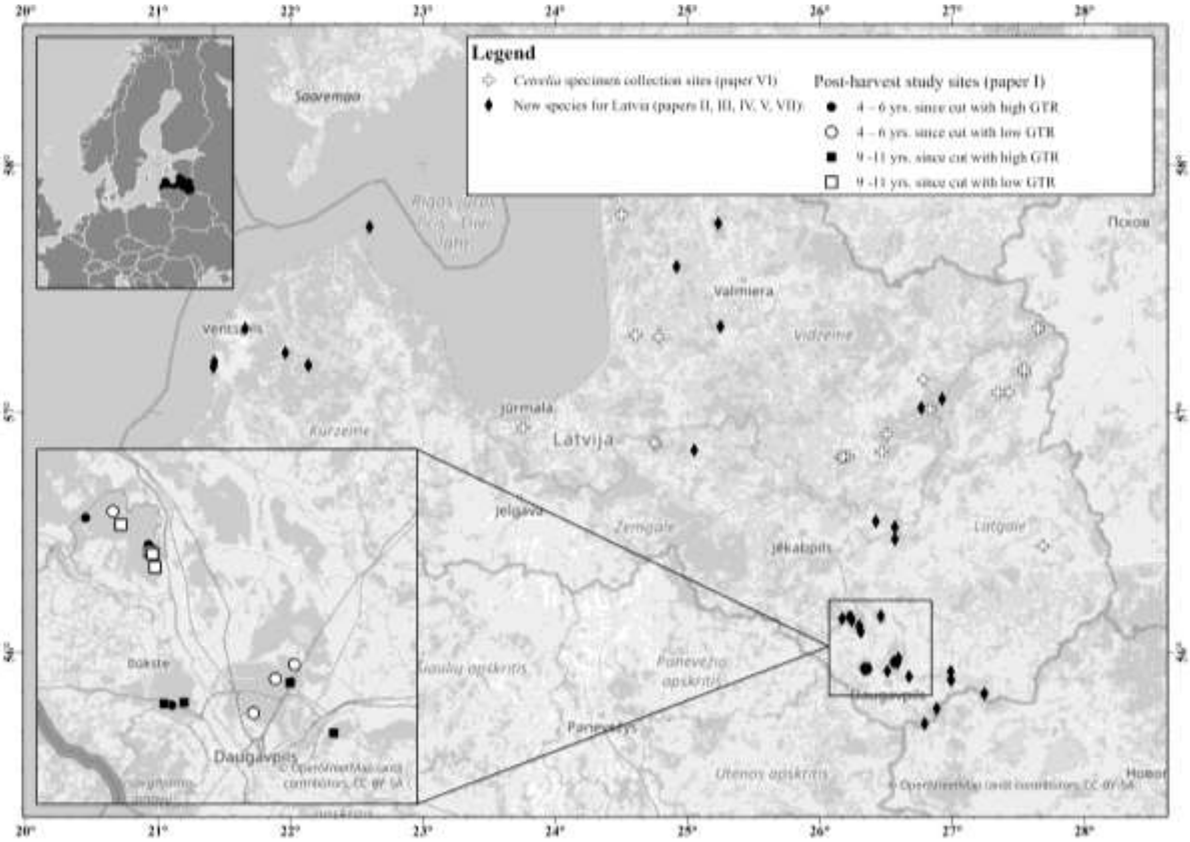

Figure 1. Visited sites where new species for Latvia were recorded (Papers II, III, IV, V and VII), and *Cetrelia* specimen collection sites (from Paper VI). The zoomed map presents study sites of the study I.

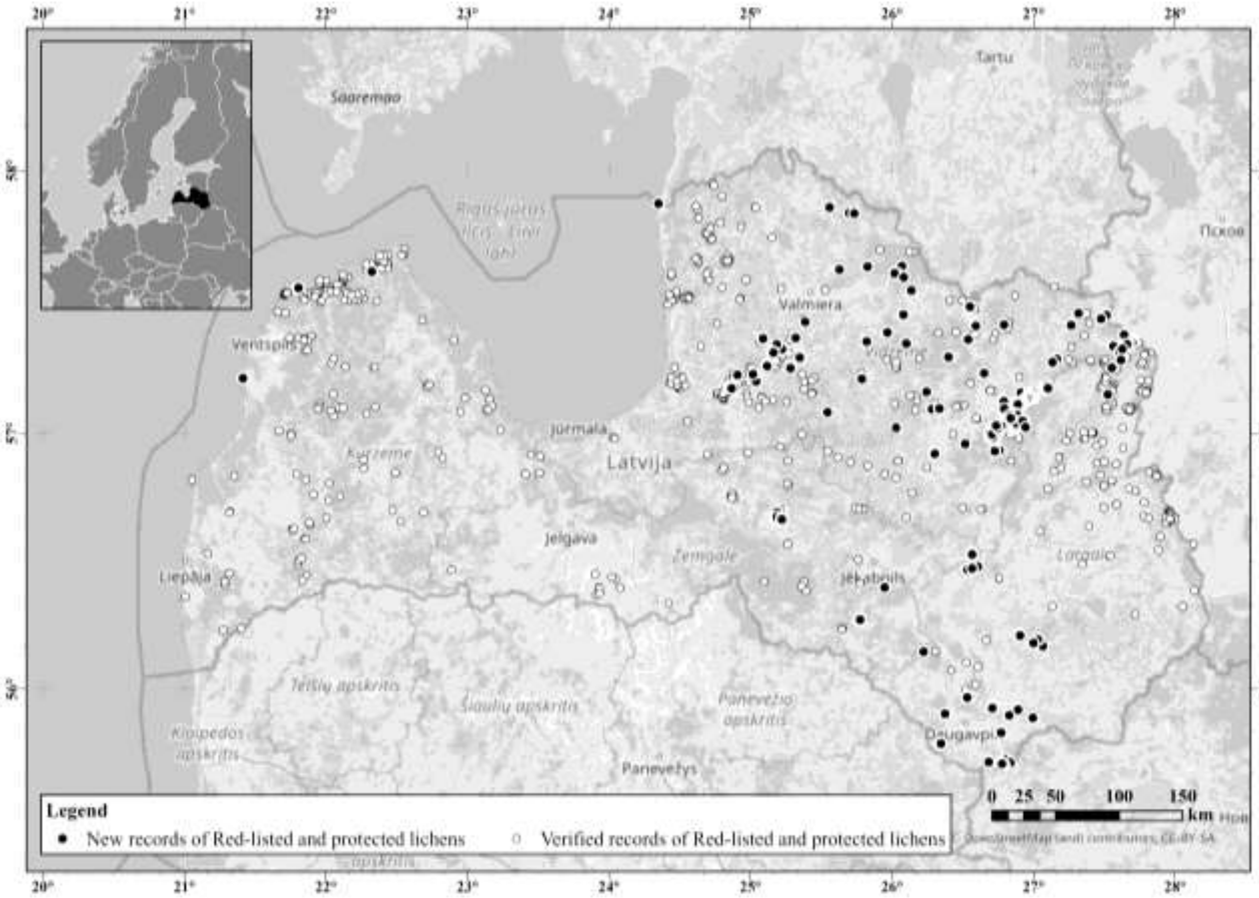

Figure 2. Noteworthy lichen records. Black dots - visitied sites for lichen diversity background study, where noteworthy lichen species were recorded. White dots – verified records of noteworthy lichens, visited and/or based on herbaria material.

Spot-test reactions of thalli were checked with sodium hypochlorite solution (commercial bleach) (C) and/or 10% KOH solution (K) in field. Morphology of collected lichen specimens was examined under a dissecting microscope, anatomical structures were studied under a light microscope. At the laboratory, ethanol solution of paraphenylenediamine (PD), Lugol solution (I), commercial bleach) (C), 10% KOH solution (K) and 50% HNO_3 (N) were employed for additional spot tests and anatomical examinations. For the specimens, requiring secondary metabolite examination thin layer chromatography (TLC; solvent systems A and C) was employed (Orange et al. 2001). The collected specimens are stored in the lichenological herbarium of the University of Daugavpils (DAU).

The revision of genus *Cetrelia* in Latvia was based on herbarium material collected in territory of Latvia from 1957 to 2018 and stored in the lichenological herbarium of Daugavpils University (DAU) and the University of Latvia (RIG), as the majority of specimens of genus *Cetrelia* collected in Latvia are stored in mentioned herbarium collections. All specimens were examined for lichen substances by thin-layer chromatography (TLC; solvent A) (Orange et al.

2001). Localities of Latvian specimens were transcribed from the labels and distribution maps of *Cetrelia* species were created using ESRI ArcGIS pro 2.3. (ESRI 2011).

2.2. Lichen assemblages on dead wood in dry boreal post-harvest stands

In Latvia, the proportion of forest land makes about half of the terrestrial area of the country and the proportion of coniferous forests is ca 53%. Pine is the most frequent tree species in Latvia and approximately fourth part of dry boreal pine forests in Latvia are young-regenerated sites (Anonymous 2020). Therefore, study (**I**) focused on dry boreal post-harvest sites.

The study of lichen assemblages (**I**) in dry boreal post-harvest sites was performed in the SE part of Latvia, in the hemiboreal forest zone (according to Ahti et al. 1968). The study sites were selected from Vacciniosa type (Bušs 1976), i.e. pine dominated forest on higher fluvioglacial landforms and till mounds with Podzols (pH 3.5–5.0) having continuous moss cover and species-poor undergrowth (mostly shrubs of *Vaccinium vitis-idaea* L. and *Calluna vulgaris* (L.) Hull.) and a very sparse under-storey. The study sites were selected in 2.5–9 ha size retention-cut stands situated outside of protected areas (Fig. 2, zoomed map).

Among the study sites, four treatment types were designated, based on combinations of time since harvest (4–6 and 9–11 years) and green tree retention level ("high", 14–20 trees per ha or 30–40 m^3/ha, and "low", ≤6 trees per ha or ≤12 m^3/ha). Each of the four treatment combinations (hereafter as "treatment type") was represented by four sites, 16 sites in total. All sites were standardized to 2.5 ha in size, with 30 m wide buffer zones on each side. In all stands pine saplings have been planted, and all stands were state-owned. Total lichen sampling from woody structures per site were performed from two FWD plots (2 × 8 m) and 4–6 stumps selected along sampling transects and from 1–2 logs and 1–2 snags selected arbitrary over the whole study site (Fig. 3 and Fig.4). Lichen identification was performed employing same methods as described in the subchapter 2.1.


Figure 3. Lichen sampling on well-decayed stump in 9-11 yrs old post-harvest sites (left).

Figure 4. Well decayed stump from 9-11 yrs old post-harvest study site (right).

2.2.1. Assessment of functional traits

For each lichen and allied fungi species found on the stumps (Paper **I**), ten functional trait types among morphological, anatomical, chemical and reproduction traits were assessed (Table 1). The information related to these traits was obtained from key-books, taxonomic literature and literature about lichen compounds (Tibell 1999; Jørgensen et al. 2007; Smith et al. 2009; Thell & Moberg 2011; Ahti et al. 2013; Nguyen et al. 2013; Wirth et al. 2013).

Table 1. Description of functional trait types and their trait characteristics distinguished.

Functional trait	**Description of the trait levels**
Thallus type	Following trait groups were distinguished: 1) no thallus (non-lichenized); 2) crustose (subtypes: 2a leprose and granulose without cortex; 2b crustose with cortex; 2c endosubstratic, like have calicioids,

Functional trait	**Description of the trait levels**
	Micarea spp.); 3) foliose and squamulose; 4) fruticose (subtypes: 4a Cladonia-type thallus; 4b pendulous; 4c) erect fruticose). Foliose and squamous thallus type were combined in the dataset and analyzed as one trait type, due to absence of variation in species with squamous thallus type.
Thallus color	The trait of thallus colour had six groups based on thallus colour in dry conditions and on additional information of substances responsible for pigmentation of the thallus: 1) no colour (e.g. endosubstratic thallus); 2) grey thallus (includes atranorin); 3) greenish to greenish grey (thallus do not contain atranorin and usnic acids); 4) yellowish green (includes usnic acids); 5) lemon yellow (includes pulvinic acid derivtives), 6) brownish (do not contain acetone-soluble substances). There were no species with anthraquinone-defined thallus colour. Only one species (*Vulpicida pinastri*) represented lemon yellow thallus colour and was therefore combined with yellowish green species (group 4) in statistical analysis, but represented separately in results with descriptive statistics. Non-lichenized species do not have current trait value.
Lichen substances	Acetone-soluble lichen substances in lichen thalli or apothecia as functional trait was defined based on their 1) absence or 2) presence. Non-lichenized species do not have current trait value.
UV-screening compounds	The production of UV screening compounds by lichens, such as phenolic compounds (depsidones, depsides, diphenyl ethers), anthraquinones, xanthones or shikimic acid derivatives (calycin, mycosporines, scytonemin) etc., serve as an important protective mechanism of lichens (Nguyen et al. 2013). The trait was defined based on the 1) absence or 2) presence of acetone-soluble UV-protective substance(s) in particular lichen species thalli or apothecia.

Functional trait	**Description of the trait levels**
Photobiont type	There was no variation of photobiont types in the dataset, as species with cyanobacteria or *Trentepohlioid* algae were no presented. Therefore following basic trait values were distinguished: 1) taxa without photobionts (e.g. *Sarea resinae*, *Mycocalicium subtile*) and 2) taxa with Chlorococcoid algae (e.g. *Treuboxia*; *Chlorococcus, Coccomyxa*; *Dictyochloropsis, Stichococcus*).
Reproduction type	Following reproduction types were distinguished: 1) sexual (sub-types: 1a apothecia; 1b stalked apothecia/calicioids); 2) vegetative (sub-types: 2a soredia; 2b isidia); 3) mixed reproduction (e.g. both vegetative and sexual types occur). There was no variation within asexual (conidia) type of reproduction, same as for species forming perithecia.
Spore type	Spore type was distinguished based on the cell numbers forming the ascospore: 1) one-celled spores; 2) two-celled spores; 3) spores with more than 2 cells (including mural spores).
Spore length	Spore length trait based on maximal length of spore typical to certain species and the trait was divided into three groups: 1) short spores (<10 µ); 2) medium size spores (10-20 µ); 3) long spores (>20 µ).
Spore colour	Spore colour trait based on the presence of the pigmentation and had two groups: 1) hyaline spores and 2) coloured spores.
Spore surface	The trait corresponds to the presence of the ornamentation on the spores (facilitates the dispersal); because of low variation in our dataset, the trait had two groups: 1) spores smooth and 2) spores with ornamentation.

2.3. Statistical data analysis

In the Paper (**I**) the number of sampled logs and snags among the sites was insufficient for statistical analysis, but the difference of functional area of stumps and volume of CWD and FWD across four treatment combinations were tested with a one-way Welch ANOVA with Games-Howell post hoc analysis (before the analysis two outliers were removed to achieve normal distributions for each treatment). Homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance ($p < 0.001$). General linear models (GLMs) were used to study the effects of post-harvestage and green tree retention level on total and mean lichen species richness on stumps and on FWD per site.

The fixed factors were age of cut sites (4–6 and 9–11 yr. since cut) and GTR level (≤6 trees/ha as "low" and ≥14 trees/ha as "high"). Two un-correlated variables were also included per each model: for models (1) and (2) variables average stump functional area and average stump diameter per site, and for model (3) variables volume of FWD and CWD. GLMs were run initially including all factors and interaction between site age and GTR level. Non-significant factors were removed from the model manually one by one, commencing with the least significant factor. Difference of lichen assemblage composition among treatment types (depending on site age and GTR level) were studied for 1) stumps (full unit), 2) stumps vertical and horizontal surfaces separated, and 3) FWD. A multi-response permutation procedure (MRPP) was used to test if Sørensen (Bray-Curtis) dissimilarities among predefined groups exceed those resulting from random assignment of sample units to those classes, and it has the advantage of not requiring distributional assumptions that are seldom met with ecological assemblage data. To correct the p-values for multiple comparisons, a Bonferroni correction was applied.

In the species matrices, frequency score of the species per site (0–4 for stumps and 0–2 for FWD) were used as input. Results based on the full species matrix are presented (i.e. MRPP analysis gave similar results to full and reduced species matrices). The full species matrix was also used to find species specific to treatment type using indicator species analysis (ISA; Dufrêne & Legendre 1997). In that analysis, we distinguished the species with significant ($p<0.05$) and relatively high (>50%) indicator values.

For functional traits the assumption of data distribution was assessed by the Shapiro-Wilk test and inspection of the normal Q-Q plots. The assumption of homogeneity of variance was tested by the Levene's test. The two-way ANOVA or aligned ranks transformation

ANOVA (depending on inspection of assumption) was conducted to determine whether there is an interaction effect between two independent trait variables (age since cut and trait type) on a continuous dependent variable (species number). Descriptive statistics presented as mean ± standard deviation if data met the assumptions of normal distribution and equality of variance, whereas the median is presented if those assumptions were violated.

3. RESULTS

3.1. Background study of lichen diversity

Altogether 69 new lichen and 47 allied fungi species were registered and reported as new for Latvia during the 6-year period (2015 – 2020) of lichen diversity studies presented in the thesis (**I-VII;** Appendix 1). Of these ca. 20% of species were found and/or identified by author of thesis.

Newly recorded species of lichens and allied fungi for Latvia are represented by 86 genera, and 53 families. Of these, Teloshistaceae (10 species) and Verrucariaceae (5 species) are the most represented families among the newly recorded species. Several lichen families are recorded for a first time in Latvia – for example: Carbonicolaceae, Trapeliaceae, Pycnoraceae, Xylographaceae.

Ninety of 116 newly recorded species were found in forest habitats, 14 species in parks/wooded meadows and roadside alleys, eight on rocks and outcrops and four species in disturbed/ruderal habitats (mainly on soil). Most of newly reported taxa were epiphytic and epixylic lichens, but the number of lichenicolous fungi (37 species) was notable too. Out of newly recorded species 39 were found on tree bark, 24 species were found on dead wood; eight species on sand/soil; eight on stones and man-made calcareous substrates, two species on conifer resin, two on roots of windthrows, one on sandstone.

According to The Nature Data Management System called “OZOLS”, maintained by Nature Conservation Agency (under Ministry of Environmental Protection and Regional Development of the Republic of Latvia), 1842 records of 41 noteworthy lichen species were collected in 6-year period (2015-2020), and 754 records of 37 noteworthy lichen species were veriefied by author of thesis (Anonymous 2021). In addition, c.a. 2000 lichen and allied fungi herbaria units which represent 227 species of lichens and allied fungi are collected and positioned in lichenological herbarium of Daugavpils University (DAU).

3.2. The revision of genus *Cetrelia* in Latvia

In total, 98 specimens (collected between 1957 - 2018) were examined from two herbarium collections (RIG and DAU), as these collections contain the majority of *Cetrelia* specimens collected in Latvia. Of these 19 specimens were found by author of thesis. All examined material was sterile (without apothecia). From the examined specimens *Cetrelia cetrarioides* and *C. olivetorum* accounted for 43% and 42% while *Cetrelia monachorum* appears to be the rarest – with 15% of the examined specimens. In this study, *Cetrelia monachorum* was reported for the first time for Latvia. The studied specimens of genus *Cetrelia* mostly were found on *Alnus glutinosa*, *Fraxinus excelsior*, *Populus tremula*, *Tilia cordata*, *Quercus robur* and less frequently (7% of specimens) on *A. incana*, *Betula pendula*, *Corylus avelana*, *Padus avium* and *Picea abies* (**VI**).

3.3. Lichen richness on dead wood in post-harvest sites

Fifty-four species of lichens and allied fungi were recorded in young regenerated *Vacciniosa* forest type from all sampled substrata types (FWD, snags, stumps, logs) from 16 study sites (detailed list see in Appendix 1 Paper **I**). Most of the species found are common in Latvia, but three were recorded for the first time in the country, namely, *Calicium trabinellum* (on log and stump dead wood), *Pycnora sorophora* (on stump bark and dead wood), and *Scoliciosporum sarothamni* (on fresh FWD) **(I, III**). Stumps (n = 64) were inhabited by 48 species. FWD (n = 32 subplots) was inhabited by 43 species. On snags (n = 9) 27 species were recorded, and on logs (n = 24) 44 species. In addition, one Red-listed lichen in Latvia – *Cladonia parasitica* – was found in seven sites (all 9–11 yr. post-harvest), growing on horizontal surfaces of stumps and logs (**I**). However, stump characteristics varied only slightly among cut site treatments (see Table 2); also volumes of FWD and CWD were relatively low and similar among site treatments (p = 0.454 and p = 0.876, respectively; Table 2 and Appendix 2 in Paper **I**).

Table 2. Characteristics of stumps, downed fine and coarse woody debris (FWD and CWD, respectively) in cut sites of different age and green tree retention (GTR) level (high ≥14 and low ≤6 trees/ha). Within each site combinations 16 stumps were sampled per study plot.

Age	**4-6 yr.**		**9-11 yr.**	
GTR	**High (n=4)**	**Low (n=4)**	**High (n=4)**	**Low (n=4)**
Stumps				
Heigh (cm)	18.4±5.6	20.4±2.3	20.3±3.1	21.6±3.2
Diameter (cm)	37.1±8.3	29.2±4.0	31.4±5.8	28.8±7
Horizontal area (dm^2)	11.3±4.5	6.8±1.7	8.0±2.8	6.9±3.1
Vertical area (dm^2)	22.1±10.5	18.7±3.3	20.2±5.7	19.6±5.4
Functional horizontal area (dm^2)	9.2±4.1	6.0±1.4	5.4±2.6	5.3±2.6

Functional vertical area (dm^2)	16.4±9.6	14.8±3.4	11.7±5.1	13.2±4.4
Volume (m^3)	0.02±0.01	0.01±0.004	0.02±0.01	0.02±0.01
FWD				
Volume (m^3/ha)	0.77±0.22	0.91±0.28	1.14±0.43	0.96±0.27
CWD				
Volume (m^3/ha)	0.36±0.18	0.30±0.18	0.32±0.17	0.32±0.21

Based on the final GLM model, the total and mean species richness on stumps depended on cut site age (higher richness in 9–11 yr. sites) and on GTR level (higher richness in sites with “high” GTR level; Table 2 in Paper (**I**), Fig. 5 A). The interaction between age and GTR level, as well as stump-scale variables (average stump functional area and diameter per site) were non-significant. Any of tested variables had no significant impact on FWD total species richness (Results in Paper (**I**) Fig. 5 B).

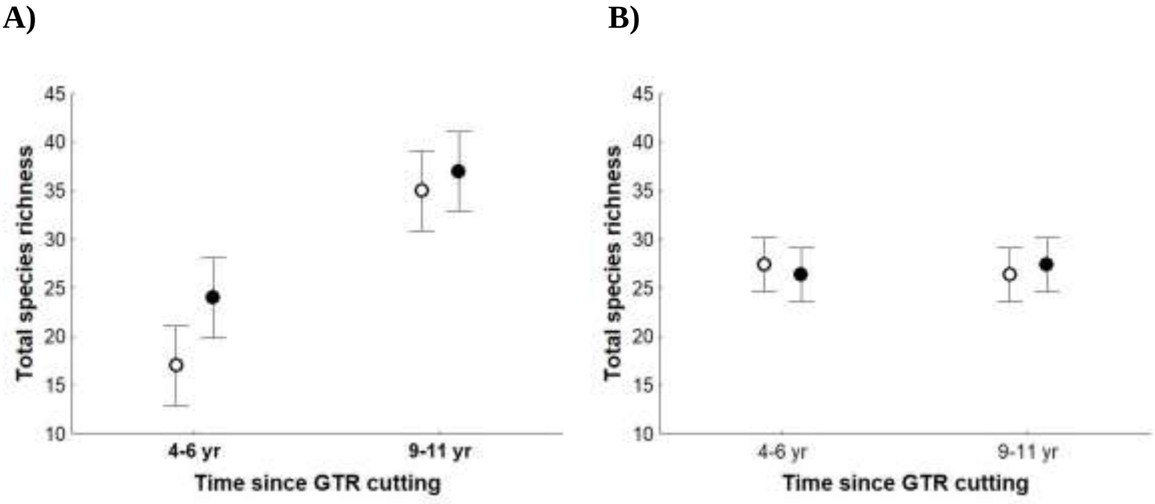

Figure 5. Total species richness on pine stumps(A) and fine woody debris (B) on 4–6 and 9–11 yr. post-harvest sites with low (≤ 6 trees/ha; open symbol) and high (≥ 14 trees/ha; filled symbol) green tree retention (GTR) level. For each treatment of post-harvest sites 16 stumps and eight 2x8m subplots for fine woody debris were surveyed.

3.4. Lichen assemblage composition on stumps and FWD in post-harvest sites

Lichen assemblages on stumps differed between age groups of cuts within the same GTR level (MRPP test; A = 0.2 and 0.4, p = 0.006 for both) and between high and low GTR level sites of the same age (A = 0.2, p = 0.007 for both). Such groupings were slightly visible in the NMS ordination (Fig. 6 A). Among tested environmental variables average functional area of the stump correlated with the second ordination axis ($r^2 = 0.24$). Lichen assemblages on FWD differed between age groups of cuts within the same GTR level (A=0.1, p=0.01 for both cases), but high and low level GTR sites had similar assemblages within the same cut age (for 4–6 yr. cut sites A=0.05, p=0.06 and for 9–11 yr. sites A=0.04, p=0.10). This pattern is visible also on NMS graph (Fig. 6 B) and none of the tested environmental variables (volume of FWD and CWD) correlated with ordination axes ($r^2 < 0.2$).

Similar assemblage patterns (age difference and dependence on GTR level) emerged also if stump vertical and horizontal surfaces were analyzed separately (A=0.1–0.2, p=0.02–0.01). In addition, vertical and horizontal surfaces differed from each other within the age × GTR level treatment (MRPP test A=0.2–0.5, p=0.01; Fig. 6 B). Focus on horizontal stump surface only (as the case of post-harvest colonization) showed clear difference of assemblages between 4–6 yr. and 9–11 yr. cut sites both on wood and on cut bark around the stump (A=0.5, p<0.001). Focus on assemblages on wood only revealed the difference between horizontal and vertical surfaces of stumps both on 4–6 yr. (A=0.4, p<0.001) and 9–11 yr. (A=0.3, p<0.001) cut sites.

The indicator species analysis (ISA) showed that 19 stump-dwelling species (seven of them from genera *Cladonia*) associated significantly with 9–11 yr. cut sites, four of them showing also the preference for GTR level (like *C. parasitica* on sites with lower GTR level, and *C. chlorophaea* on sites with higher GTR level). At the same time, only five species (*Bryoria fuscescens*, *Platismatia glauca*, *Sarea resinae*, *Scoliciosporum chlorococcum* and *S. sarothamni*) showed affinity for FWD (Paper **I**, Appendix 3).

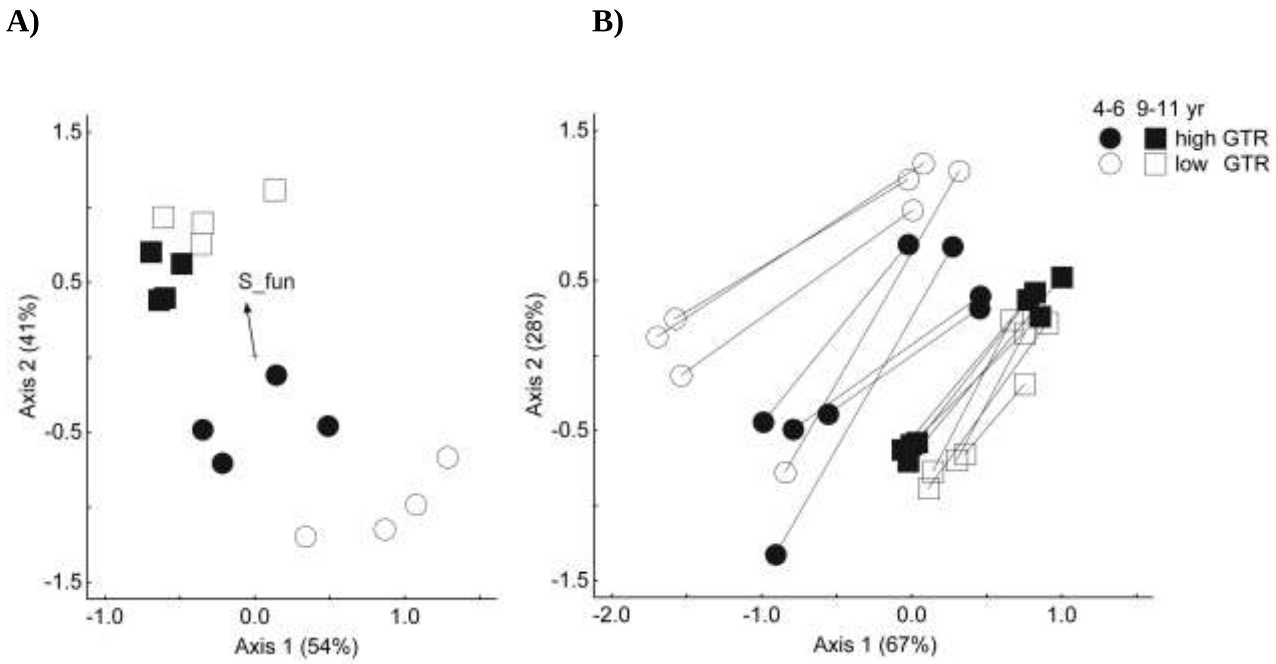

Figure 6. Total composition of lichen species assemblages on pine stumps (n = 4 stumps per site) on young and old (4-6 and 9-11 years, respectively) post-harvest sites with high (14-25 trees/ha) and low (≤ 6 trees/ha) green tree retention (GTR) level (A). Vector on the graph indicates that functional area of stumps (i.e. stump area not covered by bryophytes, S_fun) is related to the second ordination axis. Graph (B) illustrates lichen assemblages separately on vertical and horizontal surfaces of pine stumps (joint symbols on the left and right, respectively).

3.3.2. Distribution of lichen functional traits in post-harvest sites

The distribution of ten functional trait types and their characteristics within the set of 47 species of lichens and allied fungi found on stumps in young (4-6) and old (9-11) post-harvest sites is presented in the Table 3. Among lichenized species the dataset included only chlorolichens (i.e. no species with cyanobacteria or trentepohlioid algae) and dominated species with thallus that had grey or green to greenish grey colour; most of lichenized species contained also acetone soluble lichen secondary compounds. Prevailing reproduction types within the dataset of stump inhabiting species was vegetative. Among sexually disersing species spore traits did not have large variation in the dataset: most had one-celled spores and species with hyaline spores dominated over species with coloured spores, as well as more common were species with smooth surface and species with medium size spores (10-20 µ).

Based on results of Two-way ANOVA, the distribution of trait characteristics within trait types “Thallus type”, “Thallus colour” and “UV substances” differed between young (4–6 yr.) and old (9-11 yr.) post-harvest sites ((F($_{2,42}$) = 9.921, p < 0.001, F($_{3,56}$) = 11.338, p < 0.001 and F($_{1,28}$) = 26.468, p < 0.001 respectively)). Based on Tuckey HSD Post Hoc test, old sites presented higher mean richness of species with crustose and fruticose thallus (p<0,001; Fig. 7 A), species having greenish to greenish grey and yellowish green thallus colour (p<0,01; Fig. 7 B) and species with UV-protective substances (p < 0.001; (Fig. 8 B).

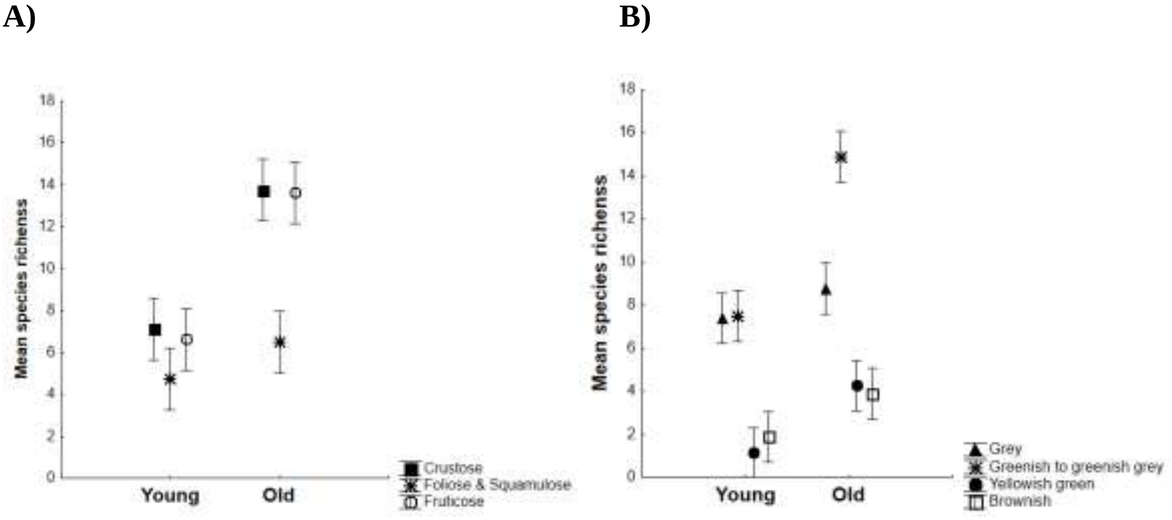

Figure 7. Mean species richness (with standard error) of different thallus type (A) and thallus colour (B) traits on stumps in 4–6 and 9–11 yr. post-harvest sites. Sample sizes see Table 3.

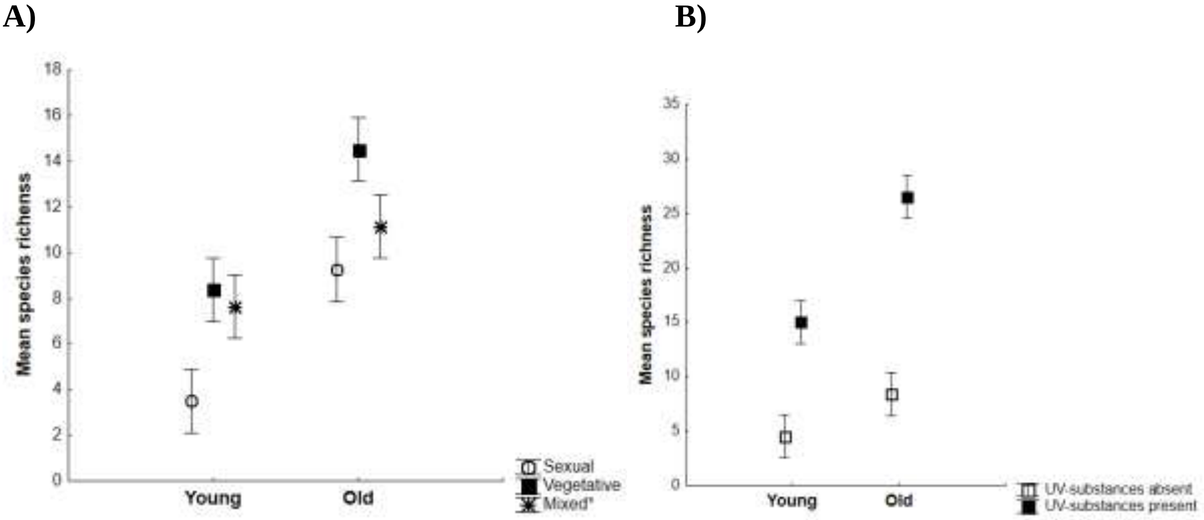

Figure 8. Mean richness of species (with standard error) according to their reproduction traits (A), and presence/absence of UV-protective substance(s) (B) on stumps in 4–6 and 9–11 yr. post-harvest sites. * - Two types of reproduction (vegetative and sexual) are applicable for one species. Sample sizes see Table 3.

Table 3. Studied lichen functional trait types and distribution of their traits in the set of lichen and allied fungi (in total, 47 species) found on Scots pine stumps in young (4-6 yr.) and old (9-11 yr.) post-harvest sites (per age treatment N = 32 stumps from 8 sites).

Functional trait types and traits	**Number of species**			**Mean±SD**	
Thallus type (N = 47 species)	**Young**	**Old**	**Total**	**Young**	**Old**
Non-lichenized	1	1	1	-	-
Crustose	12	18	18	7±1.6	14±2
Leprose and granulous	4	8	8	3±0.6	6±1.1
Crustose with cortex	5	6	6	2±0.9	5±0.7
Endosubstratic (calicioids, Micareas)	3	4	4	2±0.6	3±1
Foliose and squamulose	8	9	10	5±1	7±0.9
Fruticose	14	18	18	7±3.9	14±1.4
Cladonia-type	9	11	11	4±2.5	10±0.5
Pendulous	0	1	1	-	-
Erect fruticose	5	6	6	2±1.5	3±1.3
Thallus color (N = 47 species)					
No colour, thallus endosubstratic	2	3	3	-	2±0.5
Non-lichenized	1	1	1	-	-
Grey (atranorin)	12	13	14	7±1.9	9±1.5
Greenish to greenish grey**	14	19	19	7±3.2	15±2.2
Yellowish green (usnic acids)	3	5	5	1±0.8	4±0.7
Lemon yellow (pulvinic acid derivtives)	1	1	1	-	-
Anthraquinones	0	0	0	-	-
Brownish (acetone-non-soluble substances)	3	5	5	2±0.4	4±0.6
Substances (N = 47 species)					
No acetone-soluble lichen substances	5	5	5	2±0.9	4±0.9
Acetone-soluble lichen substances present	30	41	42	17±5	31±2.7
UV-substances (N = 47 species)					
UV-protective substances absent	7	10	11	5±1.1	8±1.4
UV-protective substances present	27	35	36	15±4.7	27±2.1
Reproductiot type (N = 47 species)					
Sexual	8	12	12	4±1.3	9±1.7
Apothecia	5	8	8	2±0.9	6±1.3

Stalked apothecia (calicioids)	3	4	4	1	3
Perithecia	0	0	0	-	-
Asexual (pycnidia)	0	0	0	-	-
Vegitative	15	20	20	8±3.3	15±0.9
Soredia	12	17	17	7±2.6	13±1
Isidia	3	3	3	1	1
Mixed ***	12	14	15	8±2	11±1.6
Spore type (N = 47 species)					
One-celled spores	16	20	20	9±2.5	17±1.7
Two-celled spores	4	6	7	2±1	4±1.6
Spores at least three-celled or mural	0	0	0	-	-
Spore length (N = 47 species)					
<10 µ	4	4	4	3±0.6	3±1
10-20 µ	15	21	21	8±2.4	17±2
>20 µ	1	1	2	-	-
Spore colour (N = 47 species)					
Hyaline spores	16	21	21	10±2.3	17±2.
Colored spores	4	5	6	1	3
Spore surface (N = 47 species)					
Smooth surface	17	22	23	10±2.4	17±2.7
Ornamented surface	3	4	4	1	3

***Do not contain atranorin and usnic acids*

**** Two types of reproduction (vegetative and sexual) are applicable for one species*

4. DISCUSSION

4.1. Contributions to the knowledge on lichen and allied fungi biota of Latvia

The total number of lichen and allied fungi species known in territory of Latvia increased by 116 taxa in 6-year period of the author's (co-)studies (**I-VII**). At present, the total biota of lichens and allied fungi counts ca. 700 species in Latvia. Most of newly recorded species are epiphytic and epixylic lichens –species associated mainly with old-growth forest habitats. Current contributions also indicate the lack of research focused on the diversity of certain species groups in Latvia – e.g. wood dwelling lichens, lichenicolous fungi, saprobic calicioid species, saxicolous lichens etc., as most of newly recorded species belong to the above mentioned groups (Papers **II-V and VII**). Out of newly recorded species, several species of lichens are potentially rare and perhaps threatened. For example, such forest species like *Chaenotheca laevigata*, *Cetrelia monachorum*, *Microcalicium ahlneri*, *Parmelia submontana*, are associated with old-growth forests, which are declining in all Baltic countries. Species like *Dermatocarpon miniatum* and *Pilophorus cereolus* grow in unpolluted streams and on undisturbed boulders and sandstones, a habitat type not frequent in the eastern Baltic region. All above mentioned species are rare in Estonia and Lithuania, and considered as threatened (Lõhmus et al. 2019; J. Motiejūnaitė pers. comments). Their situation in Latvia most probably is similar to neighboring countries. At the same time various of newly recorded lichen species like *Leptorhaphis epidermidis*, *Ochrolechia microstictoides*, *Pycnora sorophora*, as well as allied fungi species like *Clypeococcum hypocenomycis* and *Sarea difformis* are probably overlooked in Latvia.

Most of newly recorded species were collected and/or identified by visiting lichenologists (co-authors of Papers **II** and **V**), which is expectable, and demonstrates the importance of foreign specialist involvement with specific knowledge on particular lichen groups. Similar inference was done by Vondrák et al. (2016), who demonstrated that involving more lichenologists with different field experience of lichens in specialized niches is more effective for obtaining more complete species lists. For example, the lichenological meetings with field visits, carried out in Baltic countries in previous years, like Baltic Mycologist and Lichenologist symposium, Nordic Lichen Society meetings, in most cases bring together professionals and amateurs, and it notably raise the knowledge about biodiversity of the region (Motiejūnaitė & Piterāns 1998; Motiejūnaitė et al., 2006; Motiejūnaitė et al. 2012; Paper **II**; Suija et al. 2020, etc).

The general knowledge on several Red-listed, protected, and rare lichen species distribution in the territory of Latvia was noticeably increased. For example: till year 2015, 1052 records of lichens were entered in “OZOLS” while in year 2020 number of Red-listed, protected and rare lichens records was over 4000. Morever, for several species the knowledge on distribution in territory of Latvia has essentialy increased, as an example: only few localities of Red-listed and protected lichen *Mycoblastus sanguinarius* (L.) Norman were known till year 2015, while at the moment of preparation of current thesis (year 2020) over 20 localities were already known. Similar situation is with *Thelotrema lepadinum* (Ach.) Ach. with less than 20 localities known previously, and over 60 localities known at present. However, some rare lichen species like *Bactrospora dryina* (Ach.) A. Massal., *Chaenotheca cinerea* (Pers.) Tibell, *Parmeliella thriptophylla* (Ach.) Müll. Arg., *Protopannaria pezizoides* (Weber) P.M. Jørg. & S. Ekman still have very limited number of known localities, despite the fact that these species can be rather easily recognised in field.

Relative dearth in general knowledge of lichen diversity in Latvia can be explained by the lack of systematical studies of lichens and allied fungi (such as species monitoring programs, targeted ecological studies in different habitat types etc.) and low number of experts capable to identify lichen species in the country. The absence of systematical revisions of lichen herbaria collections, similar as it was done in neighboring Estonia, Lithuania, Belarus (Kukwa & Motiejūnaitė 2012; Motiejūnaitė et al. 2013; Tsurykau et al. 2015; Tsurykau & Golubkov 2015; Motiejūnaitė 2017; Tsurykau et al. 2017; Tsurykau et al. 2018; Randlane et al. 2019; Yatsyna 2020, etc), brings additional lag in knowledge of Latvian lichen biota. Previously, species identification of Latvian lichen material, where also thin-layer chromatography (TLC) methods were applied if needed, was used only in few studies. In most cases, except for the study performed by Mežaka et al. 2012 (b), TLC methods were applied only for miscellaneous collections of visiting experienced lichenologists (e.g., Czarnota & Kukwa 2010). Various lichen genera and groups, in which species determination without TLC methods is problematic, or even impossible, were never revised in Latvia (e.g. *Lepraria*, *Ochrolechia*, *Xanthoparmelia*, various species of genus *Cladonia*, sterile crustose lichens, etc.).

The revision of Latvian herbaria on genus *Cetrelia* (**VI**) was the first targeted revision of lichens using TLC methods. Until therevision, only two species, *Cetrelia olivetorum* and *C. cetrarioides*, were known in Latvia (Āboliņa et al. 2015), while the revision of herbarium material added the third species – *C. monachorum.* Same three species occur also in neighboring Estonia, Belarus and Lithuania (Kukwa & Motiejūnaitė 2012; Bely et al. 2014;

Degtjarenko et al. 2018b; Randlane et al. 2019). In most countries of Northern Europe all species of genus *Cetelia* are threatened and protected (**VI**). So far, only *C. olivetorum* and *C. cetrarioides* are strictly protected by local (Latvian) legislation. The results of Paper (**VI**) show that *C. monachorum* is as rare as *C. cetrarioides* s.str. and *C. olivetorum* s.str. During the upcoming assessment of red-listed species using IUCN criteria, it is suggested to perform the assessment for each species separately, as it was done in case of Estonia (Lõhmus et al. 2019). However, it is suggested to include C. *olivetorum* s.lat. as one conservation unit for legislative lists. Such approach will help to simplify the practical protection of *Cetrelia* species. At the same time, all species of genus *Cetrelia* should be added to monitoring programmes of rare species separately, as it can improve the understanding of the actual situation with each species.

Despite the extensive contribution brought to the general knowledge of lichens and allied fungi during last years, the total number of known lichens and allied fungi species still remains the lowest comparing to the other Baltic States (Motiejūnaitė 2017; Randlane et al. 2019). Current situation indicates the need to include lichens in the monitoring systems of the general species diversity in forest ecosystems, as the knowledge on this group of organisms is very limited in case of Latvia. Also, systematical revisions of lichen herbaria material should be performed using up-to-date literature and methods. Such great amount of work implies the co-operations with specialists from other countries who are familiar with particular groups of lichens and allied fungi, and can contribute in preparation of the new generation of Latvian lichenologists.

4.2. Lichens in post-harvest sites

Various stand- and substrate scale factors, such as volume of dead wood, the level of green tree retention and substrate diversity have an impact on wood-dwelling lichen assemblages, species richness and composition in cut-over sites (e.g. Blasy & Ellis 2014; Ranius et al. 2014; Hämäläinen et al. 2015; Hiron et al. 2017). However, there is a dearth of studies devoted to exploration of forest management activities that shape the richness of wood-dwelling lichens and their assemblages on different substrates in dry boreal post-harvest sites of hemiboreal region.

Altogether 54 species of lichens and non-lichenized fungi were found in dry boreal cut-over sites (**I**) up to 11 yrs. after cutting. The absolute majority of the species found in studied sites are common lichens of coniferous forests in hemiboreal region. Similar prevalence of forest generalist species on dead wood structures was also observed in studies done by Daniëls

(1983) in nemoral vegetation zone of Netherlands, Fałtynowicz (1986) in dry Scots pine sites in nemoral and hemiboreal vegetation zone of Poland, Spribille et al. (2008) in wide geographical scale with large areas of nemoral vegetation zones in Pacific North-West (North America) to arctic-boreal vegetation in Fennoscandia, Hämäläinen et al. (2015) in dry Scots pine sites in mid-boreal vegetation zone of Finland, Hiron et al. (2017) in conifer dominated mid-boreal vegetation zone of Sweden. Moreover, about two-third of the recorded species in study **(I)** are the lichens that may also be found on other substrates and habitats apart from pine wood and bark and from dry hemiboreal forests. For example, despite five species turned to inhabit exclusively wood on studied dead-wood structures (e.g. *Calicium glaucellum, C. trabinellum, Cladonia parasitica, Cladonia stellaris* and *Mycocalicium subtile*). Of these, *C. stellaris* is known as a common epigeic species infrequently occurring also on well decayed wood and bark, same as other species of the subgenus *Cladina* (Motiejūnaitė 2002). However, above mentioned calicioid species are known to be obligate epixyles in neighboring Lithuania and Estonia, as well as in Fennoscandia (Lõhmus & Lõhmus 2001; Appendix 1. in Spribille et al. 2008). These two calicioid species are more associated with late successional forest ecosystems, and *C. trabinellum* is considered as indicator species of lichen biocenters in neighboring Lithuania (Motiejūnaitė et al. 2004). *Cladonia parasitica* is Red-listed species in Latvia (similar as in neighboring Estonia and Lithuania) and is commonly associated with lying dead wood in natural and near natural pine forest stands. Surprisingly, in this study, *C. parasitica* was found on horizontal cut surface of stumps, but exclusively in older (9-11 year post-harvest) sites, both in high and low GTR level.

4.2.1. Lichen assemblages on stumps and importance of stumps as lichens habitat

Stumps are known to be a one of the lichen-rich dead wood structures, hosting up to a half of dead wood lichen biota, in natural and managed boreal forest ecosystems (Fałtynowicz 1986; Spribille et al. 2008; Hämäläinen et al. 2015; Svenson et al. 2016; Hiron et al. 2017; Ranius et al. 2019). In all above mentioned studies different sampling methods were used, which makes it difficult to compare lichen species richness on stumps among the studies. For example, in study performed by Fałtynowicz (1986) in Poland, author reports 39 species of lichens recorded on stump surface, while Hämäläinen et al. (2015) found 95 lichen species on same tree species (pine) stumps in Finland. Hiron et al. (2017) found 32 lichen species on pine, spruce and birch stumps in boreal forests of Sweden. The study by Spribille et al. (2008) focused on the obligate lignicolous lichen species in a large-scale geographic area and authors mention that among studied dead wood types, stumps are the structures which host highest number of obligate lignicolous lichens - 53. Blassy and Ellis (2014) reported 46 species of lichens on pine stumps in north-east Scotland. In case of Latvia (study **I**) 48 stump-dwelling lichen species were found. However, despite the difference in sampling and geographical location of study sites, in all above mentioned studies, and in the case of Latvia, authors conclude that stumps are among most lichen species rich structures in boreal forests, both, young and old, ranging total species richness on pine stumps at least between 39-48 species.

The results of study (**I**), similar to the study performed by Hämäläinen et al. (2015), Ranius et al. (2019) in Fennoscandia, and Fałtynowicz (1986) in Poland, showed that pine stumps are lichen species rich substrate even in early-successional stages. Fałtynowicz (1986) found that the vast majority of lichen species on early successional stumps (e.g. 1-5 year after felling) are epiphytes growing on remaining pine bark, which was not yet detached from wood. In addition, Fałtynowicz (1986) also suggested that colonization of cut surface of stumps by lichens is intensive 6-10 years after the logging, and the peak of lichen diversity falls on 11-16 yr. old stumps. Also, the studies of Fałtynowicz (1986) and Humprey et al. (2002) in European temperate forests, and Kruys et al. (1999) and Caruso & Rudolphi (2009) in Fennoscandian boreal forests showed that lichen diversity on conifer dead wood tends to peak at intermediate and late decay classes. The findings of study (**I**) supports the conclusions of above mentioned studies, showing that species richness of horizontal surface (cut surface) is almost two times higher in 9-11 years old post-harvest sites than in 4-6 years old sites. Also in study (**I**) it was demonstrated that early-successional (4-6 yr. old) stumps can host up to 18 species of lichens and allied fungi, and most of these are epiphytic species found on the remaining bark. In next five years of succession (9-11 yr. old stumps) species richness can almost double comparing to 4-6 yr. old stumps, and most of species are wood-dwelling, as the bark has already detached, and the variability of decay classes per stump is high. This indicates relatively rapid colonization speed of lichens on the particular substrate within the decade and makes stumps valuable component for lichen diversity conservation in early-successional post-harvest sites.

The results of study (**I**) for the first time demonstrated clear difference of lichen assemblages on vertical and horizontal surfaces of stumps, showing clear evidence of separate vertical and horizontal assemblages. So far only one study has explored impact of post-harvest age and green tree retention practice on wood-dwelling lichen assemblages in dry boreal pine cut-over sites (Hämäläinen et al. 2015). Comparing the study performed by Hämäläinen et al. (2015), in study (**I**) lower number of stump-dwelling species was recorded. Such difference in species richness can be explained by distinction of geographical and climatic conditions, as well as lichen species diversity and composition differences in boreal and hemiboral vegetation zones. For example, recently such regional differences in lichen assemblages on different wood legacies were demonstrated by Lõhmus et al. (2018), in post-fire sites.

As it was expected, assemblages on younger (4-6 yr. old) and older (9-11 yr. old) stumps significantly differ; this can be explained by predominance of bark-dwelling species on young stumps, and colonization of obligate and facultative epixylic species on older stumps caused by exposure of wood substrate on stumps, similar as it was noticed by Fałtynowicz (1986). Moreover, such ability for rapid changes in lichen assemblages could be explained by evolutionary adaptation of wood-dwelling species to natural disturbances (e.g. windbreaks) which could be similar to logging process, e.g. evolutionary species pool concept suggests that most species are adapted to the naturally most abundant habitats (Taylor et al. 1990). However, the recent study of Ranius et al. (2019) showed that the evolutionary species pool concept did not explain patterns of species' occurrences (including lichens) on different wood substrates in Sweden. However, more empirical studies are needed for each habitat to understand how natural disturbances should be emulated to promote biodiversity in post-harvest sites.

The results of study (**I**) showed that the cover of bryophytes on stumps increases along the time, shaping the assemblages of lichens. Such pattern potentially can lead to the reduction of available dead wood area on stumps in second decade cut-over sites. This problem potentially could be solved by increasing mean height of stumps, to reduce the speed of bryophyte colonization and increase the available area of dead wood (functional area, not covered by bryophytes) on stumps, in logging sites, similar improvements in boreal forest management were also proposed by Blasy & Ellis (2014).

Stump harvesting, commonly practiced in Fennoscandia (Sweden and Finland), is shown to have a negative impact on wood-dwelling lichen diversity in cut-over sites (Hämäläinen et al. 2015; Persson & Egnell 2018). So far, in Latvia, stump harvesting is not much practiced, and the effects of stump extraction in cut over-sites are still being under study (Lazdiņš et al. 2009; Lībiete et al. 2019). Even more, as study (**I**) indicated that where there is notable low number and volume of logs and snags in the study sites, stumps may appear to be the main source of dead-wood for lichens during first post-logging decades in cut-over sites of Latvia. For further studies, it is suggested to make a focus dead wood-dwelling lichen assembledges in 30-40 yr old post-harvest sites, as the first forest management activities, such as thinning, are usually performed in this period. At about the same time, dead-wood structures (including stumps) saved during the harvest, most probably are totally decorticated or overgrown by bryophytes/vascular plants. In such case, mid-aged sites can have even lower amount of available dead wood substrates for lichens, than first two decade regenerated sites.

4.2.2. Lichen functional traits on stumps

Studies that explore functional diversity (e.g. variability of microclimatic conditions in forest structure, species functional trait variability etc.) in young/managed forests are rather recent. Bäcklund (2016) in Sweden, Benítez et al. (2018) in tropical montane forests in southern Ecuador, and Malíček et al. (2019) in Czech Republic showed that analysis of lichen functional traits can contribute to the deeper understanding of the mechanistic processes that control species distribution in managed forest ecosystems. However, the studies that explore the changes in the composition of lichen functional trait groups in regenerated dry boreal forests still lack. In study performed by Bäcklund (2016), non-native phorophytes were also in focus, which makes result comparison problematic. According to Friedl and Büdel (2008) chlorolichens are the most common among lichens. The results of study (**I**) also showed, that vast majority of the recorded stump-dwelling lichens were chlorolichens or non-lichenized fungi. The predominance of chlorolichens in young cut-over sites is supported by findings of Stofer et al. (2006) in main biogeographic regions of Europe (including boreal Finland) who showed that the proportion of chlorolichens increases with intensification of land use. However, mature and old-growth forests should be analyzed to get deeper understanding about the effect of logging activities on lichen photobiont composition changes in stands.

Stump dataset of the study (**I**) contained more species with vegetative and mixed reproduction strategy, than species with predominant sexual reproduction. Higher proportions of asexual species in managed rather than in primary forests was previously demonstrated in China and Czech Republic (Li et al. 2013; Malíček et al. 2019). At the same time, the results of other studies performed by Stofer et al. (2006) in in main biogeographic regions of Europe (including boreal Finland), and Lundström et al. (2013) in Sweden show an opposite pattern. Meanwhile Bässler et al. (2016) found that asexual reproductive mode facilitate establishment under low temperature conditions. However, all mentioned studies were performed in different forest ecosystem types, outside hemiboreal region. Such pattern differences could be also explained by different study designs and differences in study objects (e.g. stand scale and structure scale variables).

The fungal partner in lichens (mycobiont) reproduces sexually with spores same as other fungi. Most lichen ascospores are small, approximately 1–30 µm, which could be related to the substrate colonization strategy and dispersal over great distances (Hansson et al. 1992). Large ascospores, similar to vegetative propagules are supposed to disperse over a shorter distance, which makes large ascospores important for population turnover at a site-level dispersion, rather than to dispersal of the species over a longer distance (Hansson et al. 1992). The ascospore anatomical and physical characteristics like spore size, colour and cell number etc. - the traits, which can affect the dispersion ability of forest-dwelling lichens, especially in such extreme conditions like post-harvest sites. Based on dataset of study (**I**) species which inhabit stumps (both young and old ones) in most cases produce small or medium size, hyaline, one celled spores without ornamentation. Species with large spores are extremely uncommon on studied stumps, which does not concur with findings by Hansson et al. (1992). Nevertheless, similar pattern - prevalence of one-celled medium size spore species on dead wood substrates – was found by Pentecost (1981) for lichens distributed in Britain, indicating the ecological importance of this spore trait, for the colonization of short-living substrates (e.g. dead wood). Only several species found in post-harvest sites (both young and old) in study (**I**), (calicioids and species from genus *Physcia*) have dark spores, and none of species have such combinations of traits as multi-septate dark spores, but older (9-11 yr.) stumps can host more species with unique spore and fruit body traits (mostly calicioids), such as stalked apothecia containing dark ornamented spores. Several reproduction traits were not represented among studied species at all (e.g. perithecia or pycnidia). Also, species with multi-septate (>two-celled) spores were not found. The prevalence of small hyaline spores, probably may explain the prevalence of common species in dataset, species which tendd to disperse in large distances. However, most of stump-dwelling lichens colonized stump bark before the harvest, which makes theinterpretation of spore trait results problematic.

The colour of the upper surface of lichen thallus is mostly determined by the type of secondary lichen compounds and photobiont type and/or by pigments (such as melanin) of fungal cell walls of cortical hyphae. (Butler & Day 1998; Brodo et al. 2001; Elix & Stocker-Wörgötter 2008). Many secondary lichen compounds and pigments can function as UV-filters (Nguyen et al. 2013). The studies done by Kershaw (1975) indicate that thallus colour appears to modify the temperature of the thallus. Moreover, it was found that light thallus forms are more represented in habitats with high light intensity in lower forest layers (Robinson et al. 1989), while in forest canopy lichen assemblages, dark thallus forms (such as *Bryoria*), which contain melanin, can be more common than usnic acid containing species – e.g. *Usnea* and *Alectoria* (Färber et al. 2014). The results from stump-dwelling lichens show that almost ¾ of recorded species in the studied cut-over sites contain UV-protective substances. Natural dry boreal forests are known to be one of the most sun exposed forest types in hemiboreal region. However, the light intensity in young regenerated forest sites, especially in the first decade, is supposed to be even higher than in mid-aged or old forest ecosystems, except for the cases when natural disturbances such as windbreaks and/or forest fire has affected the ecosystem. Robinson et al. (1989) suggested that the increasing proportion of light-coloured lichens along a light intensity gradient is an expected pattern. The stump dataset analysis of study (**I**), supports the hypothesis, that the pale-coloured lichen thalli traits are more common in well-lit conditions, than the dark ones. Moreover, it is obvious that most of bark dwelling species found on stumps in study (**I**) are the species which survived after the unnatural disturbance (forest harvest). Such finding allows to suggest that presence or absence of the UV-protective substances, and color of thalli (which in many cases are defined by lichen substances), are expected to be one of the key traits associated with the survival/extinction of species populations under disturbance conditions, at least in a short-term perspective.

We found that on 9-11 yr. old stumps the proportion of crustose and fruticose thalli (the latter mainly represented by species of genus *Cladonia*), was higher than of species with foliose and squamulose thalli, and it doubled on older stumps compared to the younger (4-6 yr old stumps) ones. Similar prevalence of crustose and/or Cladonia-type lichens on conifer dead wood in boreal sites are reported by Faltynovicz (1986); Caruso et al. (2010); Hämäläinen et al. (2015; 2021). Caruso et al. (2010), showed also the rapid increase in occupancy of conifer stumps by crustose species during the first decade. Moreover, stumps in older successional stage were also in focus in studies performed by Faltynovicz (1986) and Caruso et al. (2010), and the replacement of crustose species by species with other thallus traits was observed in both cases. Also, in both of above mentioned cases, authors conclude, that in the end of the second decade after harvest, most of stump wood surface was covered by bryophytes, and was not functioning as a full-scale substrate for lichens.

4.2.3. Fine woody debris

Nowadays, harvesting of stump and fine woody debris for biofuel production is well practiced in Fennoscandia. However, in Baltic countries the harvest of FWD is much more common than stump extraction. Moreover, Baltic States are among largest wood pellet producers in Europe, and FWD is used as one of the main raw materials for wood pellets production. The potential impact of FWD (including slash) harvest on lichens richness have been assessed to be modest in mid-boreal spruce (Caruso et al. (2008); Svensson et al. (2013) and pine dominating sites (Hämäläinen et al. (2015). Hämäläinen et al. (2015) found 69 lichen species on FWD in post-harvest pine sites, while in study (**I**) 43 species (e.g. approx. 90% of species found on stumps); in both studies most of the recorded lichens were common epiphytes of hemiboreal and boreal forests. Similar to stumps, lichen assemblages on FWD changed and became more distinct in time. This result cannot be considered obvious, as according to Caruso et al. (2008) and Hämäläinen et al. (2015) downed FWD is a less specific lichen habitat and hosts mainly generalist species that are tolerant to environmental change and (or) have good establishment abilities. In case of study (**I**) five species showed affinity for FWD, of these *Platismatia glauca* and *Bryoria fuscescens* which commonly are associated with lichen communities on tree trunks and twigs in boreal forests, and *Sarea resinae* which is usually found on resin of *Picea abies*. However, FWD fraction consist of both pre- and post-harvest legacies and thus transition from corticolous to lignicolous communities can take place already on early post-harvest sites. Hiron et al. (2017) estimated the impact at the landscape scale and found that beetles and fungi were more affected by stump extraction, while lichen abundance was more affected by slash extraction. Thus, the large scale study focused on FWD extraction effect on lichen diversity in a landscape-scale, are needed in Latvia as well as in other Baltic countries.

4.2.4. Forest management and lichens

Even though sample size for stumps in our study was considerably lower, tsimilar results as in Hämäläinen et al. (2015) were obtained, i.e. higher retention level favors higher species richness on cut stumps. That can be explained by an additional pool of epiphytic lichens dwelling on retention trees (Hämäläinen et al. (2015). Altogether the result of study **I** implies that after the first decade following the harvest, the impact of green tree retention level on lichen species diversity on woody substrata has decreased. However, taking into account the sample size of study (**I**), the larger-scale study is necessary to test this hypothesis.

The results of the study **I** showed that dead wood structures in young cut-over sites can host notable lichen and allied fungi species richness during the first decade after the logging. However, the deficiency of dead wood legacies (logs and snags) in studied post-harvest sites was observed. Though snags were considerably lower in numbers, the species richness recorded on them was notably high and total frequence of some species was even higher than on stumps (e.g. for calicioids *Calicium glaucellum* and *C. trabinellum*). This indicates the importance of snags as valuable habitat for epixylic lichens on harvested sites (see also Runnel et al. 2013; Santaniello et al. 2017), as stumps probably cannot replace spectrum of habitats provided by snags (for example: kelo wood, dry wood above 2 m from ground, etc.), despite they have vertical wood surfaces similar to snags (Hämäläinen et al. 2021). The scarcity of logs and particularly of snags in post-harvest pine forest sites can be explained by local traditions of wood use as a source of firewood for house heating and illegal collection of firewood in recently cut sites (such local tradition of ‘‘cleaning’’ of cutovers have been reported also in Estonia, see Lõhmus et al. 2013). Also, disregard of local laws by logging companies is a possible cause, along with inadequate inspections by responsible environmental institutions.

Given the small sample size of tested treatment groups in the current study, general management recommendations cannot be reliably proposed and the landscape-scale impact of FWD and stump harvest on lichen biodiversity should be studied in future. Still, our study indicates clearly that harvest of pine stumps can increase negative effect to the lichen richness, as stump “life-time” is much longer than of FWD and pine stumps can be inhabited by species of conservation concern, such as *Cladonia parasitica*. According to the results of study (**I**), the level of green tree retention is supposed to have an effect on lichen species richness on stumps. Also, relatively high lichen species diversity on FWD show that the effect of FWD harvesting should be estimated more precisely in following studies. However, in this study the sample size was relatively low, thus the effect of green tree retention level on dead wood dwelling organisms should be studied in more detail, both in sites with group and dispersed green tree retention.

To follow sustainable forestry certification standards (e.g. FSC, PEFC etc.) forest management companies allowed to retain “high stumps” (live trees cut at height 2–4 m from the ground). Such structures have relatively high value for saproxylic beetles (Abrahamsson & Lindbladh 2006). In studies done by Hämäläinen et al. 2021, authors demonstrate that creation of 3-5 m high “stumps” in cut-over sites has limited value for lichen diversity in c.a. first 20 years. However, authors also mention, that long-term effect of such structure creation should be studied yet. Thus, the true long-term value of high stumps for lichens in post-harvest sites should be explored in more detail, making accents on experimental studies with stump height, both in harvested sites, and in mid-aged production forests as well. The effect on lichens of the measures proposed by Blasy & Ellis (2014) – the retention of stumps with different height has not yet been studied. Therefore, the retention of stumps with height of about 1 – 1.5 m along with “normal heigt” stumps can be studied, as an alternative to “high stumps”. Such activities could be combined with group green tree retention, which would reduce the mechanistic problems related to further forest management activities (e.g. planning the technological corridors for forest technique, preparing soil for planting of saplings etc.). The long-term effect of dead wood preservation, on lichen diversity during mid-aged boreal forest management should be studied more detaily, as the number of such studies is very limited. Sustainable forest management panning needs gathering and analysis of more detailed empirical data on biodiversity and its components for modeling the most appropriate management activities (for example species composition and assemblage changes in specific stuctures, forest types, and forest successional stages, microhabitat quantity, and quality in forest sites, population structure of specie etc.).The importance of man-made vertical deadwood (for example “high stumps”, and stumps up to 1.5 m), as well as natural downed structures (e.g. logs) for lichen diversity in boreal cut-over sites, especially in the longer time span post harvest has yet to be studied.

SUMMARY AND CONCLUSIONS

- The findings of this thesis showed that the general knowledge on biota of lichens and allied fungi in Latvia was limited, as extensive contributions done during the last years brought knowledge on 116 taxa, new for Latvian biota. In addition, the revision of genus *Cetrelia* showed the importance of regular revisions of lichen herbaria material using adequate methods of species determination. New records of previously unknown species of lichens and allied fungi in Latvia are expected in near future, as the total number of species in the country still remains the lowest among neighbouring as well as Northern European countries, and large number of lichen groups still need to be revised. Thus, the integration of lichens as organism group in Latvian biodiversity monitoring programs/systems is critically important, as various of newly recorded species are rare and threatened in other Baltic countries or/and in Northern Europe. This brings additional doubts about real knowledge of actual state of lichen biodiversity and possible threats in Latvia.

- In our study it was found that first decade post-harvest forest lichen biota can be relatively diverse, even under the condition that the performed study focused only on dead wood of only one tree species (Scots pine) in particular conditions (*Vacciniosa* type forests) and the number of sampled sites was not high. The higher level (30-40 m3/ha) of green tree retention as a conservation measure in post-cut sites showed the positive effect on stump-dwelling lichen species richness in first years after disturbance (i.e. logging). Still, the overall low amount of natural dead-wood structures (e.g. logs and snags) observed in most harvested study sites, may reduce the positive impact of green tree retention. In addition, low amount of FWD, and at the same time relatively high lichen species diversity show that the effect of FWD harvesting should be estimated more precisely in following studies. Stumps were among the most lichen species rich substrate in our study. It was found that lichen species richness on stumps can almost double in ca 5-year period. Stump dwelling lichen assemblages were distinct among young (4-5 yrs) and old (9-11 yrs) stumps, and also distinct between same age sites with different level of green tree retention. This allows to suggest that level of green tree retention can affect the formation of lichen assemblages in post-harvest sites.

- It was found that lichen assemblages on young stumps formed by lichens with different thallus types, change along the time becoming more represented by crustose and fruticose species on old stumps. Also, both young and old stump lichen assemblages are represented by species which spread by vegetative propagules, or both vegetative propagules and ascospores. Among lichenized species the dataset included only chlorolichens. Moreover, at least ¾ of recorded stump-dwelling species in the studied cut-over sites contain acetone-soluble UV-protective substances, and most of the recorded species have light thallus colour, which can be explained as the selection of particular traits by rapidly changing environmental conditions in post-cut forests. The long-term studies are purposed for the estimation of a real effect of forest management on lichen diversity.

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REFERENCES

1. Āboliņa, A., Piterāns, A. and Bambe, B. (2015). *Lichens and bryophytes in Latvia. Checklist.* Latvijas Valsts mežzinātnes institūts 'Silava'. DU AA Saule, in Latvian. Pp. 213.
2. Āboliņa, A. and Vimba, E. (1959). *Latvijas PSR Mežu ķērpju un sūnu noteicējs*. Latvijas valsts izdevniecība. Pp. 192. (in Latvian).
3. Abrahamsson, M. & Lindbladh, M. (2006). A comparison of saproxylic beetle occurrence between man-made high- and low-stumps of spruce. *Forest Ecology and Management, 226*, 230–237.
4. Ahti, T., Hämet-Ahti, L. & Jalas, J. (1968). Vegetation zones and their sections in northwestern Europe. *Annales Botanici Fennici, 5,* 169–211.
5. Ahti, T., Stenroos, S., & Moberg, R. (Ed.) (2013). *Nordic Lichen Flora Vol. 5. Cladoniaceae*. Museum of Evolution, Uppsala University. Pp. 117.
6. Andersson, L., Kriukelis, R. & Skuja, S. (2005). *Woodland key habitat inventory in Lithuania*. Vilnius: Lithuanian Forest Inventory and Management Institute, Kaunas; Linköping: Regional Forestry Board of Östra Götaland. Pp. 129.
7. Anonymous. (2020). *Central Statistical Bureau of Latvia*. (Accessed 10th June 2021). https://www.csb.gov.lv/lv/statistika/statistikas-temas/lauksaimnieciba/mezsaimnieciba/tabulas
8. Anonymous. (2021). *The Nature Data Management System called "OZOLS"*. (Accessed 10th June 2021, in registered user status). https://www.daba.gov.lv/lv/dabas-datu-sistema-ozols.
9. Aragón, G., Belinchón, R., Martínez, I., & Prieto, M. (2016). A survey method for assessing the richness of epiphytic lichens using growth forms. *Ecological Indicators, 62*, 101–105. doi:10.1016/j.ecolind.2015.11.034
10. Asplund, J. & Wardle, D. A. (2017): How lichens impact on terrestrial community and ecosystem properties. *Biological Reviews, 92* (3), 1720–1738.
11. Asplund, J., Sandling, A., Kardol, P., Wardle, D. A. (2014). The influence of tree-scale and ecosystem-scale factors on epiphytic lichen communities across a long-term retrogressive chronosequence. *Journal of Vegetation Science, 25* (4), 1100–1111.
12. Aragón, G., Martínez, I., Izquierdo, P., Belinchón, R., Escudero, A. (2010). Effects of forest management on epiphytic lichen diversity in Mediterranean forests. *Applied Vegetation Science, 13,* 183–194.

13. Bäcklund, S. (2016). *The Introduction of Pinus contorta in Sweden: Implications for forest diversity*. (Doctoral Thesis). Swedish University of Agricultural Sciences. Uppsala. Pp. 59.
14. Barkman, J.J. (1958). *Phytosociology and Ecology of Cryptogamic Epiphytes*. Van Gorcum, Assen. Pp. 628.
15. Bässler, C., Halbwachs, H., Karasch, P., et al. (2016). Mean reproductive traits of fungal assemblages are correlated with resource availability. *Ecology and Evolution, 6* (2), 582–592.
16. Belinchón, R., Martínez, I., Escudero, A., Aragón, G., Valladares, F. (2007). Edge effects on epiphytic communities in a Mediterranean *Quercus pyrenaica* forest. *Journal of Vegetation Science, 18,* 81–90.
17. Bely, P., Golubkov, V., Tsurykau, A., Sidorovich, E. (2014). The lichen genus *Cetrelia* in Belarus: distribution, ecology and conservation. *Botanica Lithuanica, 20* (2), 69–76.
18. Benítez, A., Aragónb, G., Gonzáleza, Y., Prietob M. (2018). Functional traits of epiphytic lichens in response to forest disturbance and as predictors of total richness and diversity. *Ecological Indicators, 86,* 18–26.
19. Blasy, V. & Ellis, C.J. (2014). Life on deadwood: cut stumps as a model system for the succession and management of lichen diversity. *Lichenologist, 46,* 455–469.
20. Brodo, I. M., Sharnoff, S. D. and Sharnoff, S. (2001). *Lichens of North America*. New Haven: Yale University Press. Pp. 795.
21. Brunialti, G., Frati, L., Aleffi, M., Marignani, M., Rosati, L., Burrascano, S. & Ravera, S. (2010). Lichens and bryophytes as indicators of old-growth features in Mediterranean forests, *Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology, 144* (1), 221–233. DOI: 10.1080/11263500903560959
22. Bruttan, A. (1869). Bericht über eine lichenologische Excursion in Kurund Livland. *Sityungsbericht der NaturforscherßGesellschaft bei der Universität Dorpat, 2,* 58–62.
23. Bruttan, A. (1870). Lichenen Est-, Liv- und Kurlands. *Archiv Für Die Naturkunde Liv-, Ehst- Und Kurlands, 2,* (7), 1–166.
24. Bruttan, A. (1889). Nachtrag uz den Lichenen Liv-, Est- und Kurlands. *Sityungsbericht der NaturforscherßGesellschaft bei der Universität Dorpat, 8,* 444–449.
25. Bušs, K. (1976). *Forest classification in the Latvian SSR. (Latvijas PSR meža tipoloģijas pamati).* Riga, Silava. Pp. 24.
26. Butler, M. J. and Day, A.W. (1998). Fungal melanins: a review. *Canadian Journal of Microbiology, 44,* 1115–1136.

27. Cardós, J.L.H., Martínez, I., Calvo, V., Aragón, G. (2016). Epiphyte communities in Mediterranean fragmented forests: importance of the fragment size and the surrounding matrix. *Landscape Ecology 31*, 1975–1995.
28. Caruso, A. (2008). *Lichen Diversity on Stems, Slash and Stumps in Managed Boreal Forests. Impact of Whole-tree Harvest*. (Doctoral thesis). Acta Universitatis agriculturae Sueciae 2008 (3). Pp. 44.
29. Caruso, A & Rudolphi, J. (2009). Influence of substrate age and quality on species diversity of lichens and bryophytes on stumps. *The Bryologist, 112* (3), 520–531.
30. Caruso, A., Thor, G., & Snäll, T. (2010). Colonization-extinction dynamics of epixylic lichens along a decay gradient in a dynamic landscape. *Oikos, 119* (12), 1947–1953. doi:10.1111/j.1600-0706.2010.18713.x
31. Caruso, A., Rudolphi, J., Rydin, H. (2011). Positive edge effects on forest-interior cryptogams in clear-cuts. *PLoS One, 6* (11), e27936. doi:10.1371/journal.pone.0027936
32. Caruso, A., Rudolphi, J., and Thor, G. (2008). Lichen species diversity and substrate amounts in young planted boreal forests: a comparison between slash and stumps of *Picea abies*. *Biological Conservation, 141*, 47–55.
33. Crites, S., & Dale, M.R.T. (1998). Diversity and abundance of bryophytes, lichens, and fungi in relation to woody substrate and successional stage in aspen mixedwood boreal forests. *Canadian Journal of Botany, 76* (4), 641–651.
34. Culberson, C. F. (1972). Improved conditions and new data for identification of lichen products by standardized thin-layer chromatographic method. *Journal of Chromatography A*, *72* (1), 113–125. https://doi.org/10.1016/0021-9673(72)80013-X
35. Czarnota, P. and Kukwa, M. (2010). New and noteworthy lichenized and lichenicolous fungi from Latvia. *Botanica Lithuanica, 16*, 21–27.
36. Daniëls, F.J.A. (1983). Lichen communities on stumps of *Pinus sylvestris* L. in the Netherlands. *Phytocoenologia, 11*, 431–444.
37. Degtjarenko, P., Jüriado, I., Lõhmus, P. (2018b). New Estonian records: Lichenized fungi. *Folia Cryptogamica Estonica, 55*, 151–154.
38. Degtjarenko, P., Marmor, L., & Randlane, T. (2016). Changes in bryophyte and lichen communities on Scots pines along an alkaline dust pollution gradient. *Environmental Science and Pollution Research, 23* (17), 17413–17425. doi:10.1007/s11356-016-6933-5
39. Degtjarenko, P., Matos, P., Marmor, L., Branquinho, C., Randlane, T. (2018a). Functional traits of epiphytic lichens respond to alkaline dust pollution. *Fungal Ecology, 36*, 81–88. https://doi.org/10.1016/j.funeco.2018.08.006

40. Díaz, S., and Cabido, M. (2001). Vive la différence: plant functional diversity matters to ecosystem processes. *Trends in Ecology & Evolution, 16*, 646–655.
41. Ek, T., Suško, U., Auziņš, R. (2002). *Methodology. Inventory of woodland key habitats*. Forest State Service, Latvia, Regional Forestry Board, Riga.
42. Ellis, C.J. (2012). Lichen epiphyte diversity: A species, community and trait-based review. *Perspectives in Plant Ecology, Evolution and Systematics, 14* (2), 131–152.
43. Ellis, C. & Coppins, B. J. (2006). Contrasting functional traits maintain lichen epiphyte diversity in response to climate and autogenic succession. *Journal of Biogeography, 33,* 1643–1656.
44. Elix, J., & Stocker-Wörgötter, E. (2008). *Biochemistry and secondary metabolites.* In: *Lichen Biology.* Nash, T. III (Ed.). Cambridge: Cambridge University Press. Pp. 104–133. doi:10.1017/CBO9780511790478.008
45. ESRI. (2011). *ArcGIS Desktop, Release 10*. Redlands.
46. Esseen, P.-A., Ehnström, B., Ericson, L. & Sjöberg, K. (1997). Boreal forests. *Ecological Bulletins, 46*, 16–47.
47. Ertz, D., Guzow-Krzemińska, B., Thor, G., Łubek, A., Kukwa, M. (2018). Photobiont switching causes changes in the reproduction strategy and phenotypic dimorphism in the Arthoniomycetes. *Scientific Reports, 8,* 4952.
48. Fałtynowicz, W. (1986). The Dynamics and Role of Lichens in a Managed Cladonia-scotch pine forest (Cladonio-Pinetum). *Monographiae Botanicae, 69*, 1–96.
49. Färber, L., Solhaug, K. A., Esseen, P.-A., Bilger, W., & Gauslaa, Y. (2014). Sunscreening fungal pigments influence the vertical gradient of pendulous lichens in boreal forest canopies. *Ecology, 95* (6), 1464–1471. doi:10.1890/13-2319.1
50. Fischer, J.B. (1791). *Versuch einer Naturgeschichte von Livland, 2*. Aufl. Königsberg. Pp. 826.
51. Fischer, J.B. (1778). *Versuch einer Naturgeschichte Livland*s. Leipzig. Pp 728.
52. Fedrowitz, K., J. Koricheva, S. C. Baker, D. B. Lindenmayer, B. Palik, R. Rosenvald, W. Beese, J. F. Franklin, J. Kouki, E. Macdonald, and C. Messier. 2014. Can retention forestry help conserve biodiversity? A meta-analysis. *Journal of Applied Ecology, 51* (6), 1669–1679.
53. Floren, A., Krüger, D., Müller, T., Dittrich, M., Rudloff, R., Hoppe, B., & Linsenmair, K. E. (2015): Diversity and Interactions of Wood-Inhabiting Fungi and Beetles after Deadwood Enrichment. *PLoS One, 10* (11), e0143566.

54. Friedl, T, Büdel, B. (2008). *Photobionts*. In: *Lichen biology*. Nash, T. (Ed.). Cambridge University Press, Cambridge. Pp. 9–26.
55. Franklin, J.F., Berg, D.R., Thornburg, D.A., Tappeiner, J.C. (1997). *Alternative silvicultural approaches to timber harvesting: variable retention harvest systems*. In: *Creating a forestry for the 21st Century: the science of ecosystem management*. Franklin, J.F. (Ed.). Island Press, Washington. Pp. 111–139.
56. Gauslaa, Y. (2014). Rain, dew, and humid air as drivers of morphology, function and spatial distribution in epiphytic lichens. *The Lichenologist*, *46* (1), 1–16.
57. Gerra-Inohosa, L. & Laiviņš, M. (2016). Lichens and mosses in forest ecosystems. Latvijas Veģetācija 25: 5-22. (in Latvian, summary in English).
58. Giordani, P., Brunialti, G., Bacaro, G., Nascimbene, J. (2012). Functional traits of epiphytic lichens as potential indicators of environmental conditions in forest ecosystems. *Ecological Indicators, 18*, 413–420.
59. Giordani, P., Calatayud, V., Stofer, S., Seidling, W., Granke, O., Fischer, R. (2014). Detecting the nitrogen critical loads on European forests by means of epiphytic lichens. A signal-to-noise evaluation. *Forest Ecology and Management, 311*, 29–40.
60. Green, T.G.A., Nash III, T.H., Lange, O.L. (2008). *Physiological ecology of carbon dioxide exchange*. In: *Lichen Biology*. Nash III, T.H. (Ed.). Cambridge University Press Cambridge, UK. Pp. 152–181.
61. Grindel, D. H. (1803). *Botanisches Taschenbuch für Liv-, Cur- und Estland*. Riga. Pp. 373.
62. Gustafsson, L., Appelgren, L., Jonsson, F., Nordin, U., Persson, A.A., Weslien, J. 2004. High occurrence of red-listed bryophytes and lichens in mature managed forests in boreal Sweden. *Basic and Applied Ecology* 5(2): 123-129.
63. Gustafsson, L., Kouki, J., Sverdrup-Thygeson, A. (2010). Tree retention as a conservation measure in clear-cut forests of northern Europe: a review of ecological consequences. *Scandinavian Journal of Forest Research, 25*, 295–308.
64. Gustafsson, L., Baker, S.C., Bauhus, J., Beese, W.J., Brodie, A., Kouki, J., Lindenmayer, D.B., Lõhmus, A., Pastur, G.M., Messier, C., Neyland, M., Palik, B., Sverdrup-Thygeson, A., Volney, W.J.A., Wayne, A., Franklin, J.F. (2012). Retention forestry to maintain multifunctional forests: a world perspective. *Bioscience, 62*, 633–645.
65. Gustafsson, L., Fedrowitz, K., Hazell, P. (2013). Survival and vitality of a macrolichen 14 years after transplantation on aspen trees retained at clearcutting. *Forest Ecology and Management, 291*, 436–441.

66. Hansson, L., Söderström, L. & Solbreck, C. (1992). *The ecology of dispersal in relation to conservation*. In: *The ecological principles of nature conservation*. Hansson L (Ed.). Elsevier Applied Science, London. pp 162–200.
67. Hämäläinen, A. (2016). *Retention forestry and intensified biomass harvest: epiphytic lichen assemblages under opposing ecological effects in pine-dominated boreal forests*. (Doctoral thesis). School of Forest Sciences, Faculty of Science and Forestry, University of Eastern Finland. Pp. 33. https://doi.org/10.14214/df.218
68. Hämäläinen, A., Kouki, J., Lõhmus, P. (2014). The value of retained Scots pines and their dead wood legacies for lichen diversity in clear-cut forests: The effects of retention level and prescribed burning. *Forest Ecology and Management, 324*, 89–100.
69. Hämäläinen, A., Kouki, A., and Lõhmus, P. (2015). Potential biodiversity impacts of forest biofuel harvest: lichen assemblages on stumps and slash of Scots pine. *Canadian Journal of Forest Research, 45*, 1239–1247.
70. Hämäläinen, A., Ranius, T., Strengbom, J. (2021). Increasing the amount of dead wood by creation of high stumps has limited value for lichen diversity. *Journal of Environmental Management 280*: 111646.
71. Hauck, M., Bruyn, U.D., Leuschner, C. (2013). Dramatic diversity losses in epiphytic lichens in temperate broad-leaved forests during the last 150 years. *Biological Conservation, 157*, 136–145.
72. Hautala, H., Laaka-Lindberg, S., & Vanha-Majamaa, I. (2011). Effects of Retention Felling on Epixylic Species in Boreal Spruce Forests in Southern Finland. *Restoration Ecology, 19* (3), 418–429.
73. Hedenås, H., Hedström, P. (2007). Conservation of epiphytic lichens: Significance of remnant aspen (*Populus tremula*) trees in clear-cuts: *Biological Conservation, 135*, 388 – 395.
74. Heithecker, T. D., & Halpern, C. B. (2006). Variation in microclimate associated with dispersed-retention harvests in coniferous forests of western Washington. *Forest Ecology and Management, 226* (1-3), 60–71.
75. Heithecker, T. D., & Halpern, C. B. (2007). Edge-related gradients in microclimate in forest aggregates following structural retention harvests in western Washington. *Forest Ecology and Management, 248* (3), 163–173.
76. Heugel, C. A. (1857). Beitrag zur Kryptogamenkunde der Ostsee-Gouvernements Russlands (Nachtrag). *Corresspondenzblatt des Naturforscherverein uz Riga, 9*, 45–49.

77. Heugel, C. A. (1869). Zur Flechtenflora der Ostseeprovinzen Russlands. *Corresspondenzblatt des Natuforscherverein uz Riga*, *17*, 149–175.
78. Heugel, C. A. & Müller C., J. (1847). Beitrag zur Flora von Livland. *Coresspondenzblatt des Naturforscherverein uz Riga, 2*, 48–50.
79. Hiron, M., Jonsell, M., Kubart, A., Thor, G., Schroeder, M., Dahlberg, A., Johansson, V., Ranius, T. (2017). Consequences of bioenergy wood extraction for landscape-level availability of habitat for dead wood-dependent organisms. *Journal of Environmental Management, 198* (33), 33–42.
80. Honegger, R. (2009). *Flechten: ökologische Aspekte der Wechselbeziehung zwischen Pilz und Alge [Lichens: ecological aspects of the relationship between fungi and algae]*. In: *Ökologische Rolle der Flechten. Rundgespräche der Kommission für Ökologie 36*. Bayerische Akademie der Wissenschaften (Herausgeber), Verlag Dr. Freiderich Pfeil, München. Pp. 196.
81. Humphrey, J. W., S. Davey, A. J. Peace, R. Ferris & K. Harding. (2002). Lichens and bryophyte communities of planted and semi-natural forests in Britain: the influence of site type, stand structure and deadwood. *Biological Conservation*, *107*, 165–180.
82. Jørgensen, P. M., Tønsberg, T., & Vitikainen, O (ed.). (2007). *Nordic Lichen Flora Vol. 3. Cyanolichens*. Uddevalla: The Nordic Lichen Society, Museum of Evolution, Uppsala University, Sweden. Pp. 219.
83. Jurciņš, D., Mežaka, A., Strazdiņa, L., Gerra-Inohosa, L., Perševica, G. Piterāns, A. (2014). Refound of extinct lichen *Lobaria amplissima* (Scop.) Forssell in Latvia. *Acta Biologica Universitatis Daugavpiliensis, 14* (1), 59–65.
84. Jüriado, I., Paal, J., Liira, J. (2003). Epiphytic and epixylic lichen species diversity in Estonian natural forests. *Biodiversity and Conservation, 12*, 1587−1607.
85. Jüriado, I., Liira, J., Paal, J., Suija, A. (2009). Tree and stand level variables influencing diversity of lichens on temperate broad-leaved trees in boreo-nemoral floodplain forests. *Biodiversity and Conservation, 18* (1), 105−125.
86. Juutilainen, K., Mönkkönen, M., Kotiranta, H., Halme, P. (2014). The effects of forest management on wood-inhabiting fungi occupying dead wood of different diameter fractions. *Forest Ecology and Management, 313*: 283–291.
87. Kershaw, K. A. (1975). Studies on lichen-dominated systems. XII. The ecological significance of thallus color. *Canadian Journal of Botany, 53*: 660–667.

88. Koch, N.M., Martins, S.M.D.A., Lucheta, F., Müller, S.C. (2013). Functional diversity and traits assembly patterns of lichens as indicators of successional stages in a tropical rainforest. *Ecological Indicators, 34,* 22–30.
89. Koivula, M., Vanha-Majamaa, I. (2020). Experimental evidence on biodiversity impacts of variable retention forestry, prescribed burning, and deadwood manipulation in Fennoscandia. *Ecological Processes, 9* (11). https://doi.org/10.1186/s13717-019-0209-1
90. Kranner, I., Beckett, R., Hochman, A., Nash III, T.H. (2008). Desiccation-tolerance in lichens. A Review. *Bryologist, 111*, 576–593.
91. Kruys, N., Fridman, J., Götmark, F., Simonsson, P., Gustafsson, L. (2013). Retaining trees for conservation at clearcutting has increased structural diversity in young Swedish production forests. *Forest Ecology Managagement, 304* (3), 12–321.
92. Kruys, N., Fries, C., Jonsson, B. G., Lämås, T., & Ståhl, G. (1999). Wood-inhabiting cryptogams on dead Norway spruce (*Picea abies*) trees in managed Swedish boreal forests. *Canadian Journal of Forest Research, 29* (2), 178–186. doi:10.1139/x98-191
93. Kruys, N., Jonsson, B.G. (1999). Fine woody debris is important for species richness on logs in managed boreal spruce forests of northern Sweden. C*anadian Journal of Forest Research*, *29* (8), 1295–1299.
94. Kukwa, M., Motiejūnaitė, J. (2012). Revision of the lichen genera *Cetrelia* and *Punctelia* (Lecanorales, Ascomycota) in Lithuania with implications for their conservation. *Herzogia*, *25* (1), 5–14.
95. Kuusinen, M., & Siitonen, J. (1998). Epiphytic lichen diversity in old-growth and managed Picea abies stands in southern Finland. *Journal of Vegetation Science*, *9*, 283–292.
96. Lazdiņš, A., Von Hofsten, H., Lazdiņa, D., Lazdāns, V. (2009). *Productivity and costs of stump harvesting for bioenergy production in Latvian conditions*. In: R*esearch for Rural Development*. Latvia University of Agriculture, Jelgava, Latvia. pp. 155–162.
97. Li, S., W.-Y. Liu, D.-W. Li. (2013). Bole epiphytic lichens as potential indicators of environmental change in subtropical forest ecosystems in southwest China. *Ecological Indicators, 29,* 93–104.
98. Lībiete, Z., Bārdule, A., Kļaviņš, I., Kalvīte, Z., Lazdiņš, A. (2019). Medium-term impact of stump harvesting on general soil parameters in HYLOCOMIOSA site type. *Forestry and wood processing*. DOI: 10.22616/rrd.25.2019.009
99. Lie, M. H., Arup, U., Grytnes, J. A. and Ohlson, M. (2009). The importance of host tree age, size and growth rate as determinants of epiphytic lichen diversity in boreal spruce forests. *Biodiversity and Conservation, 18* (13), 3579–3596.

100. Löbel, S., Snäil, T. & Rydin, H. (2006). Species richness patterns and metapopulation processes – evidence from epiphyte communities in boreo-nemoral forests. *Ecography, 29,* 169–182.

101. Lõhmus, P. (2003). Composition and substrata of forest lichens in Estonia: a meta-analysis. *Folia Cryptogamica Estonica, 40*, 19–38.

102. Lõhmus, A., Lõhmus, P. (2010). Epiphyte communities on the trunks of retention trees stabilise in 5 years after timber harvesting, but remain threatened due to tree loss. *Biological Conservation, 143,* 891–898.

103. Lõhmus, A., Kraut, A. (2010). Stand structure of hemiboreal old-growth forests: characteristic features, variation among site types, and a comparison with FSC-certified mature stands in Estonia. *Forest Ecology and Management, 260* (1), 155−165.

104. Lõhmus, A., Kraut, A. & Rosenvald, R. (2013). Dead wood in clearcuts of semi-natural forests in Estonia: site type variation, degradation, and the influences of tree retention and slash harvest. *European Journal of Forest Research, 132,* 335–349.

105. Lõhmus, P., Rosenvald, R., Lõhmus, A. (2006). Effectiveness of solitary retention trees for conserving epiphytes: differential short-term responses of bryophytes and lichens. *Canadian Journal of Forest Research, 36*, 1319−1330.

106. Lõhmus, P., Turja, K. & Lõhmus, A. (2010). Lichen communities on treefall mounds depend more on root-plate than stand characteristics. *Forest Ecology and Management, 260,* 1754–1761.

107. Lõhmus, P., Lõhmus, A., & Hämäläinen, A. (2018). Rapid legacy-dependent succession of lichen assemblages after forest fires: Insights from two boreal regions. *Journal of Vegetation Science, 29* (2), 200–212.

108. Lõhmus, A., Lõhmus, P. (2011). Old-forest species: the importance of specific substrata vs. stand continuity in the case of calicioid fungi. *Silva Fennica, 45* (5), 1015−1039.

109. Lõhmus, P., Marmor, L., Jüriado, I., Suija, A., Oja, E., Degtjarenko, P., Randlane, T. (2019). Red List of Estonian lichens: revision in 2019. *Folia Cryptogamica Estonica, 56,* 63−76.

110. Łubek, A., Kukwa, M., Jaroszewicz, B., Czortek P. (2021a). Composition and Specialization of the Lichen Functional Traits in a Primeval Forest—Does Ecosystem Organization Level Matter? *Forests, 12* (4): 485.

111. Łubek, A., Kukwa, M., Jaroszewicz, B., Czortek, P. (2021b). Shifts in lichen species and functional diversity in a primeval forest ecosystem as a response to environmental changes. *Forests, 12*: 686. https://doi.org/10.3390/ f12060686

112. Lundström, J., Jonsson, F., Perhans, K., Gustafsson, L. (2013). Lichen species richness on retained aspens increases with time since clear-cutting. *Forest Ecology and Management, 293,* 49–56.

113. Malíček, J., Palice, Z., Vondrák, J., Kostovčík, M., Lenzová, V., & Hofmeister, J. (2019). Lichens in old-growth and managed mountain spruce forests in the Czech Republic: assessment of biodiversity, functional traits and bioindicators. *Biodiversity and Conservation, 28,* 3497–3528. doi:10.1007/s10531-019-01834-4

114. Malta, N. (1925). Latvijas smilšakmeņu flora. *Daba, 7,* 219–226.

115. Malta, N. (1926). Die Kryptogamenflora der Sandsteinfelsen in Lettland. *Acta Horti Botanici Universitatis Latviensis, 1,* 13–32.

116. Marini, L., Nascimbene, J., Nimis, P. L. (2011). Large-scale patterns of epiphytic lichen species richness: Photobiont-dependent response to climate and forest structure. *Science of the Total Environment, 409* (20), 4381–4386.

117. Mark, K., Randlane, T., Thor, G., Hur, J.S., Obermayer, W., Saag, A. (2019). Lichen chemistry is concordant with multilocus gene genealogy in the genus Cetrelia (Parmeliaceae, Ascomycota). *Fungal Biology, 123,* 125–139.

118. MCPFE. (2020). *Forest Europe, 2020: State of Europe's Forests 2020*. Ministerial Conference on the Protection of Forests in Europe. Liaison Unit Bratislava, Slovakia. Pp. 392.

119. McMurray, J.A., Roberts, D.W., Geiser, L.H. (2015). Epiphytic lichen indication of nitrogen deposition and climate in the northern Rocky Mountains USA. *Ecological Indicators, 49,* 154–161.

120. Mereschkowski, K. S. (1913). Spisok lishainikov Pribaltijskogo kraja. *Uchenyje zapiski Kazanskogo Universiteta, 30,* 1–62 (in Russian).

121. Mežaka, A., Brūmelis, G., Piterāns, A. (2012 (a)). Tree- and stand-scale factors affecting richness and composition of epiphytic bryophytes and lichens in deciduous woodland key habitats. *Biodiversity and Conservation, 21* (12), 3221–3241.

122. Mežaka, A., Brūmelis, G., Piterāns, A., Printzen, C. (2012 (b)). Distribution of *Lepraria* in Latvia in relation to tree substratum and deciduous forest type. *Annales Botanici Fennici, 49,* 162 –170.

123. Mežaka, A., Brūmelis, G., Piterāns, A. (2008). The distribution of epiphytic bryophyte and lichen species in relation to phorophyte substrate in Latvian natural old-growth broad leaved forests. *Folia Cryptogamica Estonica, 44,* 89–99.

124. Mežaka, A., Kirillova, J. (2019). Epiphytic bryophytes and lichens and their functional trait relationships with host characteristics in the Lūznava Manor Park. *Acta Biologica Universitatis Daugavpiliensis, 19* (2), 241–251.

125. Mežaka, A., Liepiņa, L., Strazdiņa, L., Oļehnoviča, E., Piterāns, A. (2018). Bryophyte and lichen distribution in urban forests of Riga city limits. *Acta Biologica Universitatis Daugavpiliensis, 18* (2), 255–271.

126. Mežaka, A., Putna, S., Erta, I. (2015). Hotspots of bryophyte and lichen indicators in woodland key habitats of Latgale. *Environment. Technology. Resources, 2*, 197–201.

127. Miller, J.E.D, Villella, J., Stone, D., Hardman, A. (2020). Using lichen communities as indicators of forest stand age and conservation value. *Forest Ecology and Management, 475,* 118436. https://doi.org/10.1016/j.foreco.2020.118436.

128. Miške, K. (1939). *Materiāli Rīgas apkārtnes kladoniju florai*. (Thesis for obtaining doctoral candidate degeree). Rīga. Pp. 359. (in Latvian).

129. Moisejevs, R. (2015). Some new to Latvia lichens and allied fungi. *Acta Biologica Universitatis Daugavpiliensis, 15,* 285–292.

130. Motiejūnaitė, J. (2002). *Lapiškosios ir krūmiškosios kerpės*. In: *Lietuvos grybai. [Fungi of Lithuania. Foliose and fruticose lichens]*. Vol. 13, Part 1. Vilnius, Institute of Botany, Laboratory of Mycology. Pp 311.

131. Motiejūnaitė, J., Berglund, T., Czarnota, P., Himelbrant, D., Högnabba, F., Konoreva, L. A., Korchikov, E. S., Kubiak, D., Kukwa, M., Kuznetsova, E., Leppik, E., Lõhmus, P., Prigodina Lukošienė, I., Pykälä, J., Stončius, D., Stepanchikova, I., Suija, A., Thell, A., Tsurykau, A., Westberg, M. (2012). Lichens, lichenicolous and allied fungi found in Asveja Regional Park (Lithuania). *Botanica Lithuanica, 18* (2), 85–100.

132. Motiejūnaite, J., Czyzewska, K., Cieslinski, S. (2004). Lichens – indicators of old-growth forests in biocentres of Lithuania and north-east Poland. *Botanica Lithuanica, 10* (1), 59–74.

133. Motiejūnaitė, J. (2017). Supplemented checklist of lichens and allied fungi of Lithuania. *Botanica Lithuanica, 23,* 89–106.

134. Motiejūnaitė, J. and Piterāns, A. (1998). Materials on lichens and allied fungi of Ķemeri National Park (Latvia). – *Botanica Lithuanica, 4,* 187–196.

135. Motiejūnaitė, J. and Grochowski, P. (2014). Miscellaneous new records of lichens and lichenicolous fungi. *Herzogia, 27*, 193–198.

136. Motiejūnaitė, J., Suija, A., Lõhmus, P., Kuznetsova, E., Tõrra, T., Prigodina-Lukošienė, I. & Piterans, A. (2006). New or noteworthy lichens, lichenicolous and allied fungi found during the 16th Symposium of Mycologists and Lichenologists in Latvia. *Botanica Lithuanica, 12* (2), 113−119.

137. Motiejūnaitė, J., Uselienė, A., Uselis, V. (2013). Th genus Normandina (Verrucariaceae, Lichenized Ascomycota) in Lithuania. *Botanica Lithuanica, 19* (2), 157–160.

138. Moning, C., Werth, S., Dziock, F., Bässler, C., Bradtka, J., Hothorn T. and Müller, J. (2009). Lichen diversity in temperate montane forests is influenced by forest structure more than climate. *Forest Ecology and Management*, 258 (5), 745−751.

139. Nascimbene, J., Thor, G., Nimis, P.L. (2013). Effects of forest management on epiphytic lichens in temperate deciduous forests of Europe –a review. *Forest Ecology and Management, 298*, 27–38.

140. Nascimbene, J., Casazza, G., Benesperi, R., Catalano, I., Cataldo, D., Grillo, M., Puntillo, D. (2016). Climate change fosters the decline of epiphytic Lobaria species in Italy. *Biological Conservation, 201*, 377–384.

141. Nascimbene, J., Thor, G. & Nimis, P. L. (2013). Effects of forest management on epiphytic lichens in temperate deciduous forests of Europe – A review. *Forest Ecology Management, 298*, 27–38. https://doi.org/10.1016/j.foreco.2013.03.008

142. Nguyen, K. H., Chollet-Krugler, M., Gouault, N., and Tomasi, S. (2013). UV-protectant metabolites from lichens and their symbiotic partners. *Natural Product Reports, 30*, 1490–508.

143. Nöske, N.M., Hilt, N., Werner, F.A., Brehm, G., Fiedler, K., Sipman, H.J.M., Gradstein, S.R. (2008). Disturbance effects on diversity of epiphytes and moths in a montane forest in Ecuador. *Basic and Applied Ecology, 9*, 4–12.

144. Orange, A., James, P.W., White, F.J. (2001). *Microchemical methods for the identification of lichens*. London, British Lichen Society. Pp. 101.

145. Pawson, S. M., Brockerhoff, E. G., Norton, D. A., & Didham, R. K. (2006). Clear-fell harvest impacts on biodiversity: past research and the search for harvest size thresholds. *Canadian Journal of Forest Research, 36* (4), 1035–1046.

146. Pentecost, A. (1981). Some Observations on the Size and Shape of Lichen Ascospores in Relation to Ecology and Taxonomy. *New Phytologist, 89* (4), 667–678.

147. Persson, T., & Egnell, G. (2018). Stump harvesting for bioenergy: A review of climatic and environmental impacts in northern Europe and America. Wiley Interdisciplinary Reviews: *Energy and Environment, e307*. doi:10.1002/wene.307

148. Pinho, P., Bergamini, A., Carvalho, P., Branquinho, C., Stofer, S., Scheidegger, C., Máguas, C. (2012). Lichen functional groups as ecological indicators of the effects of land-use in Mediterranean ecosystems. *Ecological Indicators, 15*, 36–42.

149. Piterāns, A. (1982). *Lishainiki Latvii*. Zinatne (in Russian). Pp 352.

150. Piterāns, A. (2001). Checklist of the lichens of Latvia. *Latvijas Veģetācija, 3*, 5–45.

151. Prieto, M., Martínez, I., Aragón, G., Verdú, M. (2017). Phylogenetic and functional structure of lichen communities under contrasting environmental conditions. *Journal of Vegetation Science, 28* (4), 871–881.

152. Puettmann, K.J., Wilson, S.M., Baker, S.C. et al. (2015). Silvicultural alternatives to conventional even-aged forest management - what limits global adoption?. *Forest Ecosystems, 2* (8). https://doi.org/10.1186/s40663-015-0031-x

153. Randlane, T., Saag, A. & Suija, A. (2019). *Lichenized, lichenicolous and allied fungi of Estonia*. Ver. December 31, 2019 – http://esamba.bo.bg.ut.ee/checklist/est/home.php

154. Ranius, T., Caruso, A., Jonsell, M., Juutinen, A., Thor, G., Rudolphi, J. (2014). Dead wood creation to compensate for habitat loss from intensive forestry. *Biological Conservation, 169*, 277–284.

155. Ranius, T., Hämäläinen, A., Sjögren, J., Hiron, M., Jonason, D., Kubart, A., Schroeder, M., Dahlberg, A., Thor, G., Jonsell, M. (2019). The evolutionary species pool concept does not explain occurrence patterns of dead-wood-dependent organisms: implications for logging residue extraction. *Oecologia, 191*, 241–252. doi:10.1007/s00442-019-04473-2

156. Ranius, T., Johansson, P., Berg, N. and Niklasson, M. (2008). The influence of tree age and microhabitat quality on the occurrence of crustose lichens associated with old oaks. *Journal of Vegetation Science, 19*, 653–662.

157. Robinson, A.L., Vitt, D.H. Timoney, K.P. (1989). Patterns of community structure and morphology of bryophytes and lichens relative to edaphic gradients in the subarctic forest-tundra of northwestern Canada. *The Bryologist, 92* (4), 495–512.

158. Rosenvald, R.; Lõhmus, A. (2008). For what, when, and where is green-tree retention better than clearcutting? A review of the biodiversity aspects. *Forest Ecology and Management, 225* (1), 1−15.

159. Runnel, K. Rosenvald, R., Lõhmus, A. (2013). The dying legacy of green-tree retention: Different habitat values for polypores and wood-inhabiting lichens. *Biological Conservation, 159* (159), 187 −196.

160. Rudolphi, J., Jönsson, M., Gustafsson, L. (2014). Biological legacies buffer local species extinction after logging. *Journal of Applied Ecology, 51*, 53−62.

161. Santaniello, F., Djupström, L.B., Ranius, T., Weslien, J., Rudolphi, J., Thor, G. (2017). Large proportion of wood dependent lichens in boreal pine forest are confined to old hard wood. *Biodiversity and Conservation, 26* (6), 1295−1310. 10.1007/s10531-017-1301-4.

162. Sevgi, E., Yılmaz, O. Y., Çobanoğlu Özyiğitoğlu, G., Tecimen, H. B., & Sevgi, O. (2019). Factors Influencing Epiphytic Lichen Species Distribution in a Managed Mediterranean *Pinus nigra* Arnold Forest. *Diversity, 11* (4), 59. doi:10.3390/d11040059

163. Siitonen, J. (2001). Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. *Ecological Bulletins, 49,* 11–41.

164. Sillett, S. C., & Goslin, M. N. (1999). Distribution of epiphytic macrolichens in relation to remnant trees in a multiple-age Douglas-fir forest. *Canadian Journal of Forest Research, 29* (8), 1204–1215.

165. Skuja, H., and Ore, M., (1935). Ķērpis *Coenogonium nigrum* (Huds.) Zahlbr. un viņa gonīdija. *Latvijas Botāniskā Dārza raksti, 8*, 21–47. (in Latvian).

166. Smith, C. W., Aptroot, A., Coppins, B. J. et al. (eds). (2009). *The Lichens of Great Britain and Ireland*. British Lichen Society. Pp. 1046.

167. Spribille, T., Thor, G., Bunnell, F.L., Goward, T., Bjork, C.R. (2008). Lichens on dead wood: species-substrate relationships in the epiphytic lichen floras of the Pacific Northwest and Fennoscandia. *Ecography, 31,* 741e750.

168. Štikāne, K., Brūmelis, G., Piterāns, A., Moisejevs, R. (2017). Epiphytic lichen diversity in broad-leaved tree forests in Latvia. *Acta Biologica Universitatis Daugavpiliensis, 17* (1), 123–132.

169. Stofer, S., Bergamini, A., Aragón, G. et al. (2006). Species richness of lichen functional groups in relation to land use intensity. *Lichenologist, 38,* 331–353.

170. Stokland, J., Siitonen, J., & Jonsson, B. (2012). *Biodiversity in Dead Wood*. Cambridge: Cambridge University Press. 1–510 pp.

171. Suija, A., Jüriado, I., Lõhmus, P., Moisejevs, R., Motiejūnaitė J., Tsurykau, A., & Kukwa, M. (2020). Where the interesting species grow – remarkable records of lichens and lichenicolous fungi found during a Nordic Lichen Society meeting in Estonia. *Folia Cryptogamica Estonica, 57,* 73–84

172. Sundin, R., Thor, G. (1990). Some lichens from Latvia. *Graphis Scripta, 3*(1), 20–23.

173. Svensson, M., Dahlberg, A., Ranius, T., Thor, G. (2013). Occurrence Patterns of Lichens on Stumps in Young Managed Forests. *PLoS ONE, 8* (4), e62825.

174. Svensson, M., Dahlberg, A., Ranius, T., Thor, G. (2014). Dead branches on living trees occur a large part of the dead wood in managed boreal forests, but are not important for wood-dependent lichens. *Journal of Vegetation Science, 25* (3), 819–828.

175. Svensson, M., Johansson, V., Dahlberg, A., Frisch, A., Thor, G., Ranius, T. (2016). The relative importance of stand and dead wood types for wood-dependent lichens in managed boreal forests. *Fungal Ecology, 20,* 166–174.

176. Taylor, D.R., Aarssen, L.W., Loehle, C. (1990). On the relationship between r/K selection and environmental carrying capacity: a new habitat templet for plant life history strategies. *Oikos, 58,* 239–250.

177. Tibell, L. (1992). Crustose lichens as indicators of forest continuity in boreal coniferous forests. *Nordic Journal of Botany, 12* (4), 427–450.

178. Tibell, L. (1999). Calicioid lichens and fungi. *Nordic Lichen Flora, 1*, 3–71.

179. Thor, G. (1998). Red-listed lichens in Sweden: habitats, threats, protection, and indicator value in boreal coniferous forests. *Biodiversity and Conservation*, *7*, 59–72.

180. Thell, A. & Moberg, R (ed.). (2011). *Nordic Lichen Flora Volume 4: Parmeliaceae*. Uppsala. The Nordic Lichen Society, Museum of Evolution, Uppsala University. Pp.184.

181. Trest, M. T., Will-Wolf, S., Keuler, R. et al. (2015). Potential impacts of UV exposure on lichen communities: a pilot study of Nothofagus dombeyi trunks in southernmost Chile. *Ecosystem Health and Sustainability*, *1* (4), 1–12. http://dx.doi.org/10.1890/EHS15-0008R1.1

182. Tsurykau, A. & Golubkov, V. (2015). The lichens of the *Cladonia pyxidata-chlorophaea* complex in Belarus. *Folia Cryptogamica Estonica*, *52*, 63–71.

183. Tsurykau, A., Golubkov, V., & Bely, P. (2015). The Genera *Hypotrachyna*, *Parmotrema* and *Punctelia* (Parmeliaceae, Lichenized Ascomycota) in Belarus. *Herzogia, 28* (2), 736–745.

184. Tsurykau, A., Golubkov, V., & Bely, P. (2017). The genus *Lepraria* (Stereocaulaceae, lichenized Ascomycota) in Belarus. *Folia Cryptogamica Estonica*, *53*, 43–50.

185. Tsurykau, A., Golubkov, V. & Bely, P. (2018). The lichen genus *Xanthoparmelia* (Parmeliaceae) in Belarus. *Folia Cryptogamica Estonica, 55*, 125–132.

186. UNECE and FAO. (2011). *State of Europe's Forests 2011. Status and Trends in Sustainable Forest Management in Europe*, Ministerial Conference on the Protection of Forests in Europe, Forest Europe, Liaison Unit, Oslo. Pp. 337.

187. Vilén, T., Gunia, K., Verkerk, P.J., Seidl, R., Schelhaas, M.-J., Lindner, M. & Bellassen, V. (2012). Reconstructed forest age structure in Europe 1950–2010. *Forest Ecology and Management, 286,* 203–218.

188. Vondrák, J., Malíček, J., Palice, Z., Coppins, B., Kukwa, M., Czarnota, P., Sanderson, N., Acton A. (2016). Methods for obtaining more complete species lists in surveys of lichen biodiversity. *Nordic Journal of Botany, 34* (5), 619–626. doi:10.1111/njb.01053

189. Wirth, V., Hauck, M. & Schultz, M. (2013). *Die Flechten Deutschlands, 2 volumes*. E. Ulmer, Stuttgart. Pp. 1244.

190. Wolseley, P., Moncrieff, C., & Aguirre-Hudson, B. (1994). Lichens as Indicators of Environmental Stability and Change in the Tropical Forests of Thailand. *Global Ecology and Biogeography Letters, 4* (4), 116–123.

191. Yatsyna, A.P. (2020). The lichen genus Parmelia Ach. in Belarus. *Diversity of plant world, 1* (4), 5–16. (in Russian).

Appendix 1. Summary list of newly recorded lichen and allied fungi taxa for Latvia found and reported between 2015-2020. List of substrata and their abbreviations: Cor = corticoulous/epiphytic; Lig = lignicolous/epixylic, Resin = resinicolous; Root = roots of windthrows; Sax = saxicolous/epilithic; SS = sandstone; Ter = terricolous/epigeic. Species found and/or determined by the author of thesis are in **bold**.

Lichenized fungi	**Substrate**	**Paper No.**
1. *Anisomeridium polypori* (M.B. Ellis & Everh.) M.E.Barr	Cor	II
2. *Athallia alnetorum* (Giralt, Nimis & Poelt) Arup, Frödén & Søchting	Cor; Sax	II
3. *Athallia cerinella* (Nyl.) Arup, Frödén & Søchting	Cor	II
4. *Athallia holocarpa* (Hoffm.) Arup, Frödén & Søchting	Lig; Sax	II
5. *Athallia pyracea* (Ach.) Arup, Frödén & Søchting	Cor	II
6. *Bacidia fraxinea* Lönnr.	Cor	II
7. *Bacidina delicata* (Larbal. ex Leight.) V.Wirth & Vězda	Cor	II
8. *Biatora meiocarpa* (Nyl.) Arnold	Cor	II
9. ***Calicium parvum*** Tibell	Cor	III
10. ***Calicium pinastri*** Tibell	Cor	V
11. ***Calicium trabinellum*** (Ach.) Ach.	Lig	III
12. *Caloplaca chlorina* (Flot.) Sandst	Sax	II
13. *Caloplaca duplicata* (Vain.) H.Olivier	Sax	II
14. *Caloplaca ulcerosa* Coppins & P.James	Cor	II
15. *Candelariella efflorescens* R.C.Harris & W.R.Buck	Cor	II
16. ***Carbonicola anthracophila*** (Nyl.) Bendiksby & Timdal	Cor; Lig	III
17. ***Carbonicola myrmecina*** (Ach.) Bendiksby & Timdal	Lig	III
18. ***Cetrelia monachorum*** (Zahlbr.) W.L. Culb. & C.F. Culb.	Cor	VI
19. *Chaenotheca hispidula* (Ach.) Zahlbr	Cor	II
20. ***Chaenotheca laevigata*** Nádv.	Lig	III

21. *Chaenotheca xyloxena* Nádv.	Lig	II
22. *Chrysothrix flavovirens* Tønsberg	Cor	II
23. *Cresporhaphis wienkampii* (J. Lahm ex Hazsl.) M.B.Aguirre	Cor	II
24. ***Dermatocarpon miniatum*** (L.) W.Mann.	Sax	IV
25. *Diplotomma pharcidium* (Ach.) M.Choisy	Cor	II
26. *Eopyrenula leucoplaca* (Wallr.) R.C.Harris	Cor	II
27. *Fuscidea arboricola* Coppins & Tønsberg	Cor;Lig	II
28. *Gallowayella weberi* (S.Y. Kondr. & Kärnefelt) S.Y.Kondr., Fedorenko, S.Stenroos, Kärnefelt, Elix, J.-S.Hur & A.Thell	Cor	II
29. *Gregorella humida* (Kullh.) Lumbsch	Ter	II
30. *Gyalecta derivata* (Nyl.) H.Olivier	Cor	II
31. *Gyalecta flotowii* Körb	Cor	II
32. *Lecanora farinaria* Borrer	Cor	II
33. *Lecanora subcarpinea* Szatala	Cor	II
34. ***Lecania croatica*** (Zahlbr.) Kotlov	Cor	V
35. *Leptogium byssinum* (Hoffm.) Nyl.	Ter	II
36. *Micarea anterior* (Nyl.) Hedl.	Lig	II
37. *Micarea byssacea* (Th.Fr.) Czarnota, Guzow-Krzemińska & Coppins	Lig; Cor	II
38. *Micarea micrococca* (Körb.) Gams ex Coppins	Cor	II
39. *Micarea peliocarpa* (Anzi) Coppins & R.Sant.	Lig	II
40. *Normandina acroglypta* (Norman) Aptroot	Cor	II
41. *Ochrolechia androgyna* (Hoffm.) Arnold	Cor	II
42. *Ochrolechia microstictoides* Räsänen	Lig;Cor	II
43. *Parmelia serrana* A.Crespo, M.C.Molina & D.Hawksw.	Cor	II
44. *Parmelia submontana* Nádv. ex Hale	Cor	II
45. ***Peltigera extenuata*** (Vainio) Lojka	Ter	III
46. *Phaeophyscia endophoenicea* (Harm.) Moberg	Cor	II
47. ***Pilophorus cereolus*** (Ach.) Th. Fr.	Ter/SS	VII

48. *Polycauliona phlogina* (Ach.) Arup, Frödén & Søchting	Lig	II
49. *Protothelenella sphinctrinoidella* (Nyl.) H.Mayrhofer & Poelt	Ter	II
50. *Psilolechia clavulifera* (Nyl.) Coppins	Root	II
51. ***Pycnora praestabilis*** (Nyl.) Hafellner	Lig	V
52. ***Pycnora sorophora*** (Vain.) Hafellner	Cor	III
53. *Rinodina septentrionalis* Malme	Cor	II
54. *Rinodina sophodes* (Ach.) A.Massal.	Cor	II
55. *Schismatomma pericleum* (Ach.) Branth & Rostr.	Cor	II
56. ***Scytinium teretiusculum*** (Wallr.) Otálora, P.M. Jørg. & Wedin	Cor	VII
57. ***Scoliciosporum sarothamni*** (Vain.) Vězda	Cor	I
58. *Solitaria chrysophthalma* (Degel.) Arup, Frödén & Søchting	Lig	II
59. *Steinia geophana* (Nyl.) Stein	Ter	II
60. *Strigula jamesii* (Swinscow) R.C.Harris	Cor	II
61. *Thelocarpon superellum* Nyl.	Ter	II
62. ***Trapelia coarctata*** (Sm.) M.Choisy	Sax	IV
63. *Trapelia corticola* Coppins & P.James	Lig	II
64. ***Trapelia placodioides*** Coppins & P.James	Sax	IV
65. *Umbilicaria hirsuta* (Sw. ex Westr.) Hoffm.	Sax	IV
66. *Verrucaria tectorum* (A.Massal.) Körb.	Sax	II
67. *Verrucaria xyloxena* Norman	Ter	II
68. *Xylographa parallela* (Ach.) Fr.	Lig	II
69. *Zwackhia sorediifera* (P.James) Ertz	Cor	II
Non lichenized, lichenicolous taxa	**Host**	**Paper No.**
70. *Arthonia epiphyscia* Nyl.	*Physcia aipolia*	II
71. *Arthonia molendoi* (Heufl. ex Frauenf.) R.Sant.	*Xanthoria parietina*	II
72. ***Arthrorhaphis aeruginosa*** R. Sant. & Tønsberg	*Cladonia* spp.	V
73. *Corticifraga fuckelii* (Rehm) D. Hawksw. & R.Sant.	*Peltigera neckeri*	II

74. ***Chaenothecopsis epithallina*** Tibell	*Chaenotheca trichialis*	V
75. ***Clypeococcum hypocenomycis*** D. Hawksw.	*Hypocenomyce scalaris*	III
76. *Didymocyrtis epiphyscia* Ertz & Diederich s. lat.	*Xanthoria parietina*	II
77. *Didymocyrtis ramalinae* (Roberge ex Desm.) Ertz, Diederich & Hafellner	*Ramalina fraxinea*	II
78. *Ellisembia lichenicola* Heuchert & U.Braun	*Ramalina fraxinea*	II
79. *Epicladonia sandstedei* (Zopf) D.Hawksw.	*Cladonia coniocraea*	II
80. *Erythricium aurantiacum* (Lasch) D. Hawksw. & A.Henrici	*Physcia* spp.	II
81. *Graphium aphthosae* Alstrup & D.Hawksw.	*Peltigera neckeri*	II
82. *Homostegia piggotii* (Berk. & Broome) P.Karst.	*Parmelia submontana*	II
83. ***Illosporium carneum*** Fr.	*Peltigera extenuata*	III
84. *Lichenochora obscuroides* (Linds.) Triebel & Rambold	*Phaeophyscia orbicularis*	II
85. *Lichenochora weillii* (Werner) Hafellner & R.Sant.	*Physconia enteroxantha*	II
86. *Lichenoconium lecanorae* (Jaap) D.Hawksw.	*Evernia prunastri*	II
87. *Lichenoconium pyxidatae* (Oudem.) Petr. & Syd.	*Cladonia* aff.*chlorophaea*	II
88. *Lichenoconium usneae* (Anzi) D.Hawksw.	*Evernia prunastri*	II
89. *Lichenoconium xanthoriae* M.S.Christ.	*Xanthoria parietina*	II

90. *Lichenodiplis lecanorae* (Vouaux) Dyko & D.Hawksw.	*Lecanora* aff.*hagenii*	II
91. *Marchandiomyces corallinus* (Roberge) Diederich & D.Hawksw.	*Physcia tenella*	II
92. *Phaeopyxis punctum* (A. Massal.) Rambold, Triebel & Coppins	*Cladonia digitata*	II
93. *Pyrenochaeta xanthoriae* Diederich	*Xanthoria parietina*	II
94. *Reconditella physconiarum* Hafellner & Matzer	*Physconia distorta*	II
95. *Refractohilum peltigerae* (Keissl.) D.Hawksw.	*Peltigera* spp.	II
96. *Sphinctrina turbinata* (Pers.: Fr.) De Not.	*Pertusaria pertusa*	II
97. *Stigmidium microspilum* (Körb.) D.Hawksw.	*Graphis scripta*	II
98. *Taeniolella punctata* M.S. Christ. & D.Hawksw.	*Graphis scripta*	II
99. *Telogalla olivieri* (Vouaux) Nik.Hoffm. & Hafellner	*Xanthoria parietina*	II
100. *Thelocarpon epibolum* Nyl. var. *epibolum*	*Peltigera neckeri*	II
101. *Tremella lichenicola* Diederich	*Violella fucata*	II
102. *Tremella phaeophysciae* Diederich & M.S.Christ.	*Phaeophyscia orbicularis*	II
103. *Trichonectria anisospora* (Lowen) van den Boom & Diederich	*Hypogymnia physodes*	II
104. *Trichonectria rubefaciens* (Ellis & Everh.) Diederich & Schroers	*Parmelia sulcata*	II
105. *Vouauxiomyces santessonii* D.Hawksw.	*Platismatia glauca*	II
106. *Xenonectriella leptaleae* (J.Steiner) Rossman & Lowen	*Physcia aipolia*	II
Non lichenized, saprobic or resinicolous taxa	**Substrate**	**Paper No.**
107. ***Chaenothecopsis savonica*** (Räsänen) Tibell	Lig	III
108. ***Chaenothecopsis pusiola*** (Ach.) Vain	Lig	VIII

109. *Chaenothecopsis viridireagens* (Nádv.) A.F.W.Schmidt	Lig	II
110. *Leptorhaphis epidermidis* (Ach.) Th.Fr.	Cor	II
111. ***Microcalicium ahlneri*** Tibell	Lig	VIII
112. ***Microcalicium arenarium*** (Hampe ex A. Massal.) Tibell	Root	III
113. *Peridiothelia fuliguncta* (Norman) D.Hawksw.	Cor	II
114. *Sarea difformis* (Fr.) Fr.	Resin	II
115. *Sarea resinae* (Fr.: Fr.) Kuntze	Resin	II
116. *Stictis brunnescens* Gilenstram, Döring & Wedin	Lig	III

ORIGINAL PAPERS

I

Nova Hedwigia, Vol. 109 (2019), Issue 1-2, 247–266 **Article**

Lichen assemblages on Scots pine stumps and fine woody debris in hemiboreal post-harvest sites: the impact of site age and green tree retention

Rolands Moisejevs[1], Jurga Motiejūnaitė[2], Piret Lõhmus[3]*

[1] Institute of Life Sciences and Technology, Daugavpils University, Parādes 1a, Daugavpils, Latvija

[2] Nature Research Centre, Žaliųjų ežerų 49, Vilnius, Lithuania

[3] Institute of Ecology and Earth Sciences, University of Tartu, Lai 40, Tartu, Estonia

* Corresponding author: piret.lohmus@ut.ee

With 4 figures and 2 tables

Abstract: Retention of live trees and dead wood structures in clear-cut sites is a common sylviculture measure for biodiversity purposes. We studied lichen assemblages on pine stumps and fine woody debris (FWD) in 16 post-cut (4–6 and 9–11 yr. old) dry boreal pine stands in Latvia to explore what type of substrata and stand-scale characters (e.g., retention level, time since harvest) are related to lichen species richness and differences in composition. We found 48 lichen species on stumps and 43 species on FWD. Majority of the species (except *Cladonia parasitica*) were common lichens of coniferous forests in hemiboreal regions. Time since harvest and retention level had positive impacts on richness on stumps, but not on FWD. Increase in total species richness on stumps in older post-harvest sites compared to the younger ones was strong and relatively rapid. Notwithstanding species richness, assemblages on FWD and on stumps were distinct between older and younger cut sites. The impact of time also emerged when assemblages on vertical and horizontal stump surfaces were separated. We conclude that pine stumps are important to lichen richness and post-harvest recovery of the epixylic lichen biota, especially in the face of alarming scarcity of snags and logs in cut-over sites in Latvia, where dead wood legacies (particularly snags) are not retained in sufficient amount.

Key words: coarse woody debris; epixylic; species diversity; logging; Latvia

Introduction

Young and mid-age structurally simplified forest stands have become more frequent in modern forest landscapes of Northern Europe (UNECE & FAO 2011, Vilén et al. 2012). In particular, the availability of dead wood (e.g., standing and downed coarse and fine

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woody debris) is reduced by logging and it is considered that in European production forests the current volumes of dead wood are less than 10% of what is found in natural forests (Stokland et al. 2012). Meanwhile species dependent on dead wood constitute 20–25% of all forest-dwelling species, as have been estimated for Fennoscandia (Siitonen 2001). To reduce negative impacts of logging on biodiversity loss and to ensure sustainable forest management policies, different management practices have been applied. Retention of live trees (i.e. green tree retention) and dead wood structures in cut sites is one of the most frequently applied practices in northern Europe (Gustafsson et al. 2010, Gustafsson et al. 2012). Recent studies have shown that retention of woody legacies (fine woody debris, snags and logs) can provide suitable microhabitats for species of various organism groups, like saproxylic beetles and polypores (Juutilainen et al. 2014, Floren et al. 2015), as well as for lichens (Lõhmus & Lõhmus 2010, Lundström et al. 2013, Runnel et al. 2013, Ranius et al. 2014, Hämäläinen et al. 2014).

Lichens are considered a valuable component of forest ecosystems, with important roles in nutrient turnover, water uptake and retention, as food and habitat for various organisms, etc. (Ellis 2012, Asplund & Wardle 2017). A large proportion of forest-dwelling lichens in boreal forests use dead wood as the main or facultative substratum (Spribille et al. 2008). The dynamic process of substratum decay provides suitable microhabitat conditions for different lichen assemblages over the course of time (Fałtynowicz 1986, Lõhmus & Lõhmus 2001). For example, many wood-dependent lichens in boreal Scots pine (*Pinus sylvestris* L.; hereafter "pine") forests are confined to old hard wood, such as snags, low natural stumps and logs (Santaniello et al. 2017). Norway spruce (*Picea abies* (L.) Karst.; hereafter "spruce") and pine stumps in cut-over sites can support rich epixylic lichen assemblages (Caruso et al. 2008, Svensson et al. 2013, Hämäläinen et al. 2015), thus providing "buffering" substrata to maintain populations of dead wood lichens at the landscape scale. In managed boreal spruce forest, lichen species richness is higher on fine woody debris (FWD) when equal volumes of coarse woody debris (CWD) and FWD are compared (Kruys & Jonsson 1999). Attached dead branches make a significant proportion of all available dead wood in boreal forests, nevertheless such types of substrata mainly support generalist lichen species (Svensson et al. 2014). Downed fine woody debris (including slash) also can provide suitable microhabitats for a relatively large biomass of dead wood dwelling lichens (Kruys & Jonsson 1999, Svensson et al. 2014, Hämäläinen et al. 2015); however, several studies have shown that only few species are present on such substrata (Caruso et al. 2008, Svensson et al. 2016).

It can be expected that dead wood legacies may provide species rich epixylic lichen assemblages during the first post-harvest decade both in boreal and hemiboreal regions of North-Europe (Caruso & Rudolphi 2009, Runnel et al. 2013). However, the difference in wood dwelling lichen assemblages and/or species composition between stands in boreal and hemiboreal regions may differ (e.g., for burned forests see Lõhmus et al. 2018). Unfortunately, in the hemiboreal region, lichen assemblages on dead wood have been representatively studied only in Estonia (e.g., Lõhmus & Lõhmus 2001, Lõhmus & Lõhmus 2011, Runnel et al. 2013), and not in Latvia, Nordic countries or Russia, so far.

In Latvia, same as in Estonia, the proportion of forest land makes about half of the terrestrial area of the country and the proportion of coniferous forests in both countries is also similar (ca 50%). Pine is the second most frequent tree species in Latvia and dry boreal pine forests cover ca 6% (i.e. about 205 000 ha) of total forest area of Latvia; about one fourth of these forests are young-regenerated. General regulations of Ministry Cabinet of Latvia (Anonymous 2000) require that at least four largest structures per hectare of dead wood should be left as retention in the clear cut sites. However, in post-harvest sites, local people are traditionally allowed collection of dead wood for house heating. Additionally, during the last decade slash and largest fractions of FWD have been collected to produce wood pellets and briquettes in most logging sites. Neither of these processes are regulated or accounted for in forestry statistics and result in comparatively low amounts of dead wood in logged areas of Latvian forests.

The aim of the current study was to describe lichen assemblages on pine dead wood structures (stumps, fine woody debris, hereafter FWD, snags and logs) in post-cut 4–6 and 9–11 yr. old dry boreal pine stands in Latvia. The study was specifically aimed to explore what type of substrata and stand-scale characters (e.g., decay stage, proportion of wood; green tree retention level, time since harvest, volume of dead wood) are related to the lichen species richness and composition on pine dead wood legacies. We also aimed to find out whether the assemblages on vertical and horizontal stump surfaces are distinct.

Materials and Methods

Study area and design

The study was performed in the SE part of Latvia, in the hemiboreal forest zone (according to Ahti et al. 1968). In the study region, the average air temperature is 17.5 °C in July and –6 °C to –7 °C in February; the annual precipitation is 600–650 mm (Turlais 2011). The study sites were selected from Vacciniosa type (Bušs 1976), i.e. pine dominated forest on higher fluvioglacial landforms and till mounds with Podzols (pH 3.5–5.0) having continuous moss cover and species-poor undergrowth (mostly shrubs of *Vaccinium vitis-idaea* L. and *Calluna vulgaris* (L.) Hull.) and very sparse under-storey. The study sites were selected in 2.5–9 ha size retention-cut stands situated outside of protected areas (Fig. 1). Among the study sites, four treatment types were designated, based on combinations of time since harvest (4–6 and 9–11 years) and green tree retention level ("high", 14–20 trees per ha or 30–40 m^3/ha, and "low", ≤6 trees per ha or ≤12 m^3/ha). Each of the four treatment combinations (hereafter as "treatment type") was represented by four sites, 16 sites in total. Minimal distance between the study sites was 1 km. Sites were selected from comparatively homogeneous, flat relief to minimize variation on humidity conditions among the study sites. The primary site selection was based on Latvia's State Forests data. Prior to fieldwork selected sites were visited to confirm in the field the data of forest age and site type by the first author. All sites were standardized to 2.5 ha in size, with 30 m wide buffer zones on each side. In all stands pine saplings have been planted,

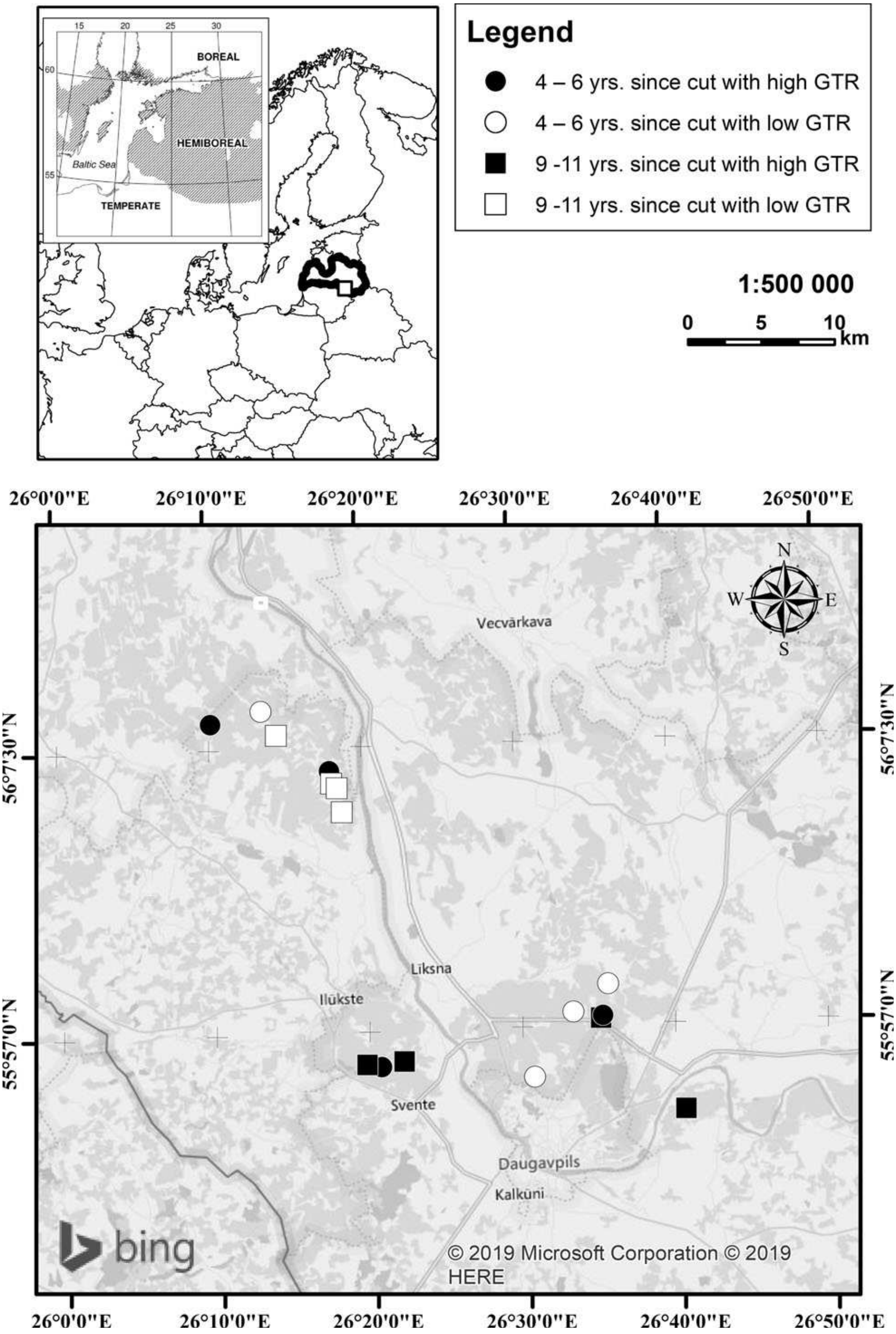
BOREAL
HEMIBOREAL
TEMPERATE
Baltic Sea
15
20
25
30
60
55
Legend
● 4 – 6 yrs. since cut with high GTR
○ 4 – 6 yrs. since cut with low GTR
■ 9 -11 yrs. since cut with high GTR
□ 9 -11 yrs. since cut with low GTR
1:500 000
0 5 10 km
26°0'0"E
26°10'0"E
26°20'0"E
26°30'0"E
26°40'0"E
26°50'0"E
56°7'30"N
55°57'0"N
N
S
W
E
Vecvārkava
Līksna
Ilūkste
Svente
Daugavpils
Kalkūni
bing
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Fig. 1. Location of the study sites in SE part of Latvia. Hemiboreal zone (shaded on the upper left panel) in the Baltic region has been delineated according to Ahti et al. (1968).

and all stands are state-owned. Total lichen sampling from woody structures per site were performed from two FWD plots (2 × 8 m) and 4–6 stumps selected along sampling transects and from 1–2 logs and 1–2 snags selected arbitrary over the whole study site.

Field work

Field work was performed by the first author from June till September of 2016. In each study site four N–S orientated 50 m long transects (divided to 1 m sections) were arranged in N, S, W and E sides of study site to describe characteristics of pine stumps, pine coarse woody debris (CWD; i.e. logs with diameter ≥10 cm) and fine woody debris (FWD; i.e., fallen branches and thin laying trunks of dead wood with diameter 1–9.9 cm). Among FWD, there was occasional (<1% of all FWD) presumable admixture of other species (spruce and birch). The nearest distance between transect lines was at least 50 m.

The diameter of all FWD and CWD that had diameter ≥1 cm at the cross section by transect line were measured and based on collected data, volumes of downed woody debris were calculated based on the method by Van Wagner (1968). To describe lichen assemblages in each study site 1–2 logs were selected arbitrarily among the ones that crossed four transect lines. The length, diameter of log base and top were recorded. In current study most of the sampled logs were in direct contact with soil surface. Over the study site all snags were investigated (only nine snags over all study sites were found). The height of snag and DBH were recorded. For each transect, one stump was selected randomly, so that 4 stumps were surveyed per 2.5 ha study plot area. Stump characteristics, such as height, decay stage of wood at five-point scale (according to Lõhmus & Kraut 2010), and functional habitat area of the stump (i.e. wood and bark not overgrown by bryophytes and vascular plats) were recorded. The decay of vertical and horizontal surfaces was evaluated separately (at four and three different points of the surface, respectively). Data on lichen species occurrence on stumps were recorded separately for vertical and horizontal surfaces, and records on bark and wood were separated as well.

Two FWD sampling plots (2 × 8 m) were established at each site along transects at the N and S part of the study site. Lichen species growing on FWD were surveyed for 40 minutes per plot. One side of the FWD sampling plot was situated along the 21–29 m of the transect. Lichen species occurrence on arbitrarily selected logs per site was recorded using four 50 × 20 cm plots (metal frame with grid of 5 × 5 cm, 40 sheets in total) per log. Plots were placed along the log from the widest end toward the top and with a distance of 20 cm from previous one. First and last plots were at the log's horizontal surface, second on the vertical left side and third on the vertical right side (both about 3–5 cm from the ground). Additional lichen species growing outside log plots were also recorded. On snags, lichens were sampled using two 50 × 20 cm plots (same frame as for the logs). One of the plots was placed 20 cm from the base and the second plot at the breast height (about 130 cm from the base) of the snag. All plots were positioned at the N side of the snag.

Most lichen species were identified *in situ*. Doubtful specimens were collected and later identified in the laboratory using routine lichenological methods, including spot tests and standardized methods of thin layer chromatography (TLC) (Orange et al. 2001). Species of the genus *Lepraria* Ach., were determined in field using C and K spot tests. For confirmation of species identification 36 samples of *Lepraria* spp. were determined using TLC; in all cases field determinations appeared to be correct. In the case of *Mycocalicium subtile* (Pers.) Szatala, 30 specimens were collected and identified in laboratory for confirmation. In all cases the species was identified correctly in field. All collected data of *Micarea denigrata* s. lat. were treated together in analysis as *Micarea* sp., and juvenile specimens of *Usnea* were treated as *Usnea hirta* (L.) Weber ex F.H. Wigg. The nomenclature of taxa follows Nordin et al. (2011).

Statistical analyses

Difference of functional area of stumps and volume of CWD and FWD across four treatment combinations were tested with a one-way Welch ANOVA with Games-Howell post hoc analysis (before the analysis two outliers were removed to achieve normal distributions for each treatment). Homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance ($p < 0.001$).

General linear models (GLMs) were used to study the effects of post-cut age and green tree retention level on (1) total and (2) mean lichen species richness on stumps and on fine woody debris (FWD) per site. The number and distribution of logs and snags among the sites was insufficient for statistical analysis. The fixed factors were age of cut sites (4–6 and 9–11 yr. old) and GTR level (≤6 trees/ha as "low" and ≥14 trees/ha as "high"). Two un-correlated variables were also included per each model: for models (1) and (2) variables average stump functional area and average stump diameter per site, and for model (3) variables volume of FWD and CWD. GLMs were run initially including all factors and interaction between site age and GTR level. Non-significant factors were removed from the model manually one by one, commencing with the least significant factor.

Difference of lichen assemblage composition among treatment types (depending on site age and GTR level) were studied for 1) stumps (full unit), 2) stumps vertical and horizontal surfaces separated, and 3) FWD. A multi-response permutation procedure (MRPP) was used to test if Sørensen (Bray-Curtis) dissimilarities among predefined groups exceed those resulting from random assignment of sample units to those classes, and it has the advantage of not requiring distributional assumptions that are seldom met with ecological assemblage data. To correct the p-values for multiple comparisons, a Bonferroni correction was applied.

In the species matrices, frequency score of the species per site (0–4 for stumps and 0–2 for FWD) were used as input. Results based on the full species matrix are presented (i.e. MRPP analysis gave similar results to full and reduced species matrices). The full species matrix was also used to find species specific to treatment type using indicator species analysis (ISA; Dufrêne & Legendre 1997). In that analysis, we distinguished the species with significant ($p<0.05$) and relatively high (>50%) indicator values.

The results of MRPP test were visualised using nonmetric multidimensional scaling (NMS). NMS was run on Sørensen distances and the medium autopilot mode options (Sørensen dissimilarity; two-axes dimension; 200 runs with real data and 100 with randomized data; stability criterion 0.00001). Two-dimensional solutions were acceptable based on mean stress values (<19.3). Coefficients of determination (r^2) were calculated between distances in the ordination space and dissimilarities in the original space as an expression of variation accounted for by ordination axes. Two continuous factors were added to the analysis to explain assemblage gradients along the NMS axes (for stumps, functional area and average diameter, and for volumes of FWD and CWD per ha). A cut-off value of $r^2>0.2$ was used as a criterion for regarding an environmental factor as sufficiently strongly related to an ordination axis to be represented by a vector in the NMD diagram. The MRPP, ISA and NMS analysis were performed with the software package PC-ORD 5.0 (McCune & Mefford 1999).

Results

Altogether 54 species of lichens and allied fungi were recorded from all sampled substrata types from 16 study sites (Appendix 1). Stumps were inhabited by 48 species, of them only one, *Placynthiella dasaea,* was exclusive for this type of substratum. Fine woody debris (FWD) was inhabited by 43 species, including four exclusive species (Appendix 1). On snags (n = 9) 27 species were recorded and on logs (n = 24) 44 species, adding one new species to the list (*Buellia griseovirens*) (Appendix 1). Most of the species found in the study are common in Latvia, but three were recorded for the first time in the country, namely, *Calicium trabinellum*, *Pycnora sorophora*, and *Scoliciosporum sarothamni*. In addition, one Red-listed lichen in Latvia – *Cladonia parasitica* – was found in seven sites (all 9–11 yr. post-harvest), growing on horizontal surfaces of stumps and logs (Appendix 1). Stump characteristics varied slightly among cut site combinations (Table 1), showing significantly higher horizontal area in 4–6 yr. and 9–11 yr. old sites with high level of GTR (Welch's $F_{(3, 30.838)} = 5.447$, $p = 0.004$) and higher functional area on 4–6 yr. old sites with high level of GTR (Welch's $F_{(3, 30.831)} = 5.012$, $p = 0.006$). Well decayed stumps (classes 3–4) occurred only on old cut sites (Appendix 2). Volumes of FWD and CWD were relatively low and similar among site treatments ($p = 0.454$ and $p = 0.876$, respectively; Table 1).

Based on the final GLM model, the total and mean species richness on stumps depended on cut site age (higher richness in 9–11 yr. sites) and on GTR level (higher richness in sites with "high" GTR level; Table 2, Fig. 2a). The interaction between age and GTR

Table 1. Characteristics of stumps, lying fine and coarse woody debris (FWD and CWD, respectively) in cut sites of different age and green tree retention (GTR) level (high ≥14 and low ≤6 trees/ha). Within each site combinations 16 stumps were sampled.

Age	**4–6 yr.**		**9–11 yr.**	
GTR	**High**	**Low**	**High**	**Low**
Stumps				
Height (cm)	18.4±5.6	20.4±2.3	20.3±3.1	21.6±3.2
Diameter (cm)	37.1±8.3	29.2±4.0	31.4±5.8	28.8±7
Horizontal area (dm^2)	11.3±4.5	6.8±1.7	8.0±2.8	6.9±3.1
Vertical area (dm^2)	22.1±10.5	18.7±3.3	20.2±5.7	19.6±5.4
Functional horizontal area (dm^2)	9.2±4.1	6.0±1.4	5.4±2.6	5.3±2.6
Functional vertical area (dm^2)	16.4±9.6	14.8±3.4	11.7±5.1	13.2±4.4
Volume (m^3)	0.02±0.01	0.01±0.004	0.02±0.01	0.02±0.01
FWD				
Volume (m^3/ha)	0.77±0.22	0.91±0.28	1.14±0.43	0.96±0.27
CWD				
Volume (m^3/ha)	0.36±0.18	0.30±0.18	0.32±0.17	0.32±0.21

Table 2. The final results of general linear model (GLM) analyses for total and mean lichen species richness on stumps depending on the cut site age (Age) and on the level of green tree retention (GTR).

	Total richness				**Mean richness**			
	df	MS	F	p	df	MS	F	p
Model	2	521	34.7	**<0.001**	2	217	77.3	**<0.001**
GTR	1	81.0	5.40	**0.037**	1	19.1	6.80	**0.022**
Age	1	961	64.1	**<0.001**	1	415	148	**<0.001**
Error	13	15.0			13	2.81		

level, as well as stump-scale variables (average stump functional area and diameter per site) were non-significant. No tested variables had significant impact on FWD total species richness (df = 1, MS = 0.56, F = 0.04, p>0.05; Fig. 2b).

Lichen assemblages on stumps differed between age groups of cuts within the same GTR level (MRPP test; A = 0.2 and 0.4, p = 0.006 for both) and between high and low GTR level sites of the same site age (A = 0.2, p = 0.007 for both). Such groupings were slightly visible in the NMS ordination (Fig. 3a). Among tested environmental variables average functional area of the stump correlated with the second ordination axis ($r^2 = 0.24$). Indicator species analysis showed that 19 species (seven of them *Cladonia*) associated signifi-

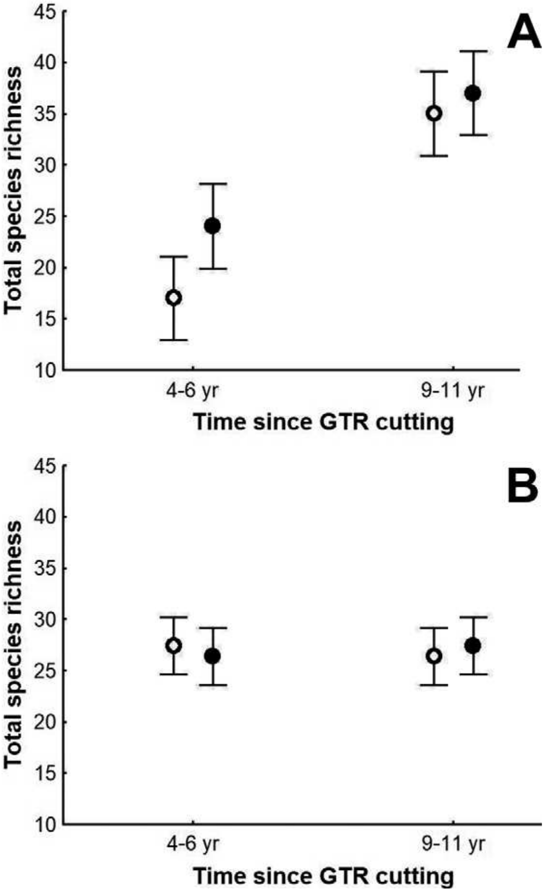

Fig. 2. Total species richness on pine stumps (A) and FWD (B) on 4–6 and 9–11 yr. post-harvest sites with low (≤6 trees/ha; open symbol) and high (≥14 trees/ha; filled symbol) green tree retention (GTR) level.

cantly with 9–11 yr. cut sites, four of them showing also the preference for GTR level (like *C. parasitica* on sites with lower GTR level) (Appendix 3).

Similar assemblage pattern on age difference emerged also if stump vertical and horizontal surfaces were analyzed separately (A = 0.2, p<0.001). In addition, vertical and horizontal surfaces differed from each other within the same age group (MRPP test A = 0.3, p<0.001, Fig. 4). A focus on horizontal stump surface only (as the case of post-cut colonization) showed clear difference of assemblages between 4–6 yr. and 9–11 yr. cut sites both on wood and on bark around stump (A = 0.5, p<0.001). A focus on assemblages on wood only revealed the difference between horizontal and vertical surfaces of stumps both on 4–6 yr. (A = 0.4, p<0.001) and 9–11 yr. (A = 0.3, p<0.001) cut sites.

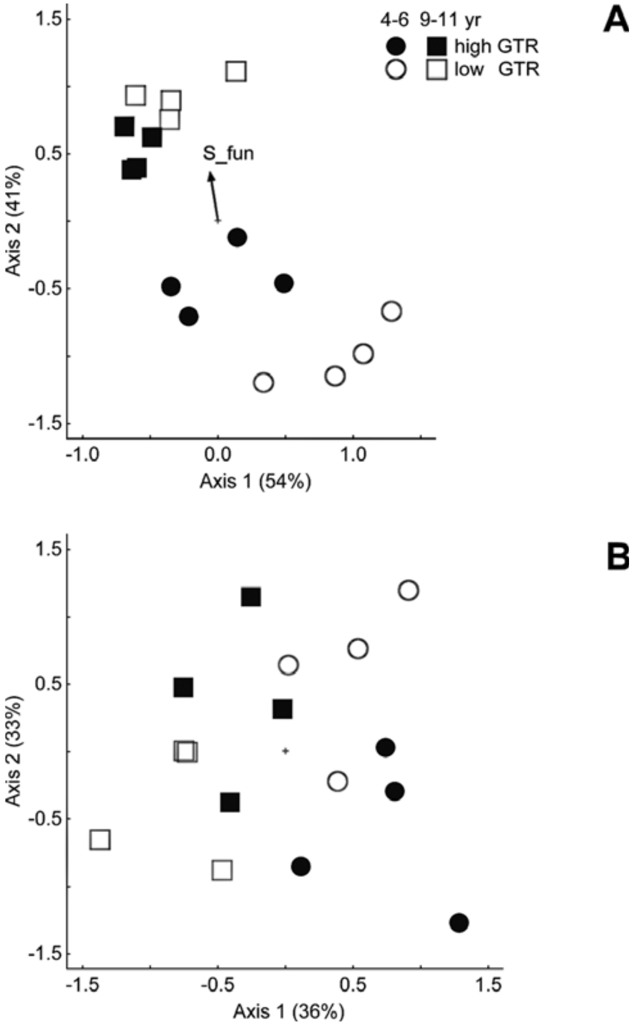

Fig. 3. The composition of lichen species assemblages on pine stumps (A) and FWD (B) depending on years (yr.) since cutting and green tree retention (GTR) level (“high” ≥14 trees/ha and “low” ≤7 trees/ha). Functional area of stumps (S_fun) is related to second ordination axis.

Lichen assemblages on FWD differed near-significantly between age groups of cuts within the same GTR level ($A = 0.1$, $p \geq 0.008$ for both cases), but high and low level GTR sites had similar assemblages within the same cut age (for 4–6 yr. cut sites $A = 0.05$, $p = 0.06$ and for 9–11 yr. sites $A = 0.04$, $p = 0.10$). This pattern is also visible in the NMS ordination (Fig. 3b) and none of the tested environmental variables (volume of FWD and CWD) correlated with the ordination axes ($r^2 < 0.2$). Only three species showed affinity for FWD (*Cladonia fimbriata*, *C. ochrochlora* and *Violella fucata*; Appendix 3).

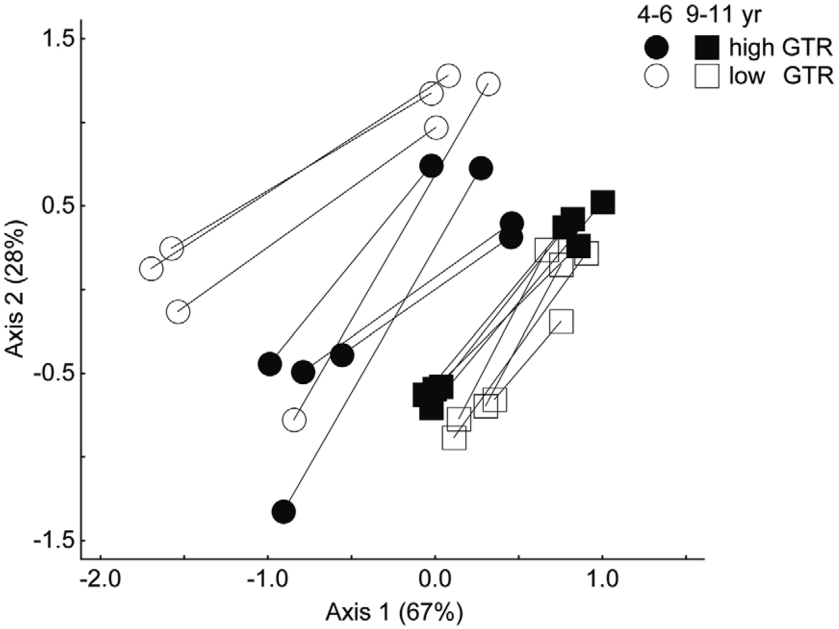

Fig. 4. Lichen assemblages on vertical and horizontal surfaces of pine stumps (symbols on left and right side of the line, respectively) on 4–6 and 9–11 yr. old green tree retention sites with different GTR level ("high" ≥14 trees/ha and "low" ≤6 trees/ha).

Discussion

The majority of the species found during this study are common lichens of coniferous forests in the hemiboreal region. Even the species newly reported to Latvia reflect the effect of understudy of Latvian lichen diversity than their regional rarity. Moreover, about two-third of the recorded species may also be found on other substrata and habitats apart from pine wood and bark and outside dry hemiboreal forests. Similar studies that examined the lichens on Norway spruce stumps and slash in Sweden (Caruso et al. 2008, Svensson et al. 2013) also reported that the assemblages on the investigated woody substrata were dominated by generalist species. Prevalence of generalist species was also obvious in studies of lichens on stumps of *Pinus sylvestris* in the Netherlands, Poland and Finland (Daniëls 1983, Fałtynowicz 1986, Hämäläinen et al. 2015). One species in our study, however, made an exception: *Cladonia parasitica*, the lichen which is considered as a key woodland habitat indicator species in Latvia (Ek et al. 2002) and was reported from the studied sites for the first time outside of protected habitats in the country.

In addition, our results point to biogeographic differences in lichen diversity and composisiton between the hemiboreal and middle boreal forests. The list of species found on pine stumps and FWD was shorter than that presented for unburned retention cut-sites in middle boreal forests by Hämäläinen et al. (2015), i.e. 54 vs 77 species, respectively. This can partly be linked with notably higher sampling effort of stumps per site in Finland, but the low overlap of species list (45%) also indicates differences in assemblage composition on FWD and stumps between middle-boreal and hemiboreal regions. For example, *Evernia prunastri, Melanohalea exasperatula, Parmelia sulcata, Sarea resinae, Scoliciosporum chlorococcum* and *Strangospora moriformis* were quite common in our plots, but not in Finland. Meanwhile, *Cetraria sepincola, Cladonia bacilliformis, Parmeliopsis hyperopta* and *Xylographa vitiligo* were reported as common by Hämäläinen et al. (2015) but not found during our study. Of the latter, *X. vitiligo* is not even known in Latvia and more southern Lithuania. There are very few comparative studies to make strong conclusion about the impact of regional species pools and biogeographic differences in pine forests, however representative study on burned pine forests in Estonia and Eastern Finland showed also that several epiphytes were generally more frequent in the middle-boreal than hemi-boreal region (Lõhmus et al. 2018).

It is known that various stand- and substratum scale factors, such as volumes of dead wood, green tree retention level and diversity of available substrata have an impact on wood-dwelling lichen assemblages, species richness and composition in cut-over sites (e.g., Blasy & Ellis 2014, Ranius et al. 2014, Hämäläinen et al. 2015). The current study showed that among stand-scale factors, green tree retention level (high versus low) had only a slight impact on stump assemblages in early (4–6 yrs.) post-harvest sites, with its importance decreasing in older (9–11 yrs.) sites and showing no effect on the assemblages of downed FWD in the sites of both age groups. Even though sample size for stumps in our study was considerably lower, we obtained similar results as in Hämäläinen et al. (2015), where higher retention level (50 m^3/ha vs. 10m^3/ha) resulted in slightly higher species richness on cut stumps 12 years after harvest (and was related to positive shade effect of retention trees), but did not affect the assemblages on downed FWD or older stumps (being pre-harvest legacies). Altogether this implies that after the first decade following the harvest, the impact of GTR and its retention level on lichen species diversity on woody substrata has decreased.

Post-harvest age was more important for lichen assemblages than GTR level both on stumps and on FWD. For species richness, it was however statistically important only for stumps. The increase in total species richness on stumps (summed on horizontal and vertical surfaces) was relatively rapid, as richness increased twofold (in low-retention sites) or by one-third (in high-retention sites) between 4–6 to 9–11 yrs. post-harvest. This effect may be related to the development of wood-dependent assemblages (particularly on horizontal stump surfaces) and new substratum qualities developed during the decomposition of stumps (i.e. decay stage, difference between vertical and horizontal wood surfaces; see also Caruso & Rudolphi 2009). In addition, based on Fałtynowicz (1986), in early stages of decay vertical surfaces of pine stumps still retain most of their bark and are largely colonized by the species characteristic to live tree bases; however, after five years, more species including terricolous ones, start to appear, so the communities accumulate diversity by retaining lichens from early successional stages in addition to adding those of later stages. Similar succession was noted by Krüger & Daniels (1998) for cut surfaces of pine stumps, where they noted that stumps aged 10–12 yrs. contained intermediate lichen communities consisting of both early and late stage colonizers. In terms of community structure, it is difficult to make any comparisons because Fałtynowicz (1986) and Krüger & Daniels (1998) largely neglected crustose species, noting only the most conspicuous and identifiable in field. However, our full assemblage analysis revealed that assemblages on pine stumps become more homogeneous over time (such a trend was also detected if horizontal and vertical surfaces were separated; see Fig. 3a and 4). This might be related to stabilization of late stage colonizers (e.g., *Cladonia* species) and decrease of functional area (i.e. available free space for colonizations) over time.

Similar to stumps, lichen assemblages on FWD change and become more distinct over time. This result cannot be considered obvious, as according to Caruso et al. (2008), Hämäläinen et al. (2015) and the results of our study, downed FWD is a less specific lichen habitat and hosts mainly generalist species that are tolerant to environmental change and (or) have good establishment abilities. In addition, the FWD fraction consists of both pre- and post-cut legacies and thus transitions from corticolous to lignicolous communities can take place already on early post-cut sites. Indeed, several wood-dwelling/terricolous species were found on 4–6 yr. cut sites, like *Cladonia macilenta*, *C. stellaris*, *Micarea denigrata*, *Placynthiella icmalea* and *Trapeliopsis flexuosa*. However, it is possible, that the distinction was shaped by a diminished supply of fallen branches from retention trees, as assemblages on older cut sites were not influenced by GTR level, and the volume of FWD was slightly lower on older sites (which apparently stems from the local tradition of deadwood collection, see below).

In our study, the number of retained logs and snags and their distribution among the sites were insufficient for statistical analysis, so we only included them in general observations of species diversity (Appendix 1). Only one species was found on logs and snags which was not recorded also on stumps and FWD, a common and ubiquitous microlichen *Buellia griseovirens.* Though snags were lower in numbers, the species richness recorded on them was notably high and total occurrence of some species was even higher than on stumps (e.g., *Calicium glaucellum* and *C. trabinellum*). This indicates the importance of snags as valuable habitat for epixylic lichens on harvested sites (see also Runnel et al. 2013). The scarcity of logs and particularly of snags in post-harvest pine forest sites can be explained by local traditions of wood use as a source of firewood for house heating and illegal collection of firewood in cut sites (such local tradition of "cleaning" of cutovers have been reported also in Estonia, see Lõhmus et al. 2013). However, during the last few years the internal rules of Latvia's State Forests encouraged the practice the retention of "high stumps" (trees cut at height 2–4 m from the ground), that in future potentially can ensure suitable habitats for snag dwelling organisms. This is in agreement with the measures proposed by Blasy & Ellis (2014) and results achieved for saproxylic beetles (Abrahamsson & Lindbladh 2006). However, the impact of such structures on lichen diversity in cut-over sites has yet to be studied.

Given the small sample size of tested treatment types in the current study, general management recommendations cannot be reliably proposed. However, we suggest that in pine dominated Vacciniosa type stands, slash and FWD could be harvested from cut over sites in same volumes as it has been up to now; however, the harvest of stumps may negatively affect lichen richness and should be evaluated more thoroughly in Latvia. In addition, because of alarming scarcity of CWD stuctures in studied cut-over sites, more CWD stuctures (particularly snags) should be retained and the post-cut control of retention legacies and the illegal harvest of CWD should be regulated more strictly. We support that leaving high (pine) stumps in cut over sites is useful precautionary management activity for lichen species conservation in industrially exploited forests.

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References

Abrahamsson, M. & Lindbladh, M. (2006): A comparison of saproxylic beetle occurrence between man-made high- and low-stumps of spruce. – Forest Ecol. Managem. 226: 230–237.

Ahti, T., Hämet-Ahti, L. & Jalas, J. (1968): Vegetation zones and their sections in northwestern Europe. – Ann. Bot. Fenn. 5: 169–211.

Anonymous (2000): Law on forests. Legal acts of the Republic of Latvia. – Available from: https://likumi.lv/ta/en/en/id/2825-law-on-forests

Asplund, J. & Wardle, D.A. (2017): How lichens impact on terrestrial community and ecosystem properties. – Biol. Rev. Cambridge Philos. Soc. 92: 1720–1738.

Blasy, V. & Ellis, C.J. (2014): Life on deadwood: cut stumps as a model system for the succession and management of lichen diversity. – Lichenologist 46: 455–469.

Bušs, K. (1976): Forest classification in the Latvian SSR. (Latvijas PSR meža tipoloģijas pamati). – Rīga, Silava (In Latvian).

Caruso, A. & Rudolphi, J. (2009): Influence of substrate age and quality on species diversity of lichens and bryophytes on stumps. – Bryologist 112: 520–531.

Caruso, A., Rudolphi, J. & Thor, G. (2008): Lichen species diversity and substrate amounts in young planted boreal forests: a comparison between slash and stumps of *Picea abies*. – Biol. Conservation. 141: 47–55.

Daniëls, F.J.A. (1983): Lichen communities on stumps of *Pinus sylvestris* L. in the Netherlands. – Phytocoenologia 11: 431–444.

Dufrêne, M. & Legendre, P. (1997): Species assemblages and indicator species: the need for a flexible asymmetrical approach. – Ecol. Monogr. 67: 345–366.

Ek, T., Suško, U. & Auziņš, R. (2002): Mežaudžu atslēgas biotopu inventarizācija. Metodika. – Rīga, Valsts meža dienests (In Latvian).

Ellis, C.J. (2012): Lichen epiphyte diversity: a species, community and trait-based review. – Perspect. Plant Ecol. Evol. Syst. 14: 131–152.

Gustafsson, L., Baker, S.C., Bauhus, J., Beese, W.J., Brodie, A. et al. (2012): Retention forestry to maintain multifunctional forests: a world perspective. – BioScience 62: 633–645.

Gustafsson, L., Kouki, J. & Sverdrup-Thygeson, A. (2010): Tree retention as a conservation measure in clear-cut forests of northern Europe: a review of ecological consequences. – Scand. J. Forest Res. 25: 295–308.

Fałtynowicz, W. (1986): The Dynamics and role of lichens in a managed Cladonia-scotch pine forest (Cladonio-Pinetum). – Monogr. Bot. 69: 1–96.

Floren, A., Krüger, D., Müller, T., Dittrich, M., Rudloff, R. et al. (2015): Diversity and interactions of wood-inhabiting fungi and beetles after deadwood enrichment. – PLoS One 10 (11): e0143566.

Hämäläinen, A., Kouki, J. & Lõhmus, P. (2014): The value of retained Scots pines and their dead wood legacies for lichen diversity in clear-cut forests: the effects of retention level and prescribed burning. – Forest Ecol. Managem. 324: 89–100.

Hämäläinen, A., Kouki, A. & Lõhmus, P. (2015): Potential biodiversity impacts of forest biofuel harvest: lichen assemblages on stumps and slash of Scots pine. – Canad. J. Forest Res. 45: 1239–1247.

Juutilainen, K., Mönkkönen, M., Kotiranta, H. & Halme, P. (2014): The effects of forest management on wood-inhabiting fungi occupying dead wood of different diameter fractions. – Forest Ecol. Managem. 313: 283–291.

Krüger, O. & Daniels F.J.A. (1998): A short account on lichen succession on cut surfaces of Scots pines. – Herzogia 13: 231–233.

Kruys, N. & Jonsson, B.G. (1999): Fine woody debris is important for species richness on logs in managed boreal spruce forests of northern Sweden. – Canad. J. Forest Res. 29: 1295–1299.

Lõhmus, A. & Kraut, A. (2010): Stand structure of hemiboreal old-growth forests: characteristic features, variation among site types, and a comparison with FSC-certified mature stands in Estonia. – Forest Ecol. Managem. 260: 155–165.

Lõhmus, A. & Lõhmus, P. (2010): Epiphyte communities on the trunks of retention trees stabilise in 5 years after timber harvesting, but remain threatened due to tree loss. – Biol. Conservation 143: 891–898.

Lõhmus, A. & Lõhmus, P. (2011): Old-forest species: the importance of specific substrata vs. stand continuity in the case of calicioid fungi. – Silva Fenn. 45: 1015–1039.

Lõhmus, A., Kraut, A. & Rosenvald, R. (2013): Dead wood in clearcuts of semi-natural forests in Estonia: site type variation, degradation, and the influences of tree retention and slash harvest. – Eur. J. Forest Res. 132: 335–349.

Lõhmus, P. & Lõhmus, A. (2001): Snags, and their lichen flora in old Estonian peatland forests – Ann. Bot. Fenn. 38: 265–280.

Lõhmus, P., Lõhmus, A. & Hämäläinen, A. (2018): Rapid legacy-dependent succession of lichen assemblages after forest fires: insights from two boreal regions. – J. Veg. Sci. 29: 200–212.

Lundström, J., Jonsson, F., Perhans, K. & Gustafsson, L. (2013): Lichen species richness on retained aspens increases with time since clear-cutting. – Forest Ecol. Managem. 293: 49–56.

McCune, B. & Mefford, M. (1999): PC-ORD. Multivariate analysis of ecological data, version 4. – MjM Software Design, Gleneden Beach, Oregon.

Nordin, A., Moberg, R., Tønsberg, T., Vitikainen, O., Dalsätt, Å. et al. (2011): Santesson's checklist of Fennoscandian lichen-forming and lichenicolous fungi. Ver. 29 April 2011. – Available from: http://130.238.83.220/santesson/home.php [Accessed 6 May 2018].

Orange, A., James, P.W. & White, F.J. (2001): Microchemical methods for the identification of lichens. – London, British Lichen Society.

Ranius, T., Caruso, A., Jonsell, M., Juutinen, A., Thor, G. et al. (2014): Dead wood creation to compensate for habitat loss from intensive forestry. – Biol. Conservation 169: 277–284.

Remm, L., Lõhmus, P., Leis, M. & Lõhmus, A. (2013): Long-term impacts of forest ditching on non-aquatic biodiversity: conservation perspectives for a novel ecosystem. – PLoS ONE 8: e63086.

Runnel, K., Rosenvald, R. & Lõhmus, A. (2013): The dying legacy of green-tree retention: Different habitat values for polypores and wood-inhabiting lichens. – Biol. Conservation 159: 187–196.

Santaniello, F., Djupström, L.B., Ranius, T., Weslien, J., Rudolphi, J. et al. (2017): Large proportion of wood dependent lichens in boreal pine forest are confined to old hard wood. – Biodivers. & Conservation 26: 1295–1310.

Siitonen, J. (2001): Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. – Ecol. Bull. 49: 11–41.

Spribille, T., Thor, G., Bunnell, F.L., Goward, T. & Bjork, C.R. (2008): Lichens on dead wood: species-substrate relationships in the epiphytic lichen floras of the Pacific Northwest and Fennoscandia. – Ecography 31: 741e750.

Stokland, J., Siitonen, J. & Jonsson, B. (2012): Biodiversity in Dead Wood. – Cambridge, Cambridge University Press.

Svensson, M., Dahlberg, A., Ranius, T. & Thor, G. (2013): Occurrence patterns of lichens on stumps in young managed forests. – PLoS ONE 8: e62825.

Svensson, M., Dahlberg, A., Ranius, T. & Thor, G. (2014): Dead branches on living trees occur a large part of the dead wood in managed boreal forests, but are not important for wood-dependent lichens. – J. Veg. Sci. 25: 819–828.

Svensson, M., Johansson, V., Dahlberg, A., Frisch, A., Thor, G. et al. (2016): The relative importance of stand and dead wood types for wood-dependent lichens in managed boreal forests. – Fungal Ecology 20: 166–174.

Turlajs, J. (2011): Latvijas ģeogrāfijas atlants [Geographical atlas of Latvia]. – Rīga: Publishing house "Jāņa sēta".

UNECE and FAO (2011): State of Europe's Forests 2011. Status and trends in sustainable forest management in Europe. – Ministerial Conference on the Protection of Forests in Europe, Forest Europe Liaison Unit, Oslo.

Van Wagner, C.E. (1968): The line intercept method in forest fuel sampling. – Forest Science 14: 20–26.

Vilén, T., Gunia, K., Verkerk, P.J., Seidl, R., Schelhaas, M.-J. et al. (2012): Reconstructed forest age structure in Europe 1950–2010. – Forest Ecol. Managem. 286: 203–218.

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Appendix 1. The occurrences (observations per treatment or per substratum unit) of lichen species on stumps (A), fine woody debris (B), logs (C) and snags (D) in Latvian green tree retenion (GTR) cut sites with different GTR level ("high", ≥ 14 trees/ha and "low", ≤ 6 trees/ha) and time since harvest. Growing on wood (W) and/or bark surface of the stump is distinguished, as well as Red-listed lichens[1] (RL) and species reported as new for Latvia (N; N1 – published already in Moisejevs 2017[2]). Non-lichenised or saprotrophic calicioid species are marked with asterisk.

Time since GTR harvest	**4–6 yr.**				**9–11 yr.**					
GTR level	**High**		**Low**		**High**		**Low**			
Type of substratum	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**C**	**D**[3]
n = (A-B sites; C-D units)	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**24**	**9**
Bryoria fuscescens	–	2	–	2	–	1	–	2	–	–
Buellia griseovirens	–	–	–	–	–	–	–	–	14	6
Calicium glaucellum	–	–	1 W	–	4 W	–	4 W	–	15	1
Calicium trabinellum $^{\mathrm{N1}}$	–	–	–	–	1 W	–	1 W	–	10	1
Chaenotheca ferruginea	1 B	1	–	2	4 BW	2	2 W	2	1	2
Cladonia arbuscula/mitis	3 BW	–	1 W	4	3 BW	3	1 BW	3	1	–
Cladonia botrytes	1 W	1	–	–	4 W	2	4 BW	2	11	–
Cladonia cenotea	2 BW	–	–	1	4 BW	–	4 BW	–	3	–
Cladonia chlorophaea	1 W	1	–	3	4 BW	3	–	–	8	–
Cladonia coniocraea	4 BW	3	4 BW	4	4 BW	4	4 BW	3	10	1
Cladonia cornuta	2 B	–	–	–	4 BW	–	4 BW	–	3	–
Cladonia digitata	3 B	2	4 B	3	4 BW	2	3 BW	2	3	4
Cladonia fimbriata	4 B	2	–	3	4 BW	4	4 BW	4	9	2
Cladonia floerkeana	–	–	–	–	–	1	4 BW	2	1	–
Cladonia juv.	4 BW	4	4 BW	4	4 BW	4	4 BW	4	23	8
Cladonia macilenta	4 BW	4	1 W	4	4 BW	4	4 BW	3	15	–
Cladonia ochrochlora	3 BW	–	1 W	1	4 BW	–	4 BW	3	5	–
Cladonia parasitica $^{\mathrm{RL}}$	–	–	–	–	3 W	–	4 W	–	4	–
Cladonia rangiferina	3 BW	–	4 B	–	4 BW	–	4 BW	–	3	–
Cladonia stellaris	3 W	4	–	4	–	4	1 W	4	1	–
Evernia prunastri	1 W	4	–	4	2 BW	4	2 W	4	4	2
Hypocenomyce scalaris	3 B	2	3 B	2	4 B	2	4 BW	1	10	4
Hypogymnia physodes	4 BW	4	4 BW	4	4 BW	4	4 BW	4	22	6
Hypogymnia tubulosa	–	1	–	1	–	–	1 BW	1	4	–

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[1] Anonymous 2013. Regulation of Cabinet of Ministers Nr. 940 (Accepted: 01.01.2013). Noteikumi par mikroliegumu izveidošanas un apsaimniekošanas kārtību, to aizsardzību, kā arī mikroliegumu un to buferzonu noteikšanu. https://likumi.lv/doc.php?id=253746 [Accessed 20 September 2018]. (in Latvian).

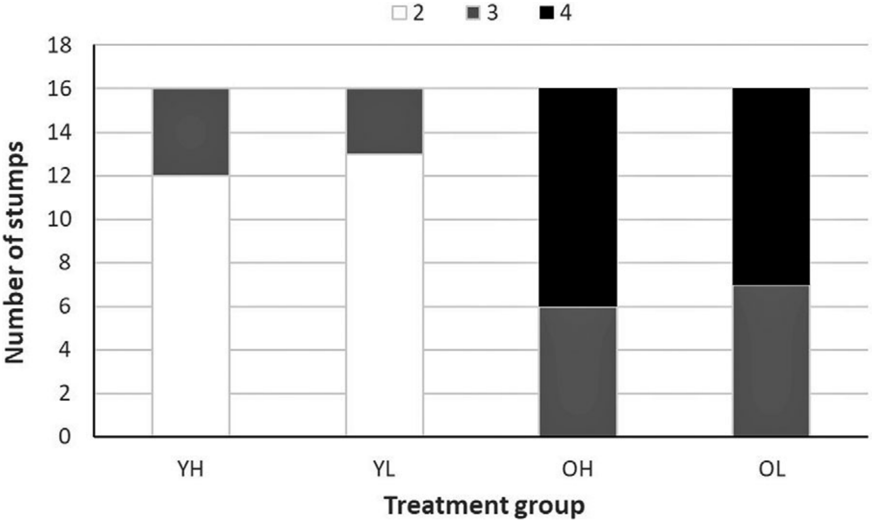
[2] Moisejevs, R. 2017. Lichens and allied fungi new for Latvia. Folia Cryptog. Estonica 54: 9–12.

[3] In our study all sampled snags were at least 2.5 m high and had at least 18 cm diameter at breast height (DBH).

Appendix 1. cont.

Time since GTR harvest	**4–6 yr.**				**9–11 yr.**					
GTR level	**High**		**Low**		**High**		**Low**			
Type of substratum	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**C**	**D**^{3}
n = (A-B sites; C-D units)	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**24**	**9**
Imshaugia aleurites	2 B	4	4 B	1	2 B	3	4 BW	3	6	6
Lecanora pulicaris	2 B	2	–	3	4 B	4	4 BW	4	15	7
Lecanora varia	–	–	–	–	4 W	1	3 BW	–	17	6
Lecidea nylanderi	4 B	1	2 B	1	4 B	2	3 B	–	4	6
Lecidea turgidula	3 B	–	4 B	–	4 BW	1	1 B	–	–	–
Lepraria incana	–	3	–	4	–	4	3 B	3	5	1
Lepraria jackii	4 BW	–	4 B	–	4 BW	–	4 BW	–	7	1
Melanohalea exasperatula	1 B	4	–	4	–	4	3 B	4	8	2
Melanohalea olivacea	–	2	–	1	–	–	–	–	1	–
Micarea denigrata	–	2	1 W	3	4 BW	3	2 W	–	7	–
Micarea prasina s.lat	–	1	–	–	3 BW	1	3 W	–	4	2
Mycocalicium subtile *	4 W	–	4 W	–	4 W	–	4 W	–	22	8
Parmelia sulcata	3 BW	4	2 BW	4	4 BW	3	4 BW	3	13	2
Parmeliopsis ambigua	3 BW	4	4 BW	4	4 BW	4	4 BW	4	21	2
Physcia adscendens	1 W	1	–	1	–	2	–	2	–	–
Physcia tenella	–	–	–	–	2 BW	–	1 W	–	1	–
Placynthiella dasaea	–	–	–	–	4 W	1	3 W	–	–	–
Placynthiella icmalea	4 W	4	4 W	4	4 W	4	4 BW	4	2	–
Platismatia glauca	–	–	–	1	–	1	–	4	–	–
Pseudevernia furfuracea	4 B	4	–	4	2 BW	4	–	4	7	1
Pycnora sorophora ^{N1}	–	–	–	–	1 W	–	1 B	–	1	1
Sarea resinae *	–	2	–	1	–	2	–	4	–	–
Scoliciosporum chlorococcum	–	4	–	4	–	4	–	4	–	–
Scoliciosporum sarothamni ^{N}	–	1	–	1	–	2	–	2	–	–
Strangospora moriformis	4 B	3	3 B	2	4 B	1	3 B	2	–	–
Trapeliopsis flexuosa	4 BW	4	4 BW	4	4 BW	4	4 BW	4	2	–
Trapeliopsis granulosa	3 B	–	3 W	1	4 BW	3	4 BW	1	–	–
Tuckermannopsis chlorophylla	–	–	–	1	3 BW	4	2 W	4	–	–
Usnea hirta	–	4	–	3	4 BW	4	2 W	4	3	1
Violella fucata	1 BW	4	1 W	3	3 BW	4	3 W	4	16	4
Vulpicida pinastri	3 BW	4	1 B	2	3 BW	1	4 BW	3	12	4
Total	**34**	**35**	**24**	**39**	**42**	**41**	**45**	**36**	**44**	**27**

Appendix 2. The maximal number of decay classes (five–point scale according to Lõhmus & Kraut 2010) per stump among treatment types (YH and YL: 4–6 yr. old sites with high, ≥14 trees/ha and low, ≤6 trees/ha GTR level, respectively; OH and OL: 9–11 yr. old sites with high and low GTR level, respectively).



Appendix 3. Lichen species association based on indicator species analysis to stumps and fine woody debris (FWD) in pine dominated dry-boreal cut sites with different age and green tree retention (GTR) level. Only species with high indicator value (IV>50%) and statistical significance (p<0.05) are given. Cut site treatment types: 1: 4–6 yr. high GTR level (≥ 14 trees/ha); 2: 9–11 yr.; 3: 9–11 yr. high GTR; 4: 9–11 yr. low GTR (≤ 6 trees/ha).

Substratum	**Stump**				**FWD**			
Treatment	**Age × GTR**	**IV(p)**	**Age**	**IV(p)**	**Age × GTR**	**IV(p)**	**Age**	**IV(p)**
Calicium glaucellum			2	93(0.001)				
Chaenotheca ferruginea	3	58(0.049)	2	80(0.001)				
Cladonia botrytes	4	57(0.009)	2	93(0.001)				
Cladonia cenotea			2	88(0.001)				
Cladonia chlorophaea	3	88(0.006)						
Cladonia coniocraea			2	63(0.024)				
Cladonia cornuta	4	50(0.055)	2	93(0.001)				

Appendix 3. cont.

Substratum	**Stump**				**FWD**			
Treatment	**Age × GTR**	**IV(p)**	**Age**	**IV(p)**	**Age × GTR**	**IV(p)**	**Age**	**IV(p)**
Cladonia fimbriata			2	77(0.002)			1	59(0.024)
Cladonia floerkeana	4	100(0.001)						
Cladonia ochrochlora			2	81(0.001)			2	68(0.04)
Cladonia parasitica	4	67(0.011)	2	88(0.001)				
Hypocenomyce scalaris			2	68(0.013)				
Lecanora pulicaris	4	65(0.001)	2	91(0.001)				
Lecanora varia	3	62(0.023)	2	100.0(<0.001)				
Lepraria incana	4	75(0.022)						
Micarea denigrata	3	57(0.050)	2	70(0.015)				
Micarea prasina s.lat			2	75(0.007)				
Placynthiella dasaea			2	88(0.001)				
Platismatia glauca					4	57(0.033)		
Pseudevernia furfuracea	1	67(0.036)						
Trapeliopsis granulosa			2	77(0.002)				
Tuckermannopsis chlorophylla			2	63(0.030)				
Usnea hirta			2	88(0.003)				
Violella fucata			2	74(0.020)			2	64(0.028)

II

Ninety-one species of lichens and allied fungi new to Latvia with a list of additional records from Kurzeme

Jurga Motiejūnaitė[*], Sergei V. Chesnokov, Paweł Czarnota, Ludmila V. Gagarina, Ivan Frolov, Dmitry Himelbrant, Ludmila A. Konoreva, Dariusz Kubiak, Martin Kukwa, Rolands Moisejevs, Irina Stepanchikova, Ave Suija, Gulnara Tagirdzhanova, Arne Thell & Andrei Tsurykau

Abstract: Motiejūnaitė, J., Chesnokov, S. V., Czarnota, P., Gagarina, L.V., Frolov, I., Himelbrant, D., Konoreva, L. A., Kubiak, D., Kukwa, M., Moisejevs, R., Stepanchikova, I., Suija, A., Tagirdzhanova, G., Thell, A. & Tsurykau, A. 2016. Ninety-one species of lichens and allied fungi new to Latvia with a list of additional records from Kurzeme. – Herzogia **29**: 143–163.

The results of lichenological excursions of the 19th Symposium of Baltic Mycologists and Lichenologists (BMLS) in Latvia, Kurzeme region, 22–26 September 2014, are reported. A list of 290 species is presented, of which 238 are lichenized, 43 lichen-inhabiting, and nine saprotrophic fungi: ninety-one species are new to Latvia, twelve of which (*Caloplaca duplicata*, *Cresporhaphis wienkampii*, *Ellisembia lichenicola*, *Gallowayella weberi*, *Gregorella humida*, *Lichenochora weillii*, *Parmelia serrana*, *Polycauliona phlogina*, *Reconditella physconiarum*, *Stictis brunnescens*, *Thelocarpon superellum*, and *Verrucaria tectorum*) are also new for the Baltic States. *Athallia alnetorum* is reported here for the first time in northern Europe. The presence of *Ochrolechia androgyna* s. str., *Athallia holocarpa* and *A. pyracea* is confirmed for Latvia, and *Parmelia submontana* is reported as a new host for *Homostegia piggotii*.

Zusammenfassung: Motiejūnaitė, J., Chesnokov, S. V., Czarnota, P., Gagarina, L.V., Frolov, I., Himelbrant, D., Konoreva, L. A., Kubiak, D., Kukwa, M., Moisejevs, R., Stepanchikova, I., Suija, A., Tagirdzhanova, G., Thell, A. & Tsurykau, A. 2016. Einundneunzig Flechten, flechtenbewohnende und flechtenähnliche Pilze neu für Lettland, mit einer Liste weiterer Funde aus Kurland. – Herzogia **29**: 143–163.

Die Ergebnisse der lichenologischen Exkursionen im Rahmen des 19. Symposiums Baltischer Mykologen und Lichenologen (BMLS) in Kurland (Lettland) vom 22.–26. September 2014 werden vorgestellt. Die Liste umfaßt 290 Arten, darunter 238 Flechten, 43 flechtenbewohnende und 9 saprophytische Pilze. 91 Arten sind neu für Lettland, darunter sind 12 (*Caloplaca duplicata*, *Cresporhaphis wienkampii*, *Ellisembia lichenicola*, *Gallowayella weberi*, *Gregorella humida*, *Lichenochora weillii*, *Parmelia serrana*, *Polycauliona phlogina*, *Reconditella physconiarum*, *Stictis brunnescens*, *Thelocarpon superellum* und *Verrucaria tectorum*) neu für die baltischen Staaten. *Athallia alnetorum* wird erstmals für Nordeuropa dokumentiert. Das Vorkommen von *Ochrolechia androgyna* s. str., *Athallia holocarpa* und *A. pyracea* in Lettland wird bestätigt. *Parmelia submontana* ist ein neuer Wirt für *Homostegia piggotii*.

Key words: Lichenized fungi, lichenicolous fungi, biodiversity, protected areas, Kurland, Baltic region.

Introduction

Lichenological investigations in Latvia date back to the 18th century (Piterāns 1982) and continued to be undertaken until the last decade of the 20th century. However, for the last three decades, new records of lichens and lichenicolous fungi have been mainly reported by partici-

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[*] Corresponding author

pants of the Symposia of Baltic Mycologists and Lichenologists (Motiejūnaitė & Piterāns 1998, Motiejūnaitė et al. 2006, Czarnota & Kukwa 2010), by fortuitous visiting lichenologists (Sundin & Thor 1990, Motiejūnaitė & Grochowski 2014), or as the results of ecological studies (Plociņa 2007, Mežaka 2009, Mežaka et al. 2008, 2009, 2012), and only occasionally as targeted lichen diversity studies (Piterāns et al. 2005, 2006). Thus, Latvian lichen biota is at present the least studied of the three Baltic States. However, the Kurzeme region is one of the better explored parts of Latvia, especially areas of Nature Reserve Moricsala, Nature Preserve Užava and Slītere National Park (Mežaka 2009).

Symposia of the Baltic Mycologists and Lichenologists (BMLS) have been held since 1959 (Randlane et al. 2000), during which the attendees have firmly kept a tradition to compile a list of species found during the field trips. A deep knowledge of certain taxonomic groups, field experience and an open mind shared by the participants has always resulted in new species for the country, even for all the Baltic States. The 19th BMLS held in the Kurzeme region (historically known as Kurland) of Latvia proved no exception and as a consequence a detailed species list of lichenized, lichenicolous and allied fungi found by the participants of the Symposium held in Šķēde on 22–26 September 2014 was compiled which significantly contributes to our knowledge of Latvian biota.

Study area

The Kurzeme region, situated in the western part of Latvia, occupies an area of 14.771 km^2. There are two major industrial cities, Liepāja and Ventspils, and the highest populations are to be found in the districts of Liepājas, Ventspils and Talsi. There is one National Park, over 30 Nature Parks, two Nature Reserves, seven protected dendrological plantations, and over 40 geological and geomorphological protected features (Dabas aizsardzības pārvalde 2015).

The region is bordered by the Baltic Sea to the west and Riga Gulf to the northeast. Highest areas above sea level are in the eastern and southeastern parts of the region, namely the Rietumkursas, Ziekeļkursas and Austrumkursas uplands reaching 189.5 m at Krievukalns. The lowlands are mainly coastal, Piejūras and Kursas, situated in the central part of the region. The largest river is Venta which is 346 km in length and has a catchment area of over 11.000 km^2 (Turlājs 2011). Outcrops of dolomite and sandstone are found along its banks and in the catchment area of the river (Rēriha 2013).

The climate of the Kurzeme region is mainly attributed to Atlantic cyclones that bring air masses and precipitation from the west and northwest. The average temperature ranges from –3 to –6°C in January, and from 16.5 to 17°C. in July. Annual precipitation ranges from 600 to 850 mm, and snow cover remains for 80–110 days (Turlājs 2011, Anonymous 2013).

A number of habitat types included into Annex I of European Union Habitat Directive are found in the region, such as 4110 Northern Atlantic wet heaths with *Erica tetralix*, 6530 *Fennoscandian wooded meadows, 9010 *Western taiga, 9020 *Fennoscandian hemiboreal natural old deciduous forests rich in epiphytes, 9050 Fennoscandian herb-rich forests with *Picea abies*, 9080 *Fennoscandian deciduous swamp woods, 9160 Sub-Atlantic and medio-European oak forests, 9180 Tilio-Acerion forests of slopes, screes and ravines, 5130 *Juniperus communis* formations on heaths or calcareous grasslands, 91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*, 91D0 Bog woodland, 8220 Siliceous (sandstone) rocky slopes with chasmophytic vegetation, 8210 Calcareous rocky slopes with chasmophytic vegetation (Anonymous 2013).

List of visited localities:

A map of the localities is presented in Fig. 1.

1 23.09.2014. Talsi district, Šķēde Forest Research Station, Mežmāja Šķēde, park, 57°14'53.4"N, 22°41'39.9"E, village, gardens, roadside scarps, planted arboretum and some old hardwood trees;

2 23.09.2014. Talsi district, vicinity of Roceži, 57°16'17"N, 22°37'31"E, village, broad-leaved trees in the roadside alley and in the village;

3 24.09.2014. Talsi district, NE of Odre village, 57°14'03.3"N, 22°43'01.0"E, old *Populus tremula* forest with spruce and birch, old farm place;

4 24.09.2014. Talsi district, Nature Park "Talsu pauguraine", SE of Sukturi, 57°14'N, 22°38'E, old planted *Larix decidua* stand with *Corylus avellana,* Sapnu ezers peat-bog;

5 24.09.2014. Talsi district, Nature Park "Talsu pauguraine", 57°15'06.9"N, 22°42'51.9"E, old planted *Abies alba* forest with spruce, birch and hardwood trees;

6 24.09.2014. Talsi district, Talsi, c. 2 km south-east of the city, 57°14'08.1"N, 22°38'04.2"E, roadside broad-leaved trees;

7 25.09.2014. Dundaga district, Slītere National Park, Mazirbe, 57°41'25.4"N, 22°19'02.1"E, the village, trees in the roadside alley, roadside sandy meadow, alder stand, pine forest on seashore sand dunes;

8 25.09.2014. Dundaga district, Slītere National Park, Slītere lighthouse environs, along Slītere Nature Trail, 57°37'51.3"N, 22°17'30.8"E, mixed old-growth forest with spruces and broad-leaved trees, roadside trees between the parking area and lighthouse;

9 25.09.2014. Dundaga district, Dundaga town, 57°30'38.0"N, 22°21'15.1"E, park of Dundaga Castle: old hardwood trees;

10 26.09.2014. Kuldiga district, Kuldiga town, 56°58'12.21"N, 21°58'24.05"E, town park, trees in the roadside alleys.

Material and methods

Air-dried samples of lichens and fungi were examined using stereomicroscopes and light microscopes and the usual spot tests with standard identification methods for lichenized and lichenicolous fungi (Smith et al. 2009). Thin Layer Chromatography (TLC) analyses (Orange et al. 2001) were carried out where required. In some cases, the opinion of experts was requested (see Acknowledgements). To check the identification of *Athallia alnetorum* and *Polycauliona phlogina,* the DNA barcoding was employed (the ITS regions including the 5.8S gene of the nuclear rDNA). The CTAB method (Aras & Cansaran 2006) was used for DNA isolations. Primers for PCR amplification of ITS were ITS1F (Gardes & Bruns 1993) and ITS4 (White et al. 1990). PCR cycling parameters followed Ekman (2001). The most similar known sequences were found using the BLAST search in the GenBank.

The nomenclature of taxa follows Nordin et al. (2011), except for some recent nomenclatural changes (Ertz et al. 2015, Schultz et al. 2015, Zhao et al. 2016). Species new for Latvia are supplied with the collectors' names and herbaria in which the specimens are deposited.

Abbreviations of collectors: AS = Ave Suija, AT = Arne Thell, ANT = Andrei Tsurykau, DH = Dmitry Himelbrant, DK = Dariusz Kubiak, GT = Gulnara Tagirdzhanova, IF = Ivan Frolov, IS = Irina Stepanchikova, JM = Jurga Motiejūnaitė, LG = Ludmila Gagarina, LK = Ludmila A. Konoreva, MK = Martin Kukwa, PC = Paweł Czarnota, and SC = Sergei V. Chesnokov.

Abbreviations of herbaria: BILAS = Institute of Botany, Vilnius, Lithuania, GPN = Gorce National Park, Poland, GSU = F. Skorina Gomel State University, Belarus, LD = Botanical Museum of Lund University, Sweden, LE = V. L. Komarov Botanical Institute, Saint-Petersburg, Russia, LECB = Saint-Petersburg State University, Russia, OLTC = Department of Mycology, Warmia and Mazury University in Olsztyn, Poland, TU = Botanical and

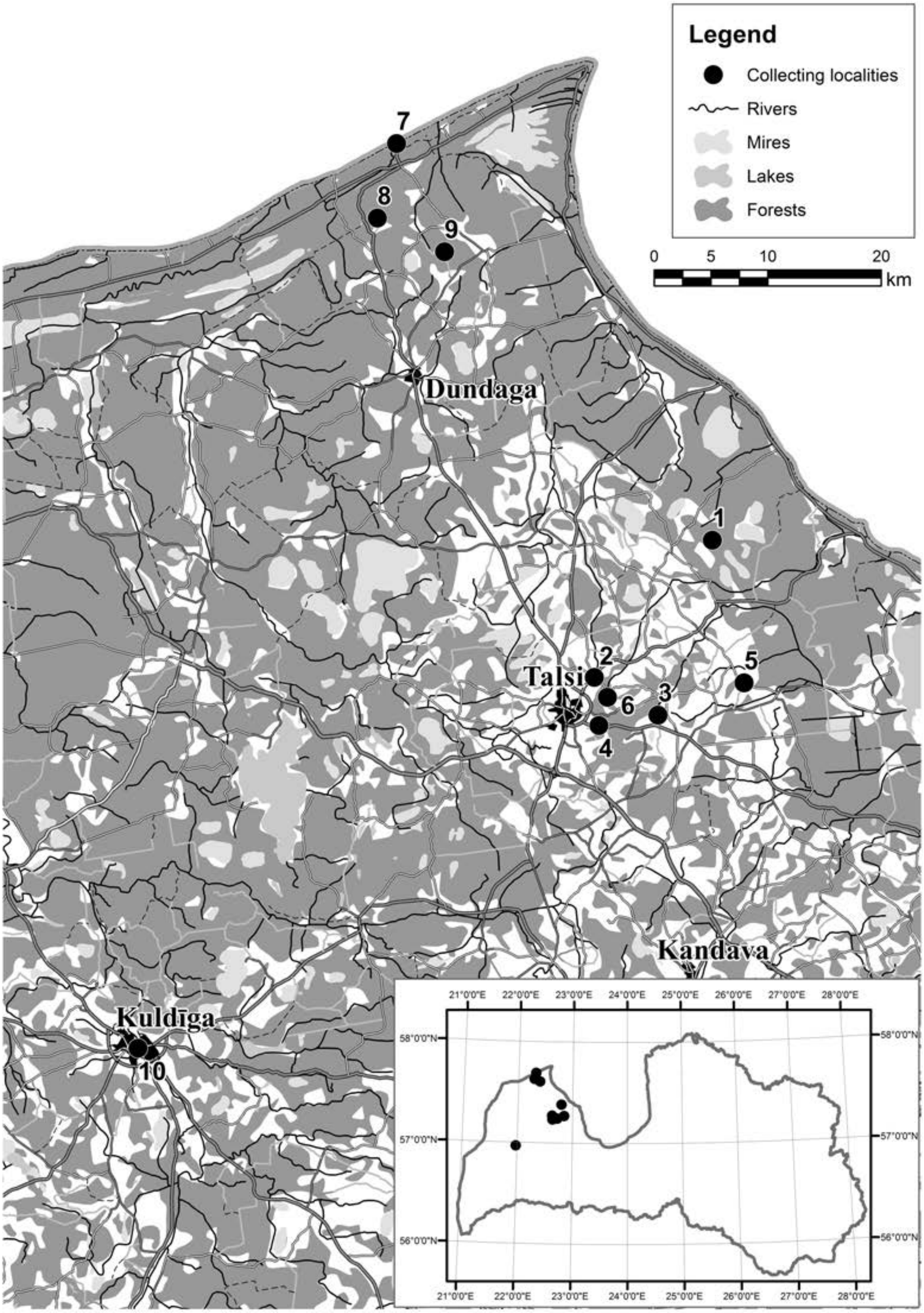

Fig. 1: Visited localities in Kurzeme Region and their situation in Latvia.

Mycological Museum, Natural History Museum of the University of Tartu, Estonia, UGDA = Gdańsk University, Poland, and Herb. IF = Private herbarium of Ivan Frolov.

List of substrata and their abbreviations: Abi = *Abies alba*, Ace = *Acer platanoides*, Aes = *Aesculus hippocastanum*, Aln = *Alnus glutinosa*, Bet = *Betula* spp., Car = *Carpinus betulus*, Coa = *Corylus avellana*, Fag = *Fagus sylvatica*, Fra = *Fraxinus excelsior*, Lar = *Larix decidua*, Mal = *Malus domestica*, Pic = *Picea abies*, Pin = *Pinus sylvestris*, Pop = *Populus tremula*, Pru = *Prunus padus*, Pyr = *Pyrus communis*, Qur = *Quercus robur*, Sal = *Salix* spp., Sor = *Sorbus aucuparia*, Til = *Tilia cordata*, Ulm = *Ulmus* spp.; cal = concrete and other anthropogenic calcareous substrata, cor = corticolous, lig = lignicolous, res = resinicolous, roo = roots of windthrows, sil = siliceous stones, mus = muscicolous (over soil, bark, stone), ter = terricolous (including plant debris).

List of taxa

! = new to Latvia; **!!** = new to all Baltic States.

Absconditella lignicola Vězda & Pišút: 5, 8 (lig Bet, Pic).

Acarospora fuscata (Schrad.) Th.Fr.: 1 (sil).

Acrocordia cavata (Ach.) R.C.Harris: 3, 4 (cor Coa, Pop, Qur).

Acrocordia gemmata (Ach.) A.Massal.: 1, 3, 4, 8 (cor Fag, Fra, Pop, Qur).

Alyxoria culmigena (Lib.) Ertz: 1 (cor Fag), SC (LE).

Alyxoria varia (Pers.) Ertz & Tehler: 3, 4, 5, 7, 8, 9 (cor Aes, Aln, Fra, Lar, Pop, Ulm).

Amandinea punctata (Hoffm.) Coppins & Scheid.: 1, 4, 7, 8, 9, 10 (cor, lig Aes, Pic, Qur, Til).

Anaptychia ciliaris (L.) Körb.: 1, 4, 5, 8 (cor Qur, Pic, Pop).

!*Anisomeridium polypori* (M.B.Ellis & Everh.) M.E.Barr: 4, 5, 7, 8 (cor Qur, Til), DH (LECB), PC (GPN).

Arthonia didyma Körb.: 1, 3, 4, 5 (cor Abi, Coa, Pop, Sor).

Arthonia leucopellaea (Ach.) Almq.: 8 (cor Bet, Pic, Pin).

Arthonia radiata (Pers.) Ach.: 3, 5 (cor Ace, Coa, Fag).

Arthonia ruana A.Massal.: 3, 4, 5 (cor Aln, Coa).

Arthonia spadicea Leight.: 1, 3, 4, 5, 8 (cor Abi, Aln, Coa, Fag, Qur, Ulm).

!!*Athallia alnetorum* (Giralt, Nimis & Poelt) Arup, Frödén & Søchting: 6, 7 (cor, sil Pru, Sal) IF (Herb. IF).

!*Athallia cerinella* (Nyl.) Arup, Frödén & Søchting: 7 (cor Sal), IF (Herb. IF).

!*Athallia holocarpa* (Hoffm.) Arup, Frödén & Søchting: 7 (lig, sil), DH (LECB), IF (Herb. IF).

!*Athallia pyracea* (Ach.) Arup, Frödén & Søchting: 2, 3, 7 (cor Aln, Fra, Sal), DH (LECB), IF (Herb. IF), MK (UGDA), JM (BILAS).

Bacidia arceutina (Ach.) Arnold: 1 (cor Pyr).

Bacidia bagliettoana (A.Massal. & De Not.) Jatta: 7 (mus, ter).

!*Bacidia fraxinea* Lönnr.: 3 (cor Pop), DH (LECB), PC (GPN).

Bacidia rubella (Hoffm.) A.Massal.: 1, 3, 4, 7, 8 (cor, mus Fag, Lar, Pop, Qur, Til).

Bacidia subincompta (Nyl.) Arnold: 1, 4 (cor, mus Fag, Pyr).

Bacidina arnoldiana (Körb.) V.Wirth & Vězda s. lat.: 3 (lig).

!*Bacidina delicata* (Larbal. ex Leight.) V.Wirth & Vězda: 3 (cor Sal), PC (GPN).

Bacidina phacodes (Körb.) Vězda: 3 (cor Qur).

Baeomyces rufus (Huds.) Rebent.: 7 (ter).

Biatora efflorescens (Hedl.) Räsänen: 4, 5, 8 (cor, mus Abi, Bet, Pic, Qur).

Biatora globulosa (Flörke) Fr.: 1, 4 (cor Qur).

Biatora helvola Körb. ex Hellb.: 5, 8 (cor Abi, Pic).

!*Biatora meiocarpa* (Nyl.) Arnold: 8 (cor Pic), MK (UGDA).

Biatoridium monasteriense J.Lahm ex Körb.: 5 (cor Fag).

Bilimbia sabuletorum (Schreb.) Arnold: 9 (cal, mus).

Bryoria fuscescens (Gyeln.) Brodo & D.Hawksw.: 1 (lig).

Buellia griseovirens (Turner & Borrer ex Sm.) Almb.: 1, 3, 4, 5, 7, 8 (cor, lig Abi, Aln, Bet, Coa, Pic, Qur, Sal).

Buellia schaereri De Not.: 8 (cor Qur).

Calicium adspersum Pers.: 9 (cor Qur).

Calicium glaucellum Ach.: 7 (cor, lig Pin).

Calicium quercinum Pers.: 9 (cor Qur).

Calicium salicinum Pers.: 1, 9 (cor, lig Til).

Calicium viride Pers.: 1, 8, 9 (cor Qur, Til).

Caloplaca cerina (Ehrh. ex Hedw.) Th.Fr. var. ***cerina***: 3, 4 (cor Ace, Pru, Qur).

!*Caloplaca chlorina* (Flot.) Sandst.: 7 (sil), IF (Herb. IF).

!!*Caloplaca duplicata* (Vain.) H.Olivier: 7 (sil), IF (Herb. IF).

Caloplaca obscurella (J.Lahm. ex Körb.) Th.Fr.: 1 (cor Pyr).

!*Caloplaca ulcerosa* Coppins & P.James: 7 (cor Sal), IF (Herb. IF).

!*Candelariella efflorescens* R.C.Harris & W.R.Buck: 1 (cor Pyr), DH (LECB).

Candelariella vitellina (Hoffm.) Müll.Arg.: 7 (lig).

Candelariella xanthostigma (Ach.) Lettau: 1, 4, 7, 8, 10 (cor Aes, Pru, Qur, Til).

Catillaria nigroclavata (Nyl.) Schuler: 3, 7 (cor Aln, Sal).

Chaenotheca brachypoda (Ach.) Tibell: 3, 4, 5, 8 (cor, lig Lar, Pop, Qur).

Chaenotheca chlorella (Ach.) Müll.Arg.: 3 (cor, lig Bet, Pic).

Chaenotheca chrysocephala (Turner ex Ach.) Th.Fr.: 1, 3, 4, 5 (cor, lig Abi, Bet, Pin, Qur).

Chaenotheca ferruginea (Turner ex Sm.) Mig.: 4 (cor Pin).

Chaenotheca furfuracea (L.) Tibell: 3, 4, 8 (cor, roo Bet, Pic, Ulm).

Chaenotheca gracilenta (Ach.) Mattsson & Middelb.: 8 (cor Ulm).

!*Chaenotheca hispidula* (Ach.) Zahlbr.: 9 (cor Til), IS (LECB).

Chaenotheca phaeocephala (Turner) Th.Fr.: 3 (lig).

Chaenotheca stemonea (Ach.) Müll.Arg.: 1, 3, 9 (cor Pic, Qur, Til).

Chaenotheca trichialis (Ach.) Th.Fr.: 1, 3, 4, 7, 8, 9 (cor, lig Lar, Pic, Qur, Til).

!*Chaenotheca xyloxena* Nádv.: 8 (lig), PC (GPN).

Chrysothrix candelaris (L.) J.R.Laundon: 1, 8, 9 (cor Qur, Til).

!*Chrysothrix flavovirens* Tønsberg: 5 (cor Pic, Pin), AS (TU), MK (UGDA, GSU), JM (BILAS).

Cladonia chlorophaea (Flörke ex Sommerf.) Spreng.: 5 (cor Pic, Pin).

Cladonia coniocraea (Flörke) Spreng.: 5, 8 (cor Abi, Fra, Lar, Pic, Qur, Til).

Cladonia cornuta (L.) Hoffm.: 7 (ter).

Cladonia digitata (L.) Hoffm.: 7, 8 (cor, lig Aln).

Cladonia fimbriata (L.) Fr.: 1 (cor Lar).

Cladonia furcata (Huds.) Schrad.: 7 (ter).

Cladonia gracilis (L.) Willd. subsp. ***gracilis***: 7 (ter).

Cladonia macilenta Hoffm.: 8 (cor Aln).

Cladonia ochrochlora Flörke: 5 (cor Aln).

Cladonia pyxidata (L.) Hoffm.: 7 (ter).

Cladonia rangiferina (L.) F.H.Wigg.: 7 (ter).

Cladonia subulata (L.) Weber ex F.H.Wigg.: 7 (ter).

Cliostomum griffithii (Sm.) Coppins: 1, 4, 5, 7, 9 (cor Abi, Lar, Qur, Sor, Til).

Coenogonium pineti (Ach.) Lücking & Lumbsch: 3, 5, 7, 8 (cor, lig Bet, Pic, Pop, Qur).

Collema limosum (Ach.) Ach.: 1 (ter).

Coniocarpon cinnabarinum DC.: 8 (cor Coa).

!!*Cresporhaphis wienkampii* (J.Lahm ex Hazsl.) M.B.Aguirre: 4 (cor Sal), DH & IS (LECB).

!*Diplotomma pharcidium* (Ach.) M.Choisy: 2 (cor Fra), AS (TU).

!*Eopyrenula leucoplaca* (Wallr.) R.C.Harris: 8 (cor Til), DH (LECB).

Evernia prunastri (L.) Ach.: 1, 4, 5, 10 (cor, lig Abi, Aes, Bet, Qur, Pyr, Til).

!*Fuscidea arboricola* Coppins & Tønsberg: 5, 8 (cor, lig Abi, Pic, Pin), MK (UGDA), PC (GPN).

!!*Gallowayella weberi* (S.Y.Kondr. & Kärnefelt) S.Y.Kondr., Fedorenko, S.Stenroos, Kärnefelt, Elix, J.-S.Hur & A.Thell: 10 (cor Aes), AT (LD).

Graphis scripta (L.) Ach.: 3, 4, 5, 8 (cor Aln, Bet, Coa, Fag, Fra, Qur).

!!*Gregorella humida* (Kullh.) Lumbsch: 1 (ter), DH (LECB), JM (BILAS).

!*Gyalecta derivata* (Nyl.) H.Olivier: 3 (cor Qur), JM (BILAS).

!*Gyalecta flotowii* Körb.: 4, 8 (cor Ulm), LG (LE), DH & GT (LECB).

Gyalecta truncigena (Ach.) Hepp: 4, 8 (cor Pop, Qur).

Gyalolechia flavorubescens (Huds.) Søchting, Frödén & Arup: 2, 3, 4 (cor Fra, Pop, Pru, Qur).

Hypocenomyce scalaris (Ach.) M.Choisy: 1 (cor Lar, Pin).

Hypogymnia physodes (L.) Nyl.: 1–10 (cor, lig Abi, Aln, Bet, Fra, Lar, Pic, Pin, Pru, Qur, Til).

Hypogymnia tubulosa (Schaer.) Hav.: 1, 4, 7 (cor, lig Bet, Lar).

Imshaugia aleurites (Ach.) S.L.F.Mey.: 8 (cor Pic).

Lecanactis abietina (Ach.) Körb.: 1, 3, 4, 5, 8, 9 (cor Abi, Aln, Bet, Lar, Pic, Til).

Lecania cyrtella (Ach.) Th.Fr.: 2, 3, 4, 7, 8 (cor Aln, Fra, Pru, Sal).

Lecania naegelii (Hepp) Diederich & van den Boom: 1, 3, 4, 7 (cor, lig Ace, Aln, Fag, Fra, Sal).

Lecanora albellula (Nyl.) Th.Fr.: 1, 4 (lig).

Lecanora allophana (Ach.) Nyl.: 2, 3, 7 (cor Ace, Fra, Pop, Ulm).

Lecanora argentata (Ach.) Malme: 4, 7, 8, 9 (cor Qur, Sal, Til).

Lecanora carpinea (L.) Vain.: 1, 3, 4, 5, 7, 8 (cor, lig Ace, Aln, Fra, Qur, Sal, Sor, Til).

Lecanora chlarotera Nyl.: 1–5, 7 (cor, lig Bet, Fag, Fra, Qur, Sor, Til).

Lecanora compallens Herk & Aptroot: 1, 3, 5, 7 (cor Abi, Pic, Pin, Pyr, Til).

Lecanora expallens Ach.: 4, 5, 7 (cor Abi, Bet, Qur).

!*Lecanora farinaria* Borrer: 5 (cor Abi), MK (UGDA).

Lecanora leptyrodes G.B.F.Nilsson: 1–4 (cor Bet, Fra, Qur, Til).

Lecanora pulicaris (Pers.) Ach.: 1, 7 (cor Bet, Pin).

Lecanora rugosella Zahlbr.: 3, 4, 7 (cor Coa, Fag, Til).

Lecanora sambuci (Pers.) Nyl.: 2 (cor Fra).

!*Lecanora subcarpinea* Szatala: 1 (cor Car), MK (UGDA).

Lecanora symmicta (Ach.) Ach.: 1, 4, 5 (cor, lig Bet, Pop, Qur).

Lecanora varia (Hoffm.) Ach.: 1 (cor Sor).

Lecidea albohyalina (Nyl.) Th.Fr.: 1 (cor Abi).

Lecidea nylanderi (Anzi) Th.Fr.: 3, 5 (cor Pic, Pin, Qur).

Lecidella elaeochroma (Ach.) M.Choisy: 1–5, 7, 8 (cor, lig Aln, Fag, Fra, Pin, Pru, Qur, Sal, Til).

Lecidella elaeochroma (Ach.) M.Choisy f. ***soralifera*** (Erichsen) D.Hawksw.: 8 (cor Til).

Lecidella euphorea (Flörke) Hertel: 7 (cor Bet).

Lecidella flavosorediata (Vězda) Hertel & Leuckert: 1, 4, 5, 8 (cor, lig Abi, Fra, Qur).

Lecidella stigmatea (Ach.) Hertel & Leuckert: 9 (cal).

Lecidella subviridis Tønsberg: 4 (cor Qur).

Lepraria elobata Tønsberg: 1, 5, 8 (cor Abi, Aln, Qur).

Lepraria incana (L.) Ach.: 1, 4, 5, 8, 9 (cor Abi, Bet, Lar, Qur).

Lepraria lobificans Nyl.: 4, 5, 7, 8 (cor, roo Abi, Fag, Fra).

Lepraria rigidula (de Lesd.) Tønsberg: 1 (cor Pyr).

!*Leptogium byssinum* (Hoffm.) Nyl.: 1 (ter), ANT (GSU).

Lobaria pulmonaria (L.) Hoffm.: 8, 9 (cor Ace, Qur).

Loxospora elatina (Ach.) A.Massal.: 1, 5, 8 (cor, lig Abi, Pic).

Melanelixia glabratula (Lamy) Sandler & Arup: 1, 3, 4, 5, 8 (cor, lig Coa, Pru, Sor, Til).

Melanelixia subargentifera (Nyl.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch: 8, 10 (cor Aes, Qur).

Melanelixia subaurifera (Nyl.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch: 1 (cor Mal).

Melanohalea exasperata (De Not.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch: 1, 4, 7, 8 (cor, lig Bet, Qur).

Melanohalea exasperatula (Nyl.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch: 1, 3, 4, 5, 7 (cor, lig Bet, Pic, Qur, Sor).

!*Micarea anterior* (Nyl.) Hedl.: 5 (lig), DH (LECB).

!*Micarea byssacea* (Th.Fr.) Czarnota, Guzow-Krzemińska & Coppins: 7, 8 (cor, lig Pin), PC (GPN).

Micarea denigrata (Fr.) Hedl.: 5, 9 (lig).

!*Micarea micrococca* (Körb.) Gams ex Coppins: 8 (cor Pic), PC (GPN).

Micarea misella (Nyl.) Hedl.: 5, 7, 8 (lig).

!*Micarea peliocarpa* (Anzi) Coppins & R.Sant.: 8 (lig), LK (LE), PC (GPN).

Micarea prasina Fr.: 3, 4, 5, 8 (lig).

Multiclavula mucida (Pers.) R.H.Petersen: 8 (lig).

Mycoblastus sanguinarius (L.) Norman: 8 (cor Bet).

Myriolecis albescens (Hoffm.) Śliwa, Zhao Xin & Lumbsch: 7 (lig, dust impregnated).

Myriolecis dispersa (Pers.) Śliwa, Zhao Xin & Lumbsch: 9 (sil).

Myriolecis hagenii (Ach.) Śliwa, Zhao Xin & Lumbsch: 2, 3, 7, 8, 9 (cor, lig Aln, Fra, Til).

Myriolecis persimilis (Th. Fr.) Śliwa, Zhao Xin & Lumbsch: 7 (cor Ace, Pin).

Naetrocymbe punctiformis (Pers.) R.C.Harris: 8 (cor Qur).

!*Normandina acroglypta* (Norman) Aptroot: 4 (cor, mus Pop), JM (BILAS, GSU).

!*Ochrolechia androgyna* (Hoffm.) Arnold: 8 (cor Aln), MK (UGDA), DK (OLTC).

Ochrolechia arborea (Kreyer) Almb.: 5 (cor Abi).

!*Ochrolechia microstictoides* Räsänen: 1, 3, 4, 7 (cor, lig Bet, Pic, Pin), MK (UGDA), DH & GT (LECB).

Ochrolechia turneri (Sm.) Hasselrot: 1 (cor Pyr).

Opegrapha vermicellifera (Kunze) J.R.Laundon: 8 (cor Fr, Ulm).

Opegrapha vulgata (Ach.) Ach.: 5, 9 (cor Qur, Til).

Pachyphiale fagicola (Hepp ex Arnold) Zwackh: 1, 5 (cor Fag).

Parmelia saxatilis (L.) Ach.: 8 (cor Bet, Pic).

!!*Parmelia serrana* A.Crespo, M.C.Molina & D.Hawksw.: 8 (cor Coa, Qur), AT (LD, LECB), ANT (GSU), AS (TU), JM (BILAS).

!*Parmelia submontana* Nádv. ex Hale: 1, 4 (cor Ace, Pru), DH (LECB), JM (BILAS).

Parmelia sulcata Taylor: 1, 4, 5, 7 (cor, lig, sil Ace, Bet, Fra, Qur, Sor).

Parmeliopsis ambigua (Wulfen) Nyl.: 4, 5 (cor Bet, Pin).

Peltigera aphthosa (L.) Willd.: 7 (ter).

Peltigera canina (L.) Willd.: 3, 7 (ter, lig).

Peltigera hymenina (Ach.) Delise: 7 (ter).

Peltigera malacea (Ach.) Funck: 7 (ter).

Peltigera neckeri Hepp ex Müll.Arg.: 7 (ter).

Peltigera praetextata (Flörke ex Sommerf.) Zopf: 3, 5, 8 (cor, ter Fra, Lar, Pop).

Peltigera rufescens (Weiss) Humb.: 7, 9 (ter).

Pertusaria albescens (Huds.) M.Choisy & Werner: 1, 3, 5, 9 (cor Ace, Pop, Pyr, Qur, Til).

Pertusaria amara (Ach.) Nyl.: 1, 4, 5, 8, 9 (cor Abi, Bet, Pic, Qur, Sor, Til).

Pertusaria coccodes (Ach.) Nyl.: 1, 4, 7, 8, 9 (cor Ace, Fra, Pop, Pyr, Qur, Til).

Pertusaria coronata (Ach.) Th.Fr.: 1, 4, 8, 9 (cor Fra, Qur, Til).

Pertusaria flavida (DC.) J.R.Laundon: 8, 9 (cor Aln, Fra, Qur).

Pertusaria leioplaca DC.: 3, 4, 8 (cor Coa, Fag, Fra, Ulm).

Pertusaria pertusa (Weigel) Tuck.: 8, 9 (cor Fra, Qur, Til).

Phaeophyscia ciliata (Hoffm.) Moberg: 4 (cor Qur).

!*Phaeophyscia endophoenicea* (Harm.) Moberg: 8 (cor, mus Fra, Til), DH (LECB), PC (GPN).

Phaeophyscia nigricans (Flörke) Moberg: 8 (cor Qur).

Phaeophyscia orbicularis (Neck.) Moberg: 2, 4, 7, 10 (cor Aes, Fra, Pop, Sal).

Phlyctis argena (Ach.) Flot.: 1, 3, 4, 5, 7, 8, 10 (cor Abi, Aes, Aln, Bet, Coa, Lar, Pop, Pru, Qur, Sor, Til).

Physcia adscendens (Fr.) H.Olivier: 1, 3, 8 (cor Aln, Til, Pic, Qur).

Physcia aipolia (Ehrh. ex Humb.) Fürnr.: 1, 2, 3, 5, 7, 8 (cor Aln, Bet, Qur).

Physcia stellaris (L.) Nyl.: 9 (cor Til).

Physcia tenella (Scop.) DC.: 1, 3, 4, 7, 8 (cor, sil Aln, Pic, Pin, Prun, Qur, Til).

Physconia detersa (Nyl.) Poelt: 1, 8 (cor Qur, Til).

Physconia distorta (With.) J.R.Laundon: 1, 4, 5, 7, 8 (cor Bet, Pru, Qur).

Physconia enteroxantha (Nyl.) Poelt: 1, 8, 10 (cor Aes, Fag, Pyr, Qur).

Physconia perisidiosa (Erichsen) Moberg: 1, 8, 10 (cor Aes, Qur).

Placynthiella dasaea (Stirt.) Tønsberg: 8 (cor Aln, Ulm).

Placynthiella icmalea (Ach.) Coppins & P.James: 1, 5, 7 (lig).

Platismatia glauca (L.) W.L.Culb. & C.F.Culb.: 1, 4, 5 (cor Bet, Pic, Pin, Qur).

Pleurosticta acetabulum (Neck.) Elix & Lumbsch: 1 (cor Qur).

Polycauliona candelaria (L.) Frödén, Arup & Søchting: 9 (cor Fra).

!!*Polycauliona phlogina* (Ach.) Arup, Frödén & Søchting: 7 (lig), IF (Herb. IF), SC (LE).

Polycauliona polycarpa (Hoffm.) Frödén, Arup & Søchting: 1, 4, 8 (cor, lig Fra, Qur, Sal).

!*Protothelenella sphinctrinoidella* (Nyl.) H.Mayrhofer & Poelt: 1 (ter), SC (LE), IS (LECB).

Pseudevernia furfuracea (L.) Zopf: 1, 4, 5, 8 (cor Bet, Pic, Pin, Qur, Sor).

!*Psilolechia clavulifera* (Nyl.) Coppins: 8 (roo Pic), PC (GPN).

Pseudoschismatomma rufescens (Pers.) Ertz & Tehler: 1, 4, 7, 8 (cor Fag, Fra, Til).

Pyrenula nitidella (Flörke ex Schaer.) Müll.Arg.: 8 (cor Coa, Fra).

Ramalina baltica Lettau: 5 (cor Qur).

Ramalina calicaris (L.) Fr.: 5 (cor Abi).

Ramalina farinacea (L.) Ach.: 1, 3, 4, 5 (cor, lig Bet, Pic, Qur, Sor).

Ramalina fastigiata (Pers.) Ach.: 1, 4, 5 (cor Fra, Qur, Til).

Ramalina fraxinea (L.) Ach.: 1, 3, 4, 7 (cor Fra, Qur, Sal).

Ramalina pollinaria (Westr.) Ach.: 1, 5 (cor Qur).

Ramalina roesleri (Hochst. ex Schaer.) Hue: 1 (cor Qur).

Ramalina sinensis Jatta: 1 (cor Sor).

Rinodina pyrina (Ach.) Arnold: 2, 4, 5 (cor Qur, Sal).

!*Rinodina septentrionalis* Malme: 7 (cor Bet), LK (LE).

!*Rinodina sophodes* (Ach.) A.Massal.: 8 (cor Qur), DH (LECB).

Ropalospora viridis (Tønsberg) Tønsberg: 4 (cor Bet, Coa, Fra).

Sarcosagium campestre (Fr.) Poetsch & Schied.: 1 (ter).

!*Schismatomma pericleum* (Ach.) Branth & Rostr.: 5 (cor Abi), DH (LECB).

Sclerophora pallida (Pers.) Y.J.Yao & Spooner: 8, 9 (cor Fra, Qur).

Scoliciosporum chlorococcum (Graewe ex Stenh.) Vězda: 4 (cor Sal).

!*Scoliciosporum sarothamni* (Vain.) Vězda: 1, 3 (cor, lig Aln, Bet, Pic, Qur), SC (LE), DH & GT (LECB), PC (GPN).

Scytinium lichenoides (L.) Otálora, P.M.Jørg. & Wedin: 8 (cor, mus Fra).

!*Solitaria chrysophthalma* (Degel.) Arup, Frödén & Søchting: 7 (lig), DH (LECB).

!*Steinia geophana* (Nyl.) Stein: 1 (ter), ANT (GSU), AS (TU).

!*Strigula jamesii* (Swinscow) R.C.Harris: 3, 8 (cor Coa, Fra), IS, DH (LECB).

Thelidium zwackhii (Hepp) A.Massal.: 1 (ter).

!!*Thelocarpon superellum* Nyl.: 7 (ter), PC (GPN).

Thelotrema lepadinum (Ach.) Ach.: 8 (cor Coa, Fra, Qur).

!*Trapelia corticola* Coppins & P.James: 8 (lig), PC (GPN).

Trapeliopsis flexuosa (Fr.) Coppins & P.James: 1 (lig).

Tuckermannopsis chlorophylla (Willd.) Hale: 1, 8 (cor, lig Bet, Pic, Pin).

Usnea hirta (L.) Weber ex F.H.Wigg.: 1 (lig).

!!*Verrucaria tectorum* (A.Massal.) Körb.: 9 (cal), DH (LECB).

!*Verrucaria xyloxena* Norman: 8 (ter), AS (TU).

Violella fucata (Stirt.) T.Sprib.: 1, 4, 5, 7 (cor Abi, Fag, Pin).

Vulpicida pinastri (Scop.) J.-E.Mattsson & M.J.Lai: 1 (lig).

Xanthocarpia lactea (A.Massal.) A.Massal.: 9 (sil).

Xanthomendoza fallax (Hepp) Søchting, Kärnefelt & S.Y.Kondr.: 10 (cor Aes).

Xanthomendoza fulva (Hoffm.) Søchting, Kärnefelt & S.Y.Kondr.: 8, 10 (cor Aes, Qur).

Xanthoparmelia conspersa (Ach.) Hale: 1, 8 (sil).

Xanthoria parietina (L.) Th.Fr.: 1–10 (cal, cor, lig, sil).

!*Xylographa parallela* (Ach.) Fr.: 7 (lig), AS (TU).

!*Zwackhia sorediifera* (P.James) Ertz: 5 (cor Abi, Qur), MK (UGDA), DH & IS (LECB), JM (BILAS).

Zwackhia viridis (Ach.) Poetsch & Schied.: 8 (cor Pop).

Non lichenized, lichenicolous taxa

!*Arthonia epiphyscia* Nyl.: 7 (on *Physcia aipolia*), AS (TU).

!*Arthonia molendoi* (Heufl. ex Frauenf.) R.Sant.: 2, 4, 7 (on *Xanthoria parietina*), AS (TU), MK (UGDA), IS (LECB), JM (BILAS).

Briancoppinsia cytospora (Vouaux) Diederich, Ertz, Lawrey & van den Boom: 1 (on *Evernia prunastri*).

!*Corticifraga fuckelii* (Rehm) D.Hawksw. & R.Sant.: 7 (on *Peltigera neckeri*), AS (TU), MK (UGDA), PC (GPN).

! *Didymocyrtis epiphyscia* Ertz & Diederich s. lat.: 7 (on *Xanthoria parietina*), MK (UGDA).

! *Didymocyrtis ramalinae* (Roberge ex Desm.) Ertz, Diederich & Hafellner: 8 (on *Ramalina fraxinea*), MK (UGDA).

!!*Ellisembia lichenicola* Heuchert & U.Braun: 7 (on *Ramalina fraxinea*), MK (UGDA, dupl. in BILAS).

!*Epicladonia sandstedei* (Zopf) D.Hawksw.: 5 (on *Cladonia coniocraea*), JM (BILAS).

!*Erythricium aurantiacum* (Lasch) D.Hawksw. & A.Henrici: 1, 4 (on *Physcia* spp.), MK (UGDA), JM (BILAS).

!*Graphium aphthosae* Alstrup & D.Hawksw.: 7 (on *Peltigera neckeri*), MK (UGDA).

!*Homostegia piggotii* (Berk. & Broome) P.Karst.: 4 (on *Parmelia submontana*), DH (LECB).

Illosporiopsis christiansenii (B.L.Brady & D.Hawksw.) D.Hawksw.: 1, 4, 7 (on *Physcia* spp., *Xanthoria parietina*, unindentified crustose lichen).

!*Lichenochora obscuroides* (Linds.) Triebel & Rambold: 4 (on *Phaeophyscia orbicularis*), MK (UGDA).

!!*Lichenochora weillii* (Werner) Hafellner & R.Sant.: 1 (on *Physconia enteroxantha*), MK (UGDA).

Lichenoconium erodens M.S.Christ. & D.Hawksw.: 1, 8 (on *Evernia prunastri*, *Ramalina fraxinea*).

!***Lichenoconium lecanorae*** (Jaap) D.Hawksw.: 10 (on *Evernia prunastri*), DH (BILAS).

!***Lichenoconium pyxidatae*** (Oudem.) Petr. & Syd.: 7 (on *Cladonia* aff. *chlorophaea*), JM (BILAS).

!***Lichenoconium usneae*** (Anzi) D.Hawksw.: 1, 8 (on *Evernia prunastri*), JM (BILAS).

!***Lichenoconium xanthoriae*** M.S.Christ.: 7 (on *Xanthoria parietina*), DH (BILAS).

!***Lichenodiplis lecanorae*** (Vouaux) Dyko & D.Hawksw.: 7 (on *Lecanora* aff. *hagenii*, *Caloplaca* sp.), AS (TU), MK (UGDA).

Lichenosticta alcicornaria (Linds.) D.Hawksw.: 5 (on *Cladonia coniocraea*, *C. ochrochlora*), AS (TU).

!***Marchandiomyces corallinus*** (Roberge) Diederich & D.Hawksw.: 1 (on *Physcia tenella*), PC (GPN).

Monodictys epilepraria Kukwa & Diederich: 5, 8 (on *Lepraria* spp.).

!***Phaeopyxis punctum*** (A.Massal.) Rambold, Triebel & Coppins: 8 (on *Cladonia digitata*, *C. macilenta*), AS (TU), JM (BILAS).

Pronectria xanthoriae Lowen & Diederich: 4, 7 (on *Xanthoria parietina*).

!***Pyrenochaeta xanthoriae*** Diederich: 4, 7 (on *Xanthoria parietina*), AS (TU), MK (UGDA).

!!***Reconditella physconiarum*** Hafellner & Matzer: 4 (on *Physconia distorta*), MK (UGDA).

!***Refractohilum peltigerae*** (Keissl.) D.Hawksw.: 7 (on *Peltigera* spp.), AS (TU), MK (UGDA).

!***Sphinctrina turbinata*** (Pers.: Fr.) De Not.: 9 (on *Pertusaria pertusa*), DH (LECB).

!***Stigmidium microspilum*** (Körb.) D.Hawksw.: 8 (on *Graphis scripta*), AS (TU).

Syzygospora physciacearum Diederich: 1, 4, 7 (on *Physcia* spp.).

!***Taeniolella punctata*** M.S.Christ. & D.Hawksw.: 3 (on *Graphis scripta*), MK (UGDA).

!***Telogalla olivieri*** (Vouaux) Nik.Hoffm. & Hafellner: 1, 2, 3, 4, 7 (on *Xanthoria parietina*), AS (TU), MK (UGDA), JM (BILAS).

!***Thelocarpon epibolum*** Nyl. var. ***epibolum***: 7 (on *Peltigera neckeri*), MK (UGDA).

Tremella hypogymniae Diederich & M.S.Christ.: 8 (on *Hypogymnia physodes*).

!***Tremella lichenicola*** Diederich: 5 (on *Violella fucata*), DH (LECB), PC (GPN).

!***Tremella phaeophysciae*** Diederich & M.S.Christ.: 4 (on *Phaeophyscia orbicularis*), MK (UGDA).

!***Trichonectria anisospora*** (Lowen) van den Boom & Diederich: 8 (on *Hypogymnia physodes*), JM (BILAS).

!***Trichonectria rubefaciens*** (Ellis & Everh.) Diederich & Schroers: 8 (on *Parmelia sulcata*), JM (BILAS).

Vouauxiella lichenicola (Linds.) Petr. & Syd.: 1, 5 (on *Lecanora chlarotera*, *L. pulicaris*).

!***Vouauxiomyces santessonii*** D.Hawksw.: 8 (on *Platismatia glauca*), JM (BILAS).

Xanthoriicola physciae (Kalchbr.) D.Hawksw.: 7 (on *Xanthoria parietina*).

!***Xenonectriella leptaleae*** (J.Steiner) Rossman & Lowen: 4 (on *Physcia aipolia*), MK (UGDA).

Non lichenized, saprobic taxa

Arthonia punctiformis Ach.: 8 (cor Qur).

!***Chaenothecopsis viridireagens*** (Nádv.) A.F.W.Schmidt: 8 (lig), LK (LE).

!***Leptorhaphis epidermidis*** (Ach.) Th.Fr.: 4 (cor Bet), DH (LECB).

Mycocalicium subtile (Pers.) Szatala: 1, 4, 5, 7 (lig).

!*Peridiothelia fuliguncta* (Norman) D.Hawksw.: 1 (cor Til), DH (LECB).

!*Sarea difformis* (Fr.) Fr.: 3 (res Pic), DH (LECB)

Sarea resinae (Fr.: Fr.) Kuntze: 3 (res Pic).

Stenocybe pullatula (Ach.) Stein: 3 (cor Aln).

!!*Stictis brunnescens* Gilenstram, Döring & Wedin: 4 (lig), IS (LECB).

Discussion

In total, 290 species are reported from the visited localities in Kurzeme, which constitutes 49 % of lichen flora previously known from Latvia (591 species according to Piterāns [2001] and various later publications, see Introduction). Among the listed species, 238 are lichenized, 43 lichen-habiting and 9 saprotrophic, non-lichenized fungi. There are 91 species new to Latvia, 12 of which (*Caloplaca duplicata*, *Cresporhaphis wienkampii*, *Ellisembia lichenicola*, *Gallowayella weberi*, *Gregorella humida*, *Lichenochora weillii*, *Parmelia serrana*, *Polycauliona phlogina*, *Reconditella physconiarum*, *Stictis brunnescens*, *Thelocarpon superellum* and *Verrucaria tectorum*) are also new for the Baltic States, and *Athallia alnetorum* is reported here for the first time in Northern Europe.

The large number of new records reflects in part the fact that Latvian lichen flora is understudied, when compared to neighbouring Lithuania and Estonia, a large portion of the species known for some time from these two Baltic States, namely *Anisomeridium polypori*, *Bacidia fraxinea*, *Chaenotheca hispidula*, *Chrysothrix flavovirens*, *Epicladonia sandstedei*, *Leptogium byssinum*, *Graphium aphthosae*, *Gyalecta flotowii*, *Leptorhaphis epidermidis*, *Lichenochora obscuroides*, *Lichenoconium lecanorae*, *Lichenoconium pyxidatae*, *Lichenoconium usneae*, *Lichenoconium xanthoriae*, *Lichenodiplis lecanorae*, *Ochrolechia microstictoides*, *Parmelia submontana*, *Phaeophyscia endophoenicea*, *Psilolechia clavulifera*, *Protothelenella sphinctrinoidella*, *Pyrenochaeta xanthoriae*, *Refractohilum peltigerae*, *Rinodina sophodes*, *Sarea difformis*, *Schismatomma pericleum*, *Scoliciosporum sarothamni*, *Steinia geophana*, *Taeniolella punctata*, *Thelocarpon epibolum* var. *epibolum*, *Tremella lichenicola*, *Tremella phaeophysciae*, *Trichonectria anisospora*, *Verrucaria xyloxena*, *Vouauxiomyces santessonii*, *Xylographa parallela* and *Zwackhia sorediifera*. Some of these species are rather rare in Lithuania and Estonia, but others are quite common in both countries, such as *Anisomeridium polypori*, *Leptorhaphis epidermidis*, *Lichenochora obscuroides*, *Lichenoconium* spp., *Ochrolechia microstictoides*, *Steinia geophana*, *Tremella lichenicola*, *T. phaeophysciae* and *Vouauxiomyces santessonii* (J. Motiejūnaitė and A. Suija, pers. comm.). On the other hand, several new records for Latvia are species that were only recently reported from Lithuania and Estonia, namely *Arthonia molendoi*, *Lecanora farinaria*, *Micarea byssacea*, *M. micrococca*, *Trichonectria rubefaciens*, *Xenonectriella leptaleae* (Suija et al. 2009, 2010, Czarnota & Guzow-Krzemińska 2010, Motiejūnaitė et al. 2010, 2012, Motiejūnaitė 2011, Lõhmus et al. 2012, Suija 2013) and several species were previously known from only Lithuania or Estonia: *Alyxoria culmigena*, *Arthonia epiphyscia*, *Caloplaca ulcerosa*, *Chaenothecopsis viridireagens*, *Didymocyrtis epiphyscia*, *Eopyrenula leucoplaca*, *Homostegia piggotii*, *Lecanora subcarpinea*, *Marchandiomyces corallinus*, *Micarea anterior*, *Rinodina septentrionalis*, *Solitaria chrysophthalma*, *Sphinctrina turbinata* and *Telogalla olivieri* from Estonia (Randlane & Saag 1999, Suija et al. 2001, 2009, Jüriado et al. 2003, Aptroot et al. 2005, Suija 2005), and *Bacidina delicata*, *Biatora meiocarpa*, *Candelariella efflorescens*, *Didymocyrtis ramali-

nae, *Gyalecta derivata*, *Peridiothelia fuliguncta*, *Strigula jamesii* and *Trapelia corticola* from Lithuania (Motiejūnaitė 1999, 2005, 2007, Motiejūnaitė et al. 1998, 2008, 2011, 2012).

Six protected species in Latvia, of 34 red-listed lichens (Piterāns 2001), were found, namely *Lobaria pulmonaria*, *Pertusaria flavida*, *P. pertusa*, *Pleurosticta acetabulum*, *Thelotrema lepadinum* and *Zwackhia viridis* all of which were recorded in the old-growth forest in Slītere National Park (locality 8); *Pleurosticta acetabulum* was also found near Šķēde Forest Research Station (locality 1), and *Lobaria pulmonaria*, *Pertusaria flavida* and *P. pertusa* also grew in an old park of Dundaga castle (locality 9).

The concerted efforts during the rather short field trip resulted in a high number of records new to Latvia, as well as extentions of known distributions of some species to the eastern Baltic region. Furthermore, presence of certain taxa, previously recorded under species complexes, was clarified. *Ochrolechia androgyna*, known in Latvia since the 1970s (Piterāns 1982), was revised according to Kukwa (2009), confirming the presence of *O. androgyna* s. str., and the *Caloplaca holocarpa* complex, known in Latvia first under the name of *C. pyracea* (Ach.) Th.Fr. (Piterāns 1982) and later as *C. holocarpa* (Hoffm.) A.E.Wade, was recorded from both bark and stones (Piterāns 2001); however, based on the revision by Arup (2009) two clearly defined entities, belonging to a phylogenetically well-defined group, have been segregated into a newly described genus *Athallia* (Arup et al. 2013), both of which, *A. holocarpa* and *A. pyracea*, were found in Kurzeme.

Notes on the species new to all Baltic States

Athallia alnetorum is very similar to *Gyalolechia flavorubescens* (Huds.) Søchting, Frödén & Arup differing from the latter in its smaller ascospores. Previously it was known only from the Alps, Southern Europe and Turkey, where it is quite common (Giralt et al. 1992, Vondrák & Wirth 2013, Vondrák et al. 2015). This is the first record for the Baltic region and Northern Europe.

Caloplaca duplicata is characterized by its grey blastidiate thallus and zeorine apothecia with orange disk and proper exciple. It was known only from the type locality in Leningrad region of Russia (TUR-V 07513) (Vainio 1878, Khodosovtsev et al. 2004). The status of the taxon has not been fully clarified, but according to molecular data obtained from the type specimen it is very close to *C. atroflava* (Turner) Mong. and *C. soralifera* Vondrák & Hrouzek (Redchenko et al. 2012, J. Vondrák, pers. comm.).

Cresporhaphis wienkampii is a rare, probably only facultatively lichenized species confined to broad-leaved trees with rough bark, and scattered throughout Europe (Aptroot 1997, Aguirre-Hudson 2009).

Ellisembia lichenicola is a lichenicolous hyphomycete described from *Physconia distorta*, but also found on other hosts. In the protologue it is characterized as parasitic on lichens, but no infection characteristics are given; furthermore, in all mentioned specimens it was associated with other lichenicolous fungi (Heuchert & Braun 2006). In our specimen, *Ellisembia lichenicola* was found on blackened, sclerotized parts of its host (*Ramalina fraxinea*), growing together with an unindentified hyphomycete. *Ellisembia lichenicola* was previously known from Denmark, Germany, Italy and Canada (Brackel 2014).

Gallowayella weberi can be confused with four other xanthorioid species, *G. fulva* (Hoffm.) S.Y.Kondr. et al., *G. sogdiana* (S.Y.Kondr. & Kärnefelt) S.Y.Kondr. et al., *Honeggeria rosmarieae* (S.Y.Kondr. & Kärnefelt) S.Y.Kondr. et al. and *Oxneria huculica* S.Y.Kondr. It is distinguished from *G. fulva* by its longer, more branched lobes, and from *O. huculica* by its narrower lobes, a more radiating growth, and lack of large helmet-shaped soralia (Kondratyuk & Kärnefelt 2003, Kondratyuk et al. 2010), and from the central Asian species *G. sogdiana* by its smaller thallus and thicker ascospore septa, and from the distantly related North American species *Honeggeria rosmarieae* by a *Jackelixia*-type of true exciple, a higher hymenium and narrower ascospores (Kondratyuk et al. 2010, Lumbsch et al. 2011). The known distribution of *Gallowayella weberi* is in northern and central Europe (Germany, Norway, Sweden & Russia) and North America (Canada, USA & Mexico). It typically grows on deciduous roadside trees in moderately polluted settlements.

Gregorella humida, a pioneer species of recently disturbed clayey soils, is scattered and rare in most countries where recorded, but apparently spreading in Central Europe (Vondrák et al. 2013). When ill-developed or sterile, *G. humida* can be confused with *Moelleropsis nebulosa* (Hoffm.) Gyeln. or *Leptogium byssinum*.

Lichenochora weillii differs from other *Lichenochora* species confined to Physciaceae by hyaline 2-celled broadly ellipsoid, 10–12 × 8–9.5 µm ascospores (Hafellner 1989). The hosts of the fungus – *Physconia* spp. – occur commonly in the eastern Baltic region.

Parmelia serrana is one of several species discovered through molecular analyses of DNA-sequences in the *P. saxatilis* group and is chemically distinct from *P. saxatilis* s. str. in containing lichesterinic, not lobaric, acid (Thell et al. 2008, Ossowska et al. 2014). Usually it is recognizable morphologically by its rather orbicular thalli with short and broad, often overlapping, lobes with rounded tips, but the longitudinal cracks and ridges on the upper side of the thallus and the clustered isidia, often concentrated to the ridges and the margins, may also occur on *P. saxatilis*. *P. submontana*, occasionally producing isidioid soredia, may be confused with *P. serrana*, but the former has elongated lobes with the margins folded downwards (Ossowska et al. 2014). A specimen recently collected in Sweden, originally determined as *P. serrana* (Thell et al. 2014), with such isidia, but partly with sublinear lobes, was redetermined as *P. saxatilis* after chemical analysis (Ossowska, pers. comm.). It is expected that additional cryptic or semi-cryptic species will be described within the *P. saxatilis* complex (Ossowska et al. 2014). *P. serrana* was believed to have a restricted distribution area (Molina et al. 2004), being recorded from southern, central and western Europe and the Canary Islands (Thell et al. 2011).

Polycauliona phlogina is characterized by its mainly sorediate thallus with only occasional small areoles (Arup 2005). It occurs throughout Europe and is quite common in the southern parts of Scandinavia (Arup 2005); it is also known from the Leningrad region of Russia (Vondrák et al. 2010).

Reconditella physconiarum is characterized by superficial perithecia and one-celled verruculose, 15–21 × 6–10 µm ascospores (Matzer & Hafellner 1990). As with *Lichenochora weillii*, the hosts of the fungus – *Physconia* spp. – are common in eastern Baltic region.

Stictis brunnescens is similar to *S. radiata* Pers., from which differs in the structure of its periphysoid layer, presence of marginal paraphyses and brown pigment in the exciple (Wedin et al. 2006). It was recently reported from the Leningrad region of Russia (Kuznetsova et al. 2012).

Thelocarpon superellum is one of the rarely recorded *Thelocarpon* species, characterized by its rather large ascomata, presence of simple paraphyses, I+ blue asci, and spores which commonly have a pseudoseptum (Kocourková-Horáková 1998).

Verrucaria tectorum is similar to the very common *V. nigrescens* except for the presence of soredia (Krzewicka 2012) and is therefore sometimes treated as a morph of the latter species (Coppins & Aptroot 2008).

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References

Aguirre-Hudson, B. 2009. *Cresporhaphis* M.B. Aguirre (1991). – In: Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. & Wolseley, P. A. (eds). The lichen flora of Great Britain and Ireland. Pp. 363–364. – London: British Lichen Society.

Anonymous. 2013. Dabas Parka “Talsu pauguraine” Dabas aizsardzības plāns [Nature protection plans for the Nature Park “Talsu pauguraine”]. – Rīga. http://www.talsi.lv/uploads/filedir/talsu_pauguraine_dap_sa.pdf [29.07.2015].

Aptroot, A. 1997. *Cresporhaphis wienkampii* en *Leptorhaphis contorta*, twee nieuwe schorsbewoners voor Nederland. – Buxbaumiella **42**: 66–67.

Aptroot, A., Czarnota, P., Jüriado, I., Kocourková, J., Kukwa, M., Lõhmus, P., Palice, Z., Randlane, T., Saag, L., Sérusiaux, E., Sipman, H., Sparrius, L. B., Suija, A. & Thüs, H. 2005. New or interesting lichens and lichenicolous fungi found during the 5th IAL Symposium in Estonia. – Folia Cryptogamica Estonica **41**: 13–22.

Aras, S. & Cansaran, D. 2006. Isolation of DNA for sequence analysis from herbarium material of some lichen specimens. – Turkish Journal of Botany **30**: 449–453.

Arup, U. 2005. A new taxonomy of the *Caloplaca citrina* group in the Nordic countries, except Iceland. – Lichenologist **38**: 1–20.

Arup, U. 2009. The *Caloplaca holocarpa* group in the Nordic countries, except Iceland. – Lichenologist **41**: 111–130.

Arup, U., Søchting, U. & Frödén, P. 2013. A new taxonomy of the family Teloschistaceae. – Nordic Journal of Botany **31**: 16–83.

Brackel, W. v. 2014. Kommentierter Katalog der flechtenbewohnenden Pilze Bayerns. – Bibliotheca Lichenologica **109**: 1–476.

Coppins, B. J. & Aptroot, A. 2008. New species and combinations in the lichens of the British Isles. – Lichenologist **40**: 363–374.

Czarnota, P. & Guzow-Krzemińska, B. 2010. A phylogenetic study of the *Micarea prasina* group shows that *Micarea micrococca* includes three distinct lineages. – Lichenologist **42**: 7–21.

Czarnota, P. & Kukwa, M. 2010. New and noteworthy lichenized and lichenicolous fungi to Latvia. – Botanica Lithuanica **16**: 21–27.

Dabas aizsardzības pārvalde [Nature Conservation Agency]. 2015. http://www.daba.gov.lv/public/lat/iadt/kurzemes_pr_novados/ [26.06.2015].

Ekman, S. 2001. Molecular phylogeny of the Bacidiaceae (Lecanorales, lichenized Ascomycota). – Mycological Research **105**: 783–797.

Ertz, D., Diederich, P., Lawrey, J. D., Berger, F., Freebury, C. E., Coppins, B., Gardiennet, A. & Hafellner, J. 2015. Phylogenetic insights resolve Dacampiaceae (Pleosporales) as polyphyletic: *Didymocyrtis* (Pleosporales, Phaeosphaeriaceae) with *Phoma*-like anamorphs resurrected and segregated from *Polycoccum* (Trypetheliales, Polycoccaceae fam. nov.). – Fungal Diversity **74**: 53–89.

Gardes, M. & Bruns, T. 1993. ITS primers with enhanced specificity for basidiomycetes. Application for the identification of mycorrhizae and rust. – Molecular Ecology **2**: 113–118.

Giralt, M., Nimis P. L. & Poelt, J. 1992. Studien über den Formenkreis von *Caloplaca flavorubescens* in Europa. – Cryptogamie, Bryologie-Lichénologie **13**: 261–273.

Hafellner, J. 1989. Studien über lichenicole Pilze und Flechten VII. Über die neue Gattung *Lichenochora* (Ascomycetes, Phyllachorales). – Nova Hedwigia **48**: 357–370.

Heuchert, B. & Braun, U. 2006. On some dematiaceous lichenicolous hyphomycetes. – Herzogia **19**: 11–21.

Jüriado, I., Randlane, T. & Saag, L. 2003. New Estonian records. Lichens. – Folia Cryptogamica Estonica **39**: 62–63.

Khodosovtsev, A. Y., Kondratyuk, S. Y., Makarova, I. I. & Oxner, A. N. 2004. Handbook of the lichens of Russia. Vol. 9. Fuscideaceae, Teloschistaceae. – Saint-Petersburg: Nauka.

Kocourková-Horáková, J. 1998. Distribution and ecology of the genus *Thelocarpon* (Lecanorales, Thelocarpaceae) in the Czech Republic. – Czech Mycology **50**: 271–302.

Kondratyuk, S. Y. & Kärnefelt, I. 2003. Five new *Xanthorias* from Holarctic. – Ukrainian Journal of Botany **60**: 121–130.

Kondratyuk, S. Y., Kärnefelt, I., Goward, T., Galloway, D., Kudratov, I., Lackovicová, A., Lisická, E. & Guttová, A. 2010. Diagnoses of new taxa. – In: Oxner, A. M. Flora of the lichens of Ukraine. Vol 2(3). Pp. 435–445. – Kiev: Naukova dumka.

Krzewicka, B. 2012. A revision of *Verrucaria* s. l. (Verrucariaceae) in Poland. – Polish Botanical Studies **27**: 3–143.

Kukwa, M. 2009. The lichen genus *Ochrolechia* in the Baltic countries. – Folia Cryptogamica Estonica **46**: 67–74.

Kuznetsova, E. S., Motiejûnaitė, J., Stepanchikova, I. S., Himelbrant, D. E. & Czarnota, P. 2012: New records of lichens and allied fungi from the Leningrad Region, Russia. III. – Folia Cryptogamica Estonica **49**: 31–37.

Lõhmus, P., Leppik, E., Motiejūnaitė, J., Suija, A. & Lõhmus, A. 2012. Old selectively cut forests can host rich lichen communities. – Nova Hedwigia **95**: 493–515.

Lumbsch, H. T., Ahti, T., Altermann, S., Amo De Paz, G., Aptroot, A., Arup, U., Bárcenas Peña, A., Bawingan, P. A., Benatti, M. N., Betancourt, L., Björk, C. R., Boonpragob, K., Brand, M., Bungartz, F., Cáceres, M. E. S., Candan, M., Chaves, J. L., Clerc, P., Common, R., Coppins, B. J., Crespo, A., Dal-Forno, M., Divakar, P. K., Duya, M. V., Elix, J. A., Elvebakk, A., Fankhauser, J. D., Farkas, E., Itatí Ferraro, L., Fischer, E., Galloway, D. J., Gaya, E., Giralt, M., Goward, T., Grube, M., Hafellner, J., Hernández M., J. E., Herrera Campos, M. A., Kalb, K., Kärnefelt, I., Kantvilas, G., Killmann, D., Kirika, P., Knudsen, K., Komposch, H., Kondratyuk, S., Lawrey, J. D., Mangold, A., Marcelli, M. P., McCune, B., Messuti, M. I., Michlig, A., Miranda González, R., Moncada, B., Naikatini, A., Nelsen, M. P., Øvstedal, D. O., Palice, Z., Papong, K., Parnmen, S., Pérez-Ortega, S., Printzen, C., Rico, V. J., Rivas Plata, E., Robayo, J., Rosabal, D., Ruprecht, U., Salazar Allen, N., Sancho, L., Santos De Jesus, L., Santos Vieira, T., Schultz, M., Seaward, M. R. D., Sérusiaux, E., Schmitt, I., Sipman, H. J. M., Sohrabi, M., Søchting, U., Søgaard, M. Z., Sparrius, L. B., Spielmann, A., Spribille, T., Sutjaritturakan, J., Thammathaworn, A., Thell, A., Thor, G., Thüs, H., Timdal, E., Truong, C., Türk, R., Umaña Tenorio, L., Upreti, D. K., van den Boom, P., Vivas Rebuelta, M., Wedin, M., Will-Wolf, S., Wirth, V., Wirtz, N., Yahr, R., Yeshitela, K., Ziemmeck, F., Wheeler, T. & Lücking, R. 2011. One hundred new species of lichenized fungi: a signature of undiscovered global diversity. – Phytotaxa **18**: 1-127.

Matzer, M. & Hafellner, J. 1990. Eine Revision der lichenicolen Arten der Sammelgattung *Rosellinia* (Ascomycetes). – Bibliotheca Lichenologica **37**: 1–138.

Mežaka, A. 2009. Bryophyte and lichen flora in relation to habitat characteristics in Moricsala Nature Reserve, Latvia. – Latvijas veģetācija **18**: 65–68.

Mežaka, A., Brûmelis, G., Piterāns, A. & Printzen, C. 2012. Distribution of *Lepraria* in relation to tree substratum and deciduous forest type (*Lepraria* in deciduous forests). – Annales Botanici Fennici **49**: 162–170.

Mežaka, A., Strazdiņa, L., Brūmelis, G. & Piterāns, A. 2008. Epifītu flora un ekoloģija Dārznīcas pilskalnā [Flora and ecology of epiphytes in Dārznīcas castle mound]. – Latvijas Veģetācija **16**: 19–34.

Mežaka, A., Strazdiņa, L., Madžule, L., Liepiņa, L., Znotiņa, V., Brūmelis, G., Piterāns, A. & Hultengren, S. 2009. Bryophyte and lichen flora in relation to habitat characteristics in Moricsala nature reserve, Latvia. – Latvijas Veģetācija **18**: 65–88.

Molina, M. C., Crespo, A., Blanco, O., Lumbsch, H. T. & Hawksworth, D. L. 2004. Phylogenetic relationships and species concepts in *Parmelia* s. str. (Parmeliaceae) inferred from nuclear ITS rDNA and β-tubulin sequences. – Lichenologist **36**: 37–54.

Motiejūnaitė, J. 1999. Dzūkijos nacionalinio parko kerpės ir su jomis susiję grybai [Lichens and allied fungi of Dzūkija National Park]. – Botanica Lithuanica **5**: 137–153.

Motiejūnaitė, J. 2005. Notes on some corticolous non-lichenized pyrenomycetes from Lithuania. – Mikologiya i Fitopatologiya **39**(5): 30–33.

Motiejūnaitė, J. 2007. Lichenized, lichenicolous and allied fungi of Žemaitija National Park (Lithuania). – Herzogia **20**: 179–188.

Motiejūnaitė, J. 2011. Lichens and allied fungi from Kamanos State Strict Nature Reserve (northern Lithuania). – Botanica Lithuanica **17**: 109–116.

Motiejūnaitė, J. & Grochowski, P. 2014. Miscellaneous new records of lichens and lichenicolous fungi. – Herzogia **27**: 193–198.

Motiejūnaitė, J. & Piterāns, A. 1998. Materials on lichens and allied fungi of Ķemeri National Park (Latvia). – Botanica Lithuanica **4**: 187–196.

Motiejūnaitė, J., Alstrup, V., Randlane, T., Himelbrant, D., Stončius, D., Hermansson, J., Urbanavichus, G., Suija, A., Fritz, Ö., Prigodina Lukošienė, I. & Johansson, P. 2008. New or noteworthy lichens, lichenicolous and allied fungi from Biržai District, Lithuania. – Botanica Lithuanica **14**: 29–42.

Motiejūnaitė, J., Berglund, T., Czarnota, P., Himelbrant, D., Högnabba, F., Konoreva, L. A., Korchikov, E. S., Kubiak, D., Kukwa, M., Kuznetsova, E., Leppik, E., Lõhmus, P., Prigodina Lukošienė, I., Pykälä, J., Stončius, D., Stepanchikova, I., Suija, A., Thell, A., Tsurykau, A. & Westberg, M. 2012. Lichens, lichenicolous and allied fungi found in Asveja Regional park (Lithuania). – Botanica Lithuanica **18**: 85–100.

Motiejūnaitė, J., Brackel, W. v., Stončius, D. & Preikša, Ž. 2011. Contribution to the Lithuanian flora of lichens and allied fungi. III. – Botanica Lithuanica **17**: 39–47.

Motiejūnaitė, J., Nordin, A., Zalewska, A., Bjelland, T., Hedenås, H., Westberg, M., Heidmarsson, S. & Prigodina, I. 1998. Materials on lichens and allied fungi of Neringa National Park (Lithuania). – Botanica Lithuanica **4**: 285–305.

Motiejūnaitė, J., Suija, A., Lõhmus, P., Kuznetsova, E., Tõrra, T., Prigodina-Lukošienė, I. & Piterāns, A. 2006. New or noteworthy lichens, lichenicolous and allied fungi found during the 16th Symposium of Mycologists and Lichenologists in Latvia. – Botanica Lithuanica **12**: 113–119.

Nordin, A., Moberg, R., Tønsberg, T., Vitikainen, O., Dalsätt, Å., Myrdal, M., Snitting, D. & Ekman, S. 2011. Santesson's Checklist of Fennoscandian Lichen-forming and Lichenicolous Fungi. Ver. 29 April 2011. http://130.238.83.220/santesson/home.php [30.03.2015].

Orange, A., James, P. W. & White, F. J. 2001. Microchemical methods for the identification of lichens. – London: British Lichen Society.

Ossowska, E., Szymczyk, R., Bohdan, A. & Kukwa, M. 2014. The lichen family Parmeliaceae in Poland. III. *Parmelia serrana*, new to Poland. – Acta Societatis Botanicorum Poloniae **83**: 81–84.

Piterāns, A. 1982. Lishainiki Latvii. – Riga: Zinatne.

Piterāns, A. 2001. Latvijas ķērpju konspekts. – Latvijas veģetācija **3**: 5–46.

Piterāns, A., Laime, B., Žeiviniece, A. & Berga, I. 2005. Lichens in Užava Nature Reserve. – Acta Biologica Universitatis Daugavpilensis **5**: 109–112.

Piterāns, A., Žeiviniece, A. & Berga, I. 2006. LU Botānikas un ekoloģijas katedras ķērpju herbārijs. – Latvijas Universitātes raksti **693**: 249–252.

Plociņa, J. 2007. Monitoring of woodland meadow management using epiphytic lichens. – In: 4th International Conference "Research and conservation of biological diversity in Baltic region". Daugavpils, 25–27 April, 2007. Book of abstracts. Pp. 88. – Daugavpils: Daugavpils University Academic Press "Saule".

Randlane, T. & Saag, A. 1999. Second checklist of lichenized, lichenicolous and allied fungi of Estonia. – Folia Cryptogamica Estonica **35**: 1–132.

Randlane, T., Saag, A. & Raitviir, A. 2000. Editorial. XIV Symposium of Baltic Mycologists and Lichenologists, September 3–8, 1999 in Järvselja, Estonia. – Folia Cryptogamica Estonica **36**: 1–6.

Redchenko, O., Vondrák, J. & Košnar, J. 2012. The oldest sequenced fungal herbarium sample. – Lichenologist **44**: 715–718.

Rēriha, I. 2013. Iežu atsegumu biotopi [Rocky outcrop biotopes]. – In: Auniņš, A. (ed.). Eiropas Savienības aizsargājamie biotopi Latvijā. Noteikšanas rokasgrāmata [Protected biotopes of European Union in Latvia. Determination handbook]. 2nd supplemented edition. Pp. 245–254. – Rīga: Latvian Fund for Nature, Ministry of Environmental Protection and Regional Development of Latvia.

Schultz, M., Wedin, M., Diel, H. & Prieto, M. 2015. *Epiphloea* belongs to Collemataceae (Lecanoromycetes, lichenized Ascomycota. – Lichenologist **47**: 369–378.

Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. & Wolseley, P. A. (eds). 2009. The lichens of Great Britain and Ireland. – London: British Lichen Society.

Suija, A. 2005. Lichenicolous fungi and lichens in Estonia II: Basidiomycota and conidial fungi. – Nova Hedwigia **80**: 349–365.

Suija, A., Czarnota, P., Himelbrant, D., Jüriado, I., Kukwa, M., Lõhmus, P. & Motiejūnaitė, J. 2009. New Estonian records. Lichenized and lichenicolous fungi. – Folia Cryptogamica Estonica **46**: 83–86.

Suija, A., Lõhmus, P., Nilson, E. & Saag, L. 2001. New Estonian records. Lichens and lichenicolous fungi. – Folia Cryptogamica Estonica **38**: 85–86.

Suija, A., Piin-Aaspõllu, T., Ahti, T., Marmor, L., Jüriado, I., Kannukene, L. & Lõhmus, P. 2010. New Estonian records. Lichenized and lichenicolous fungi. – Folia Cryptogamica Estonica **47**: 105–107.

Sundin, R. & Thor, G. 1990. Some lichens from Latvia. – Graphis Scripta **3**: 20–23.

Thell, A., Alstrup, V., Arup, U., Bendiksby, M., Czarnota, P., Feuerer, T., Haugan, R., Kärnefelt, I., Klepsland, J. T., Kukwa, M., Launis, A., Millanes, A. M., Motiejūnaitė, J., Nordin, A., Prieto, M., Pykälä, J., Seaward, M. R. D., Timdal, E., Tsurykau, A., Vitikainen, O. & Westberg, M. 2014. New or interesting lichens and lichenicolous fungi from the Vadstena area, Östergötland, Sweden. – Graphis Scripta **26**: 15–33.

Thell, A., Elix, J. A., Feuerer, T., Hansen, E. S., Kärnefelt, I., Schüler, N. & Westberg, M. 2008. Notes on the systematics, chemistry and distribution of European *Parmelia* and *Punctelia* species (lichenized ascomycetes). – Sauteria **15**: 545–559.

Thell, A., Thor, G. & Ahti, T. 2011. *Parmelia*. – In: Thell, A. & Moberg, R. (eds). Nordic Lichen Flora 4. Pp. 56–62 – Uppsala: Museum of Evolution, Uppsala University on behalf of Nordic Lichen Society.

Turlājs, J. 2011. Latvijas ģeogrāfijas atlants [Geographical atlas of Latvia]. – Rīga: Publishing house "Jāņa sēta".

Vainio, E. 1878. Lichenes in viciniis Viburgi observati. – Meddelanden Societatis pro Fauna et Flora Fennica **2**: 35–72.

Vondrák, J, Halici, M. G., Güllü, M. & Demirel, R. 2016. Contributions to the genus *Athallia* and its diversity in Turkey. – Turkish Journal of Botany **40**: 319–328.

Vondrák, J., Palice, Z., Mares, J. & Kocourková, J. 2013. Two superficially similar lichen crusts, *Gregorella humida* and *Moelleropsis nebulosa*, and a description of the new lichenicolous fungus *Llimoniella gregorellae*. – Herzogia **26**: 31–48.

Vondrák, J., Redchenko, O., Himelbrant, D., Stepanchikova, I. & Kuznetsova, E. 2010. Some sterile *Caloplaca* crusts identified by molecular data from the Leningrad region (Russia). – Folia Cryptogamica Estonica **47**: 97–99.

Vondrák, J. & Wirth, V. 2013. *Caloplaca* Th. Fr. – In: Wirth, V., Hauck, M. & Schultz, M. Die Flechten Deutschlands. Pp. 262–317. – Stuttgart: Ulmer.

Wedin, M., Döring, H. & Gilenstam, G. 2006. *Stictis* s. lat. (Ostropales, Ascomycota) in northern Scandinavia, with a key and notes on morphological variation in relation to lifestyle. – Mycological Research **110**: 773–789.

White, T., Bruns, T., Lee, S. & Taylor, J. 1990. Amplification and direct sequencing of fungal ribosomal DNA genes for phylogenies. – In: Innis, M., Gelfand, D., Sninsky, J. & White, T. (eds). PCR Protocols: a Guide to Methods and Applications. Pp. 315–322. – San Diego: Academic Press.

Zhao, X., Leavitt, S. D., Zhao, Z. T., Zhang, L. L., Arup, U., Grube, M., Pérez-Ortega S., Printzen, C., Śliwa, L., Kraichak, E., Divakar, P. K., Crespo, A. & Lumbsch, H. T. 2016. Towards a revised generic classification of lecanoroid lichens (Lecanoraceae, Ascomycota) based on molecular, morphological and chemical evidence. – Fungal Diversity. In press.

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Addresses of the authors

Jurga Motiejūnaitė, Institute of Botany, Nature Research Centre, Žaliųjų ežerų Str. 49, 08406 Vilnius, Lithuania. E-mail: jurga.motiejunaite@botanika.lt

Sergei V. Chesnokov, Laboratory of Lichenology and Bryology, Komarov Botanical Institute RAS, Professor Popov Str. 2, 197376 Saint-Petersburg, Russia. E-mail: lukinbrat@mail.ru

Paweł Czarnota, Department of Agroecology, Faculty of Biology and Agriculture, University of Rzeszów, Ćwiklińskiej Str. 1a, 35-601 Rzeszów, Poland.
E-mail: pawczarnota@poczta.onet.pl

Ludmila V. Gagarina, Laboratory of Lichenology and Bryology, Komarov Botanical Institute RAS, Professor Popov Str. 2, 97376 Saint-Petersburg, Russia. E-mail: kvercus@ya.ru

Ivan Frolov, Faculty of Biology, Ural Federal University, Mira 19, Ekaterinburg, 620002, Russia; University of South Bohemia, Department of Botany, Na Zlaté stoce 1, 370-05 České Budějovice, Czech Republic. E-mail: ivfrolov@gmail.com

Dmitry Himelbrant, Department of Botany, Saint-Petersburg State University (SPbSU), Universitetskaya emb. 7–9, 199034 Saint-Petersburg; Laboratory of Lichenology and Bryology, Komarov Botanical Institute RAS, Professor Popov Str. 2, 197376 Saint-Petersburg, Russia. E-mail: d_brant@mail.ru

Ludmila A. Konoreva, Polar-alpine Botanical Garden-Institute, 184250 Murmansk Region, Kirovsk; Laboratory of Lichenology and Bryology, Komarov Botanical Institute RAS, Professor Popov Str. 2, 197376 Saint-Petersburg, Russia. E-mail: ajdarzapov@yandex.ru

Dariusz Kubiak, Department of Mycology, University of Warmia and Mazury in Olsztyn, M. Oczapowskiego Str. 1A, 10-719 Olsztyn, Poland. E-mail: darkub@uwm.edu.pl

Martin Kukwa, Department of Plant Taxonomy and Nature Conservation, University of Gdańsk, Wita Stwosza Str. 59, 80-308 Gdańsk, Poland. E-mail: dokmak@ug.edu.pl

Rolands Moisejevs, Institute of Life Sciences and Technology, Daugavpils University, Parādes str. 1a, 5401 Daugavpils, Latvia. E-mail: rolands.moisejevs@biology.lv

Irina Stepanchikova, Department of Botany, Saint-Petersburg State University (SPbSU), Universitetskaya emb. 7–9, 199034 Saint-Petersburg; Laboratory of Lichenology and Bryology, Komarov Botanical Institute RAS, Professor Popov Str. 2, 197376 Saint-Petersburg, Russia. E-mail: stepa.ir@mail.ru

Ave Suija, Institute of Ecology and Earth Sciences, University of Tartu, Lai Str. 40, 51005 Tartu, Estonia. E-mail: ave.suija@ut.ee

Gulnara Tagirdzhanova, Saint-Petersburg State University (SPbSU), Department of Botany, Universitetskaya emb. 7–9, 199034 Saint-Petersburg, Russia. E-mail: gultagr@gmail.com

Arne Thell, Biological Museum, Department of Biology, Lund University, Box 117, 22100 Lund, Sweden. E-mail: arne.thell@biol.lu.se

Andrei Tsurykau, Department of Biology, Francisk Skorina Gomel State University, Sovetskaja Str. 104, 246019 Gomel, Belarus. E-mail: tsurykau@gmail.com

III

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Lichens and allied fungi new for Latvia

Rolands Moisejevs
Institute of Life Sciences and Technology, Daugavpils University, Parādes 1a, Daugavpils, Latvia, LV-5401.
E-mail: rolands.moisejevs@biology.lv

Abstract: Six lichenized fungi (*Calicium parvum, C. trabinellum*, *Carbonicola anthracophila*, *C. myrmecina, Peltigera extenuata*, *Pycnora sorophora*), two lichenicolous (*Clypeococcum hypocenomycis* and *Illosporium carneum*), and two saprobic calicioid fungi (*Chaenothecopsis savonica* and *Microcalicium arenarium*) are reported as new for Latvia.

Keywords: Latvia; lichenicolous; calicioid; saprobic fungi

INTRODUCTION

Several essential contributions for Latvian lichen biota have been presented recently (Āboliņa et al., 2015; Jurciņš et al., 2014; Moisejevs, 2015; Motiejūnaitė et al., 2016). These contributions added over one hundred species of lichens and allied fungi to the Latvian checklist, including re-find of *Lobaria amplissima*, a species which was considered to be extinct in the country. Currently about 690 species of lichenized and allied fungi are recorded in Latvia. This paper further supplements the knowledge on lichens and allied fungi in Latvia.

MATERIAL AND METHODS

All referred specimens were collected by the author in 2015–2016 in different regions of Latvia, during local inventories of protected habitats, according to Latvian interpretation of Annex I EU Habitat Directive in (Auniņš et al., 2013). The collections were determined using the routine lichenological methods (Smith et al., 2009). Specimens were examined under stereomicroscope Nikon SMZ 800. Water mounted hand-made cross sections were examined under light transmission microscope Nikon Eclipse E100. The nomenclature of taxa mainly follows Nordin et al. (2011). Doubtful specimens were compared with the collections at the herbarium of the Institute of Botany, Nature Research Centre, Vilnius (BILAS). For each specimen the protected habitat type and number according to Annex I EU Habitat Directive is added in brackets, if relevant. Species distribution data in neighboring countries (for Russia only Pskov region) are provided. All reference specimens are deposited at the Herbarium of Daugavpils University, Institute of Life Sciences and Technology, Laboratory of Botany (DAU).

In the species list non-lichenized saprobic fungi are marked with + and lichenicolous fungi with #.

THE SPECIES

Calicium parvum Tibell – Krāslavas County, Kaplavas District, about 250–300 m off Šilovkas lake center, 55°49’33.32”N, 27°14’37.71”E; in dry old-growth *Pinus sylvestris* forest site, burned in past (evaluated as 9010* Western Taiga), on *Pinus sylvestris* bark; 24 August 2016 (DAU 5018009001).

Note. The species is known in Belarus (A. Tsurykau pers. comm.), Estonia (Lõhmus, 1998) and Lithuania (Motiejūnaitė, 1999).

Calicium trabinellum (Ach.) Ach. – Krāslavas Co., Ūdrīšu District, Tartaks village, about 600 m E off Tartaks village, 55°52’54.454”N, 26°59’35.746”E; in boggy *Pinus sylvestris* forest site with *Ledum palustre* L. (evaluated as 91D0* Bog woodland), on wood of pine snag; 10 September 2015; DAU518008001; Daugavpils Co., Dvietes District., Kinkausku forest area, 56°8’30.884”N, 26°14’28.676”E; in young dry *Pinus sylvestris* forest, on wood of pine stump; 12 July 2016; DAU518008002.

Note. Known in Belarus (Golubkov & Titov, 1990), Estonia (Lõhmus, 1998), Lithuania (Motiejūnaitė, 1999) and Russia (Istomina & Likhacheva, 2014). In Lithuania *C. trabinellum* is treated as an indicator species of undisturbed boggy pine forests (Motiejūnaitė et al., 2004).

CARBONICOLA ANTHRACOPHILA (Nyl.) Bendiksby & Timdal – Gulbenes Co., Stradu District, highway P36, turn to Lazdaga and Kaļņa lakes, about 200-300 m from the highway, 57°3’12.551”N, 26°55’27.059”E; in old-growth dry *Pinus sylvestris* forests (evaluated as 9010* Western taiga), on *Pinus sylvestis* bark; 2 August 2015; DAU552001001; Krāslavas Co., Kaplavas District, Šilovkas lake, about 250–300 m from Šilovka lake central part, 55°49’33.32”N 27°14’37.71”E; in old-growth dry *Pinus sylvestris* forests (evaluated as 9010* Western taiga), on *Pinus sylvestis* bark; 24 August 2016; DAU552001002; Alūksnes Co., Liepnas District, about 2km to SE from Liepna city, 57°20’29.798”N; 21°39’35.462”E; in old-growth moistured *Pinus sylvestris* forest, on burned pine snag, on wood; 26 September 2016; DAU552001003.

Note. The species is known in Belarus (Yatsyna, 2012), Estonia (Randlane et al., 1999) and Lithuania (Motiejūnaitė, 1999). In all neighboring countries, the species is mainly found in old-growth, previously burned forest sites. In Latvia, in all cases the lichen was found in dry old-growth pine stands impacted by past forest fires.

CARBONICOLA MYRMECINA (Ach.) Bendiksby & Timdal – Alūksnes Co., Liepnas District, about 2 km to SE from Liepna city, 57°20’29.798”N; 21°39’35.462”E; in old-growth moistured *Pinus sylvestris* forest, on burned pine snag, on wood; 26 September 2016; DAU552002001.

Note. Known in Estonia (Randlane et al., 1999) and Lithuania (Motiejūnaitė, 1999).

+CHAENOTHECOPSIS SAVONICA (Räsänen) Tibell – Ventspils Co., Užavas District, Užava town, Nature Preserve Užava, about 600 m SE off Užava lighthouse, 57°12’17.798”N, 21°25’37.462”E; in old-growth birch-spruce-pine forest site (evaluated as 9010* Western taiga), on *Picea abies* snag; 10 September 2015; DAU527005001.

Note. *C. savonica* is known in Estonia (Lõhmus, 1998) and Lithuania (Motiejūnaitė, 1999).

#CLYPEOCOCCUM HYPOCENOMYCIS D. Hawksw. – Krāslavas Co., Ūdrīšu District, Borovka village, about 300 m N off the farmstead „Ciemati”, 55°55’9.289”N, 26°59’23.060”E; in a middle-aged *Pinus sylvestis* forest stand, on thalli of *Hypocenomyce scalaris* growing on *Pinus sylvestris*; 14 September 2015; DAU646001001; Krustpils Co., Atašienes District, About 700 m S off Teiču Nature Reserve observation tower, 56°31’28.203”N, 26°34’2.132”E; in boggy *P. sylvestris* forest with *Ledum palustre* L., (evaluated as 91D0* Bog woodland), on thalli of *Hypocenomyce scalaris* growing on *Pinus sylvestris*; 17 March 2016; DAU646001002.

Note. It is a common lichenicolous fungus, known in Belarus (Tsurykau & Khramchankova, 2011), Estonia (Randlane et al., 2015) and Lithuania (Motiejūnaitė, 1999).

#ILLOSPORIUM CARNEUM Fr. – Krustpils Co., Atašienes District, about 500 m NE off Teiču Nature reserve observation tower, 56°32’54.332''N, 26°25’25.403''E; on the railroad earthwork, on thalli of Peltigera extenuata growing on soil (it was in the state of an anamorph); 26 April 2016; DAU647001001.

Note. *Illosporium carneum* is one of the commonest peltigericolous fungi, it is known in Estonia (Suija, 2005) and Lithuania (Motiejūnaitė, 1999).

+MICROCALICIUM ARENARIUM (Hampe ex A.Massal.) Tibell – Ventspils Co, Užavas District, Užava town, Užava Nature Reserve, about 700 m SE off Užava lighthouse, 57°11’7.195’’N, 21°25’16.528”E; in old-growth birch-spruce-pine forest site (evaluated as 9010* Western taiga), on a sand layer in *Picea abies* root plate; 10 Sept 2015; DAU643003001.

Note. Known in Belarus (Golubkov, 1987), Estonia (Lõhmus, 1998) and Lithuania (Motiejūnaitė et al., 2013). In all neighboring countries the species is known only from very few localities. In Estonia it has been assessed as vulnerable (Lõhmus & Lõhmus, 2011). In Lithuania the species was known from literature data and only recently was recorded in one locality (Motiejūnaitė et al., 2013). In Belarus the species is known from a single locality, Belovezhskaya Pushcha National Park, and is considered as very rare (Golubkov, 1987). Regional distribution and sparce occurrence of *M. arenarium* is a good basis to include it to local red lists.

PELTIGERA EXTENUATA (Vainio) Lojka – Krustpils Co., Atašienes District, about 500 m NE off Teiču Nature Reserve observation tower, 56°32’54.332”N, 26°25’25.403”E; on the railroad earthwork, on soil; 26 April 2016; DAU647001001.

Note. The species is recorded in all neighboring countries (Randlane et al., 2015; Motiejūnaitė, 1999).

PYCNORA SOROPHORA (Vain.) Hafellner – Krustpils Co., Atašienes District, Nature preserve “Great Pelečāre bog”, about 300 m to NW from “Bernāni” farmstead, 56°28’22.8”N 26°34’04.9”E; in boggy *Pinus sylvestris* forest with *Ledum palustre* L. (evaluated as 91D0* Bog woodland), on bark of *Pinus sylvestris*; 25 June 2016; DAU 648001001; Ventspils Co., Kolkas District., Slītere National Park, about 300 m to S from Kolka Cape, 57°45’11.73”N 22°35’56.62”E; in dry *Pinus sylvestris* forest (evaluated as 2180 Wooded dunes of the Atlantic, Continental and Boreal region), on bark of *Pinus sylvestris*; 24 July 2016; DAU 648001002.

Note. The species is known in Belarus (Tsurykau et al., 2012), Estonia (Randlane et al., 2015) and Lithuania (Motiejūnaitė, 1999).

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REFERENCES

Āboliņa, A., Piterāns, A. & Bambe, B. 2015. *Lichens and bryophytes in Latvia. Checklist.* DU AA “Saule”. Salaspils. 213 pp.

Auniņš, A., Lārmanis, V., Rove, I., Rūsiņa, S., Laime, B. (eds). 2013. *European Union Protected Habitats in Latvia. Interpretation Manual.* Riga, Latvian Fund for Nature, Ministry of Environmental Protection and Regional Development. 320 pp.

Golubkov, V.V. 1987. Species composition and structure of lichen flora of the State Hunt Reserve “Belovezhskaya Pushcha”. Part 1. Species composition of lichen flora of Belovezhskaya Pushcha (An annotated list). *Proceedings of the Academy of Sciences of the BSSR Series of Biological Sciences* 6: 91–92 pp. (In Russian).

Golubkov, V. V. & Titov, A. N. 1990. Lichenes Caliciales RSS Belorussiae. *Novitates Systematicae Plantarum Non Vascularum* 27: 97–101. (In Russian).

Istomina, N. B. & Likhacheva, O. V. 2014. Lichens of National Park „Sebezsky”. *The second international conference «Lichenology in Russia: problems and perspectives». Programme and proceedings of the international conference dedicated to the 300th anniversary of the Komarov Botanical Institute RAS and the 100th anniversary of the Institute of Cryptogamic Plants.*(In Russian). Saint Petersburg. 263 pp.

Lõhmus, P. 1998. List of Estonian calicioid lichens and fungi. *Folia Cryptogamica Estonica* 32: 43–46.

Lõhmus, A. & Lõhmus, P. 2011. Old-forest species: the importance of specific substrata vs. stand continuity in the case of calicioid fungi. *Silva Fennica* 45(5): 1015–1039. https://doi.org/10.14214/sf.84

Jurciņš, D., Mežaka, A., Strazdiņa, L., Gerra-Inohosa, L., Perševica, G. & Piterāns, A. 2014. Refound of extinct lichen *Lobaria amplissima* (Scop.) Forssell in Latvia. *Acta Biologica Universitatis Daugavpiliensis* 14(1): 59–65.

Moisejevs, R. 2015. Some new to Latvia lichens and allied fungi. *Acta Biologica Universitatis Daugavpiliensis* 15(2): 285–292.

Motiejūnaitė, J. 1999. Checklist of lichens and allied fungi of Lithuania. *Botanica Lithuanica* 5(3): 251–269.

Motiejūnaitė, J., Czyżewska, K. & Cieśliński, S. 2004. Lichens – indicators of old-growth forests in biocentres of Lithuania and North-East Poland. *Botanica Lithuanica* 10(1): 59-74.

Motiejūnaitė, J., Chesnokov, S.V., Czarnota, P., Gagarina, L.V., Frolov, I., Himelbrant, D., Konoreva, L. A., Kubiak, D., Kukwa, M., Moisejevs, R., Stepanchikova, I., Suija, A., Tagirdzhanova, G., Thell, A. & Tsurykau, A. 2016. Ninety-one species of lichens and allied fungi new to Latvia with a list of additional records from Kurzeme. *Herzogia* 29(1): 143–163. https://doi.org/10.13158/heia.29.1.2016.143

Motiejūnaitė, J., Kukwa, M., Lõhmus, P., Markovskaja, S., Oset, M., Prigodina-Lukošienė, I., Stončius, D. Uselienė, A. 2013. Contribution to the Lithuanian flora of lichens and allied fungi. IV. *Botanica Lithuanica* 19(1): 3–7. https://doi.org/10.2478/botlit-2013-0001

Nordin, A., Moberg, R., Tønsberg, T., Vitikainen, O., Dalsätt, Å., Myrdal, M., Snitting, D. & Ekman, S. 2011. *Santesson’s Checklist of Fennoscandian*

Lichen-forming and Lichenicolous Fungi. Ver. April 29, 2011. http://130.238.83.220/santesson/home.php

Randlane, T. & Saag, A. (eds). 1999. Second checklist of lichenized, lichenicolous and allied fungi of Estonia. Folia Cryptogamica Estonica 35: 1–132.

Randlane, T., Saag, A. & Suija, A. 2015. *Lichenized, lichenicolous and allied fungi of Estonia*. Ver. December 31, 2015. http://esamba.bo.bg.ut.ee/checklist/est/home.php

Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. & Wolseley, P. A. (eds). 2009. *The lichens of Great Britain and Ireland*. British Lichen Society, London, UK. 1046 pp.

Suija, A. 2005. Lichenicolous fungi in Estonia II: Basidiomycota and conidial fungi. *Nova Hedwigia* 80(3–4): 349–365. https://doi.org/10.1127/0029-5035/2005/0080-0349

Tsurykau, A. & Khramchankova, V. 2011. Lichens from Gomel region: a provisional checklist. *Botanica Lithuanica* 17(4): 157–163.

Tsurykau, A., Khramchankova, V. & Motiejūnaitė, J. 2012: *Pycnora sorophora* (Lecanoraceae) – lichen species new to Belarus. *Botanica Lithuanica* 18 (1): 80–82. https://doi.org/10.2478/v10279-012-0010-x

Yatsyna, A. P. 2012. Note about lichens of Glussk district. In: Sharukho, I. N., Pirozhkina, I. I. & Barinova, I. N. (eds). *Problems of sustainable development of the Republic of Belarus and neighboring countries*. Abstracts of the Second International Conference. Mogilev State University Press, Mogilev. Pp. 316–319. (In Russian).

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FOUR SPECIES OF SAXICOLOUS LICHENIZED FUNGI NEW TO LATVIA

Rolands Moisejevs[1]*, Polina Degtjarenko[2]

[1]Institute of Life Sciences and Technology, Daugavpils University, Parādes Str. 1a, Daugavpils LV-5401, Latvia
[2]Institute of Ecology and Earth Sciences, University of Tartu, Lai Str. 38, Tartu EE-51005, Estonia
* Corresponding author. E-mail: rolands.moisejevs@biology.lv

Abstract

Moisejevs R., Degtjarenko P., 2017: Four species of saxicolous lichenized fungi new to Latvia [Keturios epilitinių kerpių rūšys naujos Latvijai]. – Bot. Lith., 23(1): 60–62.

Four species of saxicolous and acidophilous lichens – *Dermatocarpon miniatum*, *Trapelia coarctata*, *Trapelia placodioides*, and *Umbilicaria hirsuta* found on different types of granite boulders were reported as new to Latvian lichen biota. Data on substratum geology, accompanying species, microhabitat and distribution in neighbouring to Latvia countries are provided.

Keywords: acidophilous, epilithic, lichens.

In recent years, knowledge about lichens and allied fungi in Latvia has significantly increased (Piterāns, 2001; Āboliņa et al., 2015; Motiejūnaitė et al., 2016). Nevertheless, the saxicolous lichens still remain one of the least studied lichenized fungi group in the Baltics (Āboliņa et al., 2015; Motiejūnaitė et al., 2016). The current paper complements the knowledge about Latvian biota of lichenized fungi. Four species of saxicolous lichenized fungi were reported as new to Latvia. The species were found in 2016–2017, on rapakivi granite boulders in different regions of Latvia. All of these boulders have probably been transported to Latvia from the southwestern part of Finland during the last glaciation, i.e. Weichselian glaciation (Zelčs & Markots, 2004).

The collections were determined using the routine lichenological methods (Smith et al., 2009). Spot-test reactions were checked with 10% KOH (K), sodium hypochlorite (C), para-phenylenediamine in ethanol (Pd), and Lugol's solution (I). The nomenclature of taxa follows Nordin et al. (2011). Doubtful specimens were compared to the collections deposited at the Herbarium of the Institute of Botany, Nature Research Centre, Vilnius (BILAS). The description of substrata and list of accompanying lichen species is provided. The data on species distribution in neighbouring countries is also provided, except Pskov region for Russia, due to unconfirmed occurrence of all referred species in the region (Irina Stepanchikova, pers.comm). All collected specimens were deposited at the Herbarium of Daugavpils University, Institute of Life Sciences and Technology (DAU).

LIST OF SPECIES:

Dermatocarpon miniatum (L.) W.Mann.

The lichen inhabited well-lit surface of boulder top, on south-facing part. The accompanying species were: *Acarospora fuscata*, *Aspicilia cinerea*, *Protoparmeliopsis muralis*, *Rhizocarpon geminatum*, *Phaeophyscia nigricans*, *Phaeophyscia sciastra,* and *Xanthoparmelia conspersa*. *Dermatocarpon miniatum* is known in Belarus (Tsurykau & Khramchankova, 2011) and Estonia (Randlane et al., 1999). So far, this species is only known from literature data in Lithuania (Motiejūnaitė, 1999). *D. miniatum* is included into the Red Data Book of the Republic of Belarus (Khoruzhik, 2005).

Specimen examined: Ogres Co., Lauberes Distr., 200 m to the west of Ančiņu House, Ančiņu devil's stone; on the upper surface of exposed granite boulder, rapakivi granite with multiple cracks. Metamorphic rock – coarse-grained gneiss (metamorphosed granite) with dominance of orthoclase feldspars. Leg. et det. Rolands Moisejevs, 24 April 2017; 56°50'36.3" N, 25°03'07.1" E. Ančiņu devil's stone; DAU (438002001).

Trapelia coarctata **(Sm.) M.Choisy**

The lichen was found on the north-east-facing side of the boulder, on the bottom and central part. The microhabitat can be characterized as shaded with scabrous surface. The accompanying species were: *Candelariella aurella*, *Porpidia crustulata*, *Porpidia macrocarpa*, *Rhizocarpon geminatum,* and *Trapelia placodioides*. *Trapelia coarctata* is known in Lithuania (Motiejūnaitė, 1999), Belarus (Tsurykau & Khramchankova, 2011), and Estonia (Randlane et al., 1999).

Specimen examined: Daugavpils Co., Nīcgales Distr., protected landscape area "Nīcgales meži", included into NATURA 2000 protected territory net, 6 km to the east of railway station, Nicgale Big White Stone; on a well-lit granite boulder; rapakivi granite. Intrusive igneous rock – coarse-grained granite with porfiric texture. Felsic rock with dominance of plagioclase feldspars. Leg. Rolands Moisejevs, 12 August 2016; 56°09'07.9" N, 26°27'41.9" E. Det. Jurga Motiejūnaitė, 27 August 2016; DAU (546001001).

Trapelia placodioides **Coppins & P.James**

The lichen grew on the north-east-facing side of the boulder, on the bottom and central part. The microhabitat can be characterized as shaded with scabrous surface. The accompanying species were: *Candelariella aurella*, *Porpidia crustulata*, *Porpidia macrocarpa*, *Rhizocarpon geminatum,* and *Trapelia coarctata. Trapelia placodioides* is known in Lithuania (Motiejūnaitė, 1999) and Estonia (Randlane et al., 1999).

Specimen examined: Daugavpils Co., Nīcgales Distr., protected landscape area "Nīcgales meži", included into NATURA 2000 protected territory net, 6 km to the east of railway station, Nicgale Big White Stone; on a granite boulder; rapakivi granite. Intrusive igneous rock – coarse-grained granite with porfiric texture. Felsic rock with dominance of plagioclase feldspars. Leg. et det. Rolands Moisejevs, 12 August 2016; 56°09'07.9" N, 26°27'41.9" E. DAU (546002001).

Umbilicaria hirsuta **(Sw. ex Westr.) Hoffm.**

The species was found on the top and east-facing part of boulder surface. The surface of boulder can be described as scabrous with numerous cracks. The accompanying species were: *Acarospora fuscata, Aspicilia cinerea, Candelariella aurella, Protoparmeliopsis muralis*, and *Xanthoparmelia conspersa*. *U. hirsuta* has so far been reported only from Estonia, where it has recently been recorded in the northern part of the country (Randlane et al., 2014).

Specimen examined: Ventspils Co., Ugāles Distr., 100 m to the south of the Māteri Cemetery. The Devil's Foot Stone in Māteri is located on top of a Liepkalns Hill, in a clear meadow; on well-lit horizontal surface of a granite boulder; rapakivi granite. Intrusive igneous rock – coarse-grained granite. Felsic rock with dominance of orthoclase feldspars. Leg. Rolands Moisejevs, 12 February 2017; 57°14'35" N, 21°57'47" E. Det. Polina Degtjarenko, 13 February 2017; DAU (635003001).

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REFERENCES

Āboliņa A., Piterāns A., Bambe B., 2015: Lichens and bryophytes in Latvia. Checklist. – Salaspils.

Khoruzhik L.I., 2005: Red data book of the Republic of Belarus: Rare and endangered species of wild plants. – Minsk.

Motiejūnaitė J., 1999: Checklist of lichens and allied fungi of Lithuania. − Botanica Lithuanica, 5(3): 251−269.

Motiejūnaitė J., Chesnokov S.V., Czarnota P., Gagarina L.V., Frolov I., Himelbrant D., Konoreva L.A., Kubiak D., Kukwa M., Moisejevs R., Stepanchikova I., Suija A., Tagirdzhanova G., Thell A., Tsurykau A., 2016: Ninety-one species of lichens and allied fungi new to Latvia with a list of additional records from Kurzeme. – Herzogia, 29(1): 143–163.

Nordin A., Moberg R., Tønsberg T., Vitikainen O., Dalsätt Å., Myrdal M., Snitting D., Ekman S., 2011: Santesson's Checklist of Fennoscandian Lichen-forming and Lichenicolous Fungi. Uppsala.http://130.238.83.220/santesson/home.php [April 29, 2011].

Piterāns A., 2001: Checklist of the lichens of Latvia. – Latvijas veģetācija, 3: 5–46.

Randlane T., Lõhmus P., Martin L., Suija A., 2014: New Estonian records and amendments: Lichenized and lichenicolous fungi. – Folia Cryptogamica Estonica, 51: 135.

Randlane T., Saag A., 1999: Second checklist of lichenized, lichenicolous and allied fungi of Estonia. – Folia Cryptogamica Estonica, 35: 1–132.

Randlane T., Saag A., Suija A., 2016: Lichenized, lichenicolous and allied fungi of Estonia. Ver. December 31, 2016. http://esamba.bo.bg.ut.ee/checklist/est/home.php.

Smith C.W., Aptroot A., Coppins B.J., Fletcher A., Gilbert O.L., James P.W., Wolseley P.A., 2009: The lichens of Great Britain and Ireland. – London.

Tsurykau A., Khramchankova V., 2011: Lichens from Gomel region: a provisional checklist. – Botanica Lithuanica, 17(4): 157–163.

Zelčs V., Markots A., 2004: Deglaciation history of Latvia. – In: Ehlers J., Gibbard P.L. (eds), Quaternary Glaciations – Extent and Chronology. – Riga.

KETURIOS EPILITINIŲ KERPIŲ RŪŠYS NAUJOS LATVIJAI

Rolands Moisejevs, Polina Degtjarenko

Santrauka

Keturios epilitinės acidofilinės kerpių rūšys – *Dermatocarpon miniatum*, *Trapelia coarctata*, *Trapelia placodioides* ir *Umbilicaria hirsuta* aptiktos ant įvairių granito riedulių buvo rastos pirmą kartą Latvijoje. Straipsnyje pateikiami duomenys apie jų substrato geologiją, mikrobuveinės savybes ir rūšių paplitimą aplinkinėse šalyse.

V

New records of lichens and lichenicolous fungi from Latvia, with a list of lichenicolous fungi reported from Latvia

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New records of lichens and lichenicolous fungi from Latvia, with a list of lichenicolous fungi reported from Latvia

Rolands Moisejevs, P. Degtjarenko, J. Motiejūnaitė, A. Piterāns and D. Stepanova

R. Moisejevs ✉ (rolands.moisejevs@biology.lv) and D. Stepanova, Inst. of Life Sciences and Technology, Daugavpils Univ., Parādes 1a, LV-5401 Daugavpils, Latvia. – P. Degtjarenko, Dept of Botany, Univ. of Tartu, Tartu, Estonia, and: Biodiversity and Conservation Biology, Swiss Federal Res. Inst. WSL, Birmensdorf, Switzerland. – J. Motiejūnaitė, Inst. of Botany, Nature Research Centre, Vilnius, Lithuania. – A. Piterāns, Dept of Botany and Ecology, Univ. of Latvia, Riga, Latvia.

Four species of lichen-forming fungi (*Calicium pinastri*, *Chaenotheca laevigata*, *Lecania croatica* and *Pycnora praestabilis*) and two lichenicolous fungi (*Arthrorhaphis aeruginosa* and *Chaenothecopsis epithallina*) are reported as new for Latvia. The first comprehensive list of lichenicolous fungi in Latvia is also presented, including their hosts and distribution in Latvia (northern Europe).

Keywords: Baltic countries, distribution, lichenized fungi

Our knowledge of the lichens and allied fungi in Latvia (northern Europe) has been considerably advanced in recent years. Currently ca 640 taxa of lichenized fungi are recorded for Latvia (Āboliņa et al 2015, Moisejevs 2015, 2017, Motiejūnaitė et al. 2016, Moisejevs and Degtjarenko 2017), which is comparable to the 620 taxa known from the geographically similar territory of Lithuania (Motiejūnaitė 2017).

Lichenicolous fungi, on the other hand, have been understudied in Latvia. The first mention of lichenicolous species can be found in the paper by Mereschkowski (1913), who reported *Acolium sessile* from Jaunugulbene (Vidzeme). Later, *Diploschistes muscorum* was reported from the Gauja river valley and Riga city environs (Malta 1926, Vimba 1971). During the 13th International Symposium of Lichenologists and Mycologists of the Baltic States, two more species of lichenicolous fungi were reported (Motiejūnaitė and Piterāns 1998); a further four species were reported in the first annotated Latvian checklist of lichens (Piterāns 2001) and 16 more were added by Motiejūnaitė et al. (2006), Czarnota and Kukwa (2010) and Motiejūnaitė and Grochowski (2014). The second annotated checklist of lichens listed 15 lichenicolous taxa as supplementary data (Āboliņa et al. 2015). Further contribution was made by Motiejūnaitė et al. (2016), with 33 lichenicolous fungi reported for the first time from Latvia, complemented by the paper of Moisejevs (2017). Since a full and up-to-date list of lichenicolous fungi for Latvia is still lacking, a comprehensive list is provided here.

The current paper reports four new species of lichen-forming and two lichenicolous fungi new to Latvia, together with a list of lichenicolous fungi (61 taxa) known for Latvia, including their hosts and distribution data in the country (Table 1).

Material and methods

The material was determined by means of routine lichenological methods (Smith et al. 2009). Spot-tests were determined with 10% KOH (K), sodium hypochlorite (C), paraphenylenediamine in ethanol (Pd) and Lugol's solution (I), and secondary chemistry by thin layer chromatography (TLC) using solvent C (Orange et al. 2001). Specimens of the newly recorded species, according to the nomenclature of Wirth et al. (2010), are kept in the lichenological herbarium of University of Daugavpils (DAU).

The list of lichenicolous fungi presented below is a combination of published literature data and herbarium collections from DAU and the University of Latvia (RIG), together with those species reported in the current paper. Data on species distribution are derived from literature sources and herbarium collections (DAU and RIG). Regions of Latvia (Fig. 1) are abbreviated in the list as follows: K – Kurzeme (Kurland), V – Vidzeme, L – Latgale, R – Pieriga, Z – Zemgale, LV – all regions of Latvia; # = lichenicolous fungus.

Table 1. The list of lichenicolous fungi known from Latvia, their distribution and hosts known in the country and the references that mention the species. For the abbreviations see Fig. 1.

S. No.	Species	Host(s)	Distribution	Reference(s)
1.	*Acolium sessile* (Pers.) Arnold.	*Pertusaria* sp.	K, V	Mereschkowski 1913, Piterāns 1982, 2001, Āboliņa et al. 2015
2.	*Arthonia epiphyscia* Nyl.	*Physcia aipolia*	K	Motiejūnaitė et al. 2016
3.	*Arthonia parietinaria* Hafellner & A.Fleischhacker	*Xanthoria parietina*	K	Motiejūnaitė et al. 2016 (as *Arthonia molendoi* (Heufl. ex Frauenf.) R.Sant.)
4.	*Arthrorhaphis aeruginosa* R.Sant. & Tønsberg	*Cladonia* sp.	L	This paper
5.	*Bachmanniomyces punctum* (A. Massal.) Diederich & Pino-Bodas	*Cladonia digitata*, *C. macilenta*	K	Motiejūnaitė et al. 2016
6.	*Biatoropsis usnearum* Räsänen	*Usnea subfloridana*	V, K	Motiejūnaitė et al. 2006, Āboliņa et al. 2015, DAU Herbarium
7.	*Briancoppinsia cytospora* (Vouaux) Diederich et al.	*Evernia prunastri*, *Melanelixia subaurifera*	K, V	Czarnota and Kukwa 2010, Āboliņa et al. 2015, Motiejūnaitė et al. 2016
8.	*Chaenothecopsis consociata* (Nádv.) A.F.W.Schmidt	*Chaenotheca chrysocephala*	LV	Piterāns 2001
9.	*Chaenothecopsis epithallina* Tibell	*Chanotheca trichialis*	K	This paper
10.	*Chaenothecopsis pusilla* (A.Massal.) A.F.W.Schmidt	*Chaenotheca* sp.	LV	Piterāns 2001
11.	*Clypeococcum cetrariae* Hafellner	*Cetraria islandica*	V	Motiejūnaitė and Piterāns 1998
12.	*Clypeococcum hypocenomycis* D.Hawksw.	*Hypocenomyce scalaris*	LV	Moisejevs 2017
13.	*Corticifraga fuckelii* (Rehm) D.Hawksw. & R.Sant.	*Peltigera neckeri*	K	Motiejūnaitė et al. 2016
14.	*Didymocyrtis epiphyscia* Ertz & Diederich	*Xanthoria parietina*	K	Motiejūnaitė et al. 2016
15.	*Didymocyrtis pseudeverniae* (Etayo & Diederich) Ertz & Diederich	*Pseudevernia furfuracea*	V	Motiejūnaitė and Grochowski 2014, Āboliņa et al. 2015
16.	*Didymocyrtis ramalinae* (Roberge ex Desm.) Ertz, Diederich & Hafellner	*Ramalina fraxinea*	LV	Motiejūnaitė et al. 2016
17.	*Diploschistes muscorum* (Scop.) R.Sant.	*Cladonia* sp.	K, V	Malta 1926, Vimba 1971, Piterāns 1982, 2001
18.	*Ellisembia lichenicola* Heuchert & U.Braun	*Ramalina fraxinea*	K	Motiejūnaitė et al. 2016
19.	*Epicladonia sandstedei* (Zopf) D.Hawksw.	*Cladonia coniocraea*	K	Motiejūnaitė et al. 2016
20.	*Erythricium aurantiacum* (Lasch) D.Hawksw. & A.Henrici	*Physcia* spp.	K	Motiejūnaitė et al. 2016
21.	*Graphium aphthosae* Alstrup & D. Hawksw.	*Peltigera neckeri*	K	Motiejūnaitė et al. 2016
22.	*Heterocephalacria physciacearum* (Diederich) Millanes & Wedin	*Physcia* spp.	K	Czarnota and Kukwa 2010, Āboliņa et al. 2015, Motiejūnaitė et al. 2016
23.	*Homostegia piggotii* (Berk. & Broome) P.Karst.	*Parmelia submontana*	K	Motiejūnaitė et al. 2016
24.	*Illosporiopsis christiansenii* (B.L.Brady & D.Hawksw.) D.Hawksw.	*Physcia* spp., *Xanthoria parietina*	LV	Piterāns 2001, Czarnota and Kukwa 2010
25.	*Lichenochora obscuroides* (Linds.) Triebel & Rambold	*Phaeophyscia orbicularis*	K	Motiejūnaitė et al. 2016
26.	*Lichenochora weillii* (Werner) Hafellner & R. Sant.	*Physconia enteroxantha*	K	Motiejūnaitė et al. 2016
27.	*Lichenoconium erodens* M.S.Christ. & D.Hawksw.	*Evernia prunastri*, *Hypogymnia physodes*, *Parmeliopsis ambigua*, *Ramalina fraxinea*	LV	Motiejūnaitė et al. 2006, Āboliņa et al. 2015, Motiejūnaitė et al. 2016
28.	*Lichenoconium lecanorae* (Jaap) D.Hawksw.	*Evernia prunastri*	K	Motiejūnaitė et al. 2016
29.	*Lichenoconium pyxidatae* (Oudem.) Petr. & Syd.	*Cladonia chlorophaea*	K	Motiejūnaitė et al. 2016
30.	*Lichenoconium usneae* (Anzi) D.Hawksw.	*Evernia prunastri*	K	Motiejūnaitė et al. 2016
31.	*Lichenoconium xanthoriae* M.S.Christ.	*Xanthoria parietina*	LV	Motiejūnaitė et al. 2016
32.	*Lichenodiplis lecanorae* (Vouaux) Dyko & D.Hawksw.	*Caloplaca* sp., *Myriolecis* aff. *hagenii*	K, L	Motiejūnaitė et al. 2016
33.	*Lichenosticta alcicornaria* (Linds.) D.Hawksw.	*Cladonia coniocraea*, *C. macilenta*, *C. ochrochlora*	K, L	Czarnota and Kukwa 2010, Āboliņa et al. 2015, Motiejūnaitė et al. 2016

(*Continued*)

Table 1. Continued

S. No.	Species	Host(s)	Distribution	Reference(s)
34.	*Marchandiomyces corallinus* (Roberge) Diederich & D.Hawksw.	*Physcia tenella*	K	Motiejūnaitė et al. 2016
35.	*Monodictys epilepraria* Kukwa & Diederich	*Lepraria* spp.	K	Czarnota and Kukwa 2010, Āboliņa et al. 2015, Motiejūnaitė et al. 2016
36.	*Muellerella hospitans* Stizenb.	*Bacidia rubella*	L, V	Czarnota and Kukwa 2010, Āboliņa et al. 2015
37.	*Microcalicium disseminatum* (Ach.) Vain.	*Chaenotheca* sp.	LV	Moisejevs 2015, DAU Herbarium
38.	*Nectriopsis lecanodes* (Ces.) Diederich & Schroers	*Peltigera canina, Peltigera rufescens*	LV	Motiejūnaitė et al. 2006, Āboliņa et al. 2015, RIGG Herbarium
39.	*Nectriopsis rubefaciens* (Ellis & Everh.) M.S.Cole & D.Hawksw.	*Parmelia sulcata*	LV	Motiejūnaitė et al. 2016
40.	*Plectocarpon lichenum* (Sommerf.) D.Hawksw.	*Lobaria pulmonaria*	V	Strazdiņa et al. 2017
41.	*Pronectria anisospora* (Lowen) Lowen	*Hypogymnia physodes*	K, L, V	Motiejūnaitė et al. 2016
42.	*Pronectria leptaleae* (J.Steiner) Lowen	*Physcia aipolia*	K	Motiejūnaitė et al. 2016
43.	*Pronectria robergei* (Mont. & Desm.) Lowen	*Peltigera didactyla, P. extenuata*	K, L	Moisejevs 2017, DAU Herbarium
44.	*Pronectria xanthoriae* Lowen & Diederich	*Xanthoria parietina*	LV	Motiejūnaitė et al. 2006, Āboliņa et al. 2015, Motiejūnaitė et al. 2016
45.	*Pyrenochaeta xanthoriae* Diederich	*Xanthoria parietina*	LV	Motiejūnaitė et al. 2016
46.	*Reconditella physconiarum* Hafellner & Matzer	*Physconia distorta*	K	Motiejūnaitė et al. 2016
47.	*Refractohilum intermedium* Cl.Roux & Etayo	*Pachyphiale fagicola*	K	Czarnota and Kukwa 2010, Āboliņa et al. 2015
48.	*Refractohilum peltigerae* (Keissl.) D.Hawksw	*Peltigera* spp.	K	Motiejūnaitė et al. 2016
49.	*Sphinctrina turbinata* (Pers.) De Not.	*Pertusaria pertusa*	K,V	Motiejūnaitė et al. 2016
50.	*Stigmidium microspilum* (Körb.) D.Hawksw.	*Graphis scripta*	K	Motiejūnaitė et al. 2016
51.	*Taeniolella punctata* M.S.Christ. & D.Hawksw.	*Graphis scripta*	K	Motiejūnaitė et al. 2016
52.	*Telogalla olivieri* (Vouaux) Nik.Hoffm. & Hafellner	*Xanthoria parietina*	K	Motiejūnaitė et al. 2016
53.	*Thelocarpon epibolum* var. *epibolum* Nyl.	*Peltigera neckeri*	K	Motiejūnaitė et al. 2016
54.	*Tremella candelariellae* Diederich & Etayo	*Candelariella* sp.	LV	Czarnota and Kukwa 2010, Āboliņa et al. 2015
55.	*Tremella cetrariicola* Diederich & Coppins	*Nephromopsis chlorophylla*	K	Motiejūnaitė et al. 2006, Āboliņa et al. 2015
56.	*Tremella hypogymniae* Diederich & M.S.Christ.	*Hypogymnia physodes*	K	Motiejūnaitė and Grochowski 2014, Motiejūnaitė et al. 2016
57.	*Tremella lichenicola* Diederich	*Violella fucata*	K	Motiejūnaitė et al. 2016
58.	*Tremella phaeophysciae* Diederich & M.S.Christ.	*Phaeophyscia orbicularis*	K	Motiejūnaitė et al. 2016
59.	*Vouauxiella lichenicola* (Linds.) Petr. & Sydow	*Lecanora chlarotera, L. pulicaris*	K,V	Āboliņa et al. 2015, Motiejūnaitė et al. 2016
60.	*Vouauxiomyces santessonii* D.Hawksw.	*Platismatia glauca*	K,V	Motiejūnaitė et al. 2016
61.	*Xanthoriicola physciae* (Kalchbr.) D.Hawksw.	*Xanthoria parietina*	K	Czarnota and Kukwa 2010, Āboliņa et al. 2015, Motiejūnaitė et al. 2016

Results

New records for Latvia

#*Arthrorhaphis aeruginosa* R.Sant. & Tønsberg

Distribution

Arthrorhaphis aeruginosa is known from Europe (Wirth et al. 2010, Motiejūnaitė 2017, Tsurykau 2017), including Fennoscandia (Santesson and Tønsberg 1994, Nordin et al. 2011), and also from Greenland (Alstrup et al. 2009), North America (Esslinger 2007), South America (Flakus et al. 2008) and Asia (Sohrabi and Alstrup 2007).

Material examined

Krāslavas Co., Ūdrīšu Dist., Nature Park 'Daugavas loki', Tartaka Forest, ca 350 m W of Tartaks village, 55°53′6.9″N, 26°59′18.1″E, 150 m a.s.l., on side of old forest road in boreal forest with *Pinus sylvestris* and *Picea abies*, on primary thallus of *Cladonia* sp., 25 May 2018, leg. & det.: R.Moisejevs (DAU600000910).

Notes

The collected specimen was sterile, but it was recognized by the characteristic colour of the infected host thallus. Only *A. aeruginosa* is known to turn the infected lichen an aeruginose colour and, as stated in the protologue of the

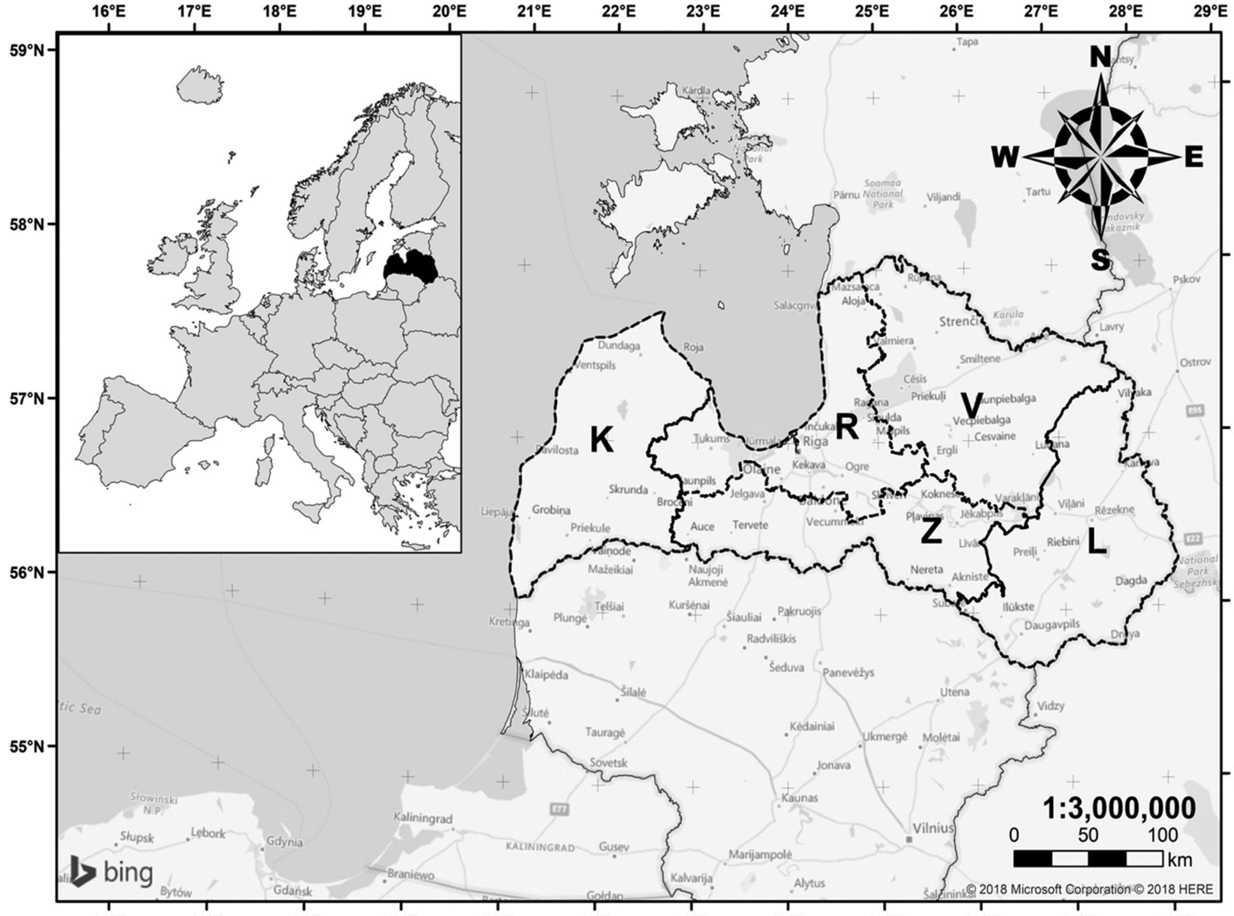

Figure 1. Regions of Latvia: K – Kurzeme (Curland), V – Vidzeme, L – Latgale, R – Pieriga, Z – Zemgale.

species '… is therefore easily recognized even when sterile' (Santesson and Tønsberg 1994).

Calicium pinastri Tibell

Distribution

Calicium pinastri is known from Europe (Tibell 1999, Śliwa and Kukwa 2008, Istomina and Likhacheva 2010, Wirth et al. 2010, Nordin et al. 2011) and North America (Hardman et al. 2017).

Material examined

Krāslava Co., Ūdrīšu Dist., Nature Park 'Daugavas loki', Tartaka forest, ca 500 m SW of Tartaks village, 55°53′7.6″N, 26°59′30.8″E, 130 m a.s.l., old-growth dry boreal forest, on bark of *P. sylvestris*, 20 June 2018, leg. & det.: R.Moisejevs (DAU600000911).

Notes

The lichen was found growing close to *Calicium parvum*, a species that resembles *C. pinastri*, but has clavate asci, while *C. pinastri* has cylindrical asci when mature.

Chaenotheca laevigata Nádv.

Distribution

Chaenotheca laevigata is a rare lichen with a wide distribution in Northern Hemisphere, being known from Europe (Wirth et al. 2010, Nordin et al. 2011), Asia (Titov 2000) and North America (Hardman et al. 2017).

Material examined

Ventspils Co., Usmas Dist., Nature Reserve 'Moricsala', ca 400 m NE of guest house, 57°11′28.6″N, 22°8′12.0″E, 25 m a.s.l., in a humid old-growth deciduous forest with *Picea abies*, on the bark of *P. abies*, 9 July 2018, leg. & det.: R.Moisejevs (DAU600000917).

Notes

Chaenotheca laevigata can be confused with *Chaenotheca chlorella*, from which it differs by its immersed thallus, ellipsoid to short cylindrical ascospores and longer ascomata.

#Chaenothecopsis epithallina Tibell

Distribution

Chaenothecopsis epithallina is distributed in central Europe, Fennoscandia (Tibell 1975, Wirth et al. 2010, Nordin et al. 2011, Tsurykau 2017) and North America (Hardman et al. 2017).

Material examined

(1) Ventspils Co., Usmas Dist., Nature Reserve 'Moricsala', ca 400 m NE of guesthouse, 57°11′33.5″N, 22°8′12.3″E, 25 m a.s.l., in an old-growth deciduous forest, on thallus of *Chaenotheca trichialis* growing on the bark of *Quercus robur*,

9 July 2018, leg. & det.: R.Moisejevs; (2) Kocēnu Co., Dīkļu Dist., ca 200 m S of Rāķis Lake, 57°35′34.1″N, 24°55′6.2″E, 120 m a.s.l., in a deciduous forest, on thallus of *C. trichialis* growing on the bark of old *Q. robur*, 23 March 2018, leg.: M. Kalniņš, det.: R.Moisejevs (DAU600000912).

Notes

Chaenothecopsis epithallina differs from the similar species *Chaenothecopsis nigra* by its association with *C. trichialis*, darker ascospores with less contrasting septum and dark green hypothecium.

Lecania croatica (Zahlbr.) Kotlov

Distribution

Lecania croatica is known from Europe (Printzen 1995, Mrak et al. 2004, Hafellner et al. 2005, Eichler et al. 2010, Vondrák et al. 2010, Kukwa et al. 2012, Motiejūnaitė 2017, Tsurykau 2017) and North America (Tønsberg 2004, Harris and Lendemer 2010).

Material examined

Daugavpils Co., Skrudalienas Dist., Nature Park ‘Silene’, ca 500 m N of Ilgas manor house, 55°41′54.5″N, 26°47′34.5″E, m a.s.l., in a deciduous forest with *Tilia cordata*, *Populus tremula* and *P. abies*, on the bark of *T. cordata*, 27 May 2018, leg. & det.: R.Moisejevs (DAU600000913).

Notes

The collected sterile specimen was checked using TLC, but no secondary compounds were found. The species was distinguished from species with a similar morphology and chemistry following the same characters as employed by Motiejūnaitė et al. (2012) and Tsurykau (2017).

Pycnora praestabilis (Nyl.) Hafellner

Distribution

Pycnora praestabilis is known in North America (Hodkinson 2009), Europe (Śliwa and Kukwa 2012, Randlane et al. 2016, Motiejūnaitė 2017), including Fennoscandia (Bendiksby and Timdal 2013).

Material examined

Daugavpils Co., Skrudalienas Dist., ca 3.5 km E of Silene town, 55°45′41.60″N, 26°52′58.08″E, 130 m a.s.l., in periphery of raised bog, on dry wood (snag) of *P. sylvestris*, 20 July 2017, leg. & det.: R.Moisejevs (DAU600000918).

Notes

From similar species of *Pycnora* and several morphologically similar species from *Xylopsora* genus, *P. praestabilis* differs in its lack of soredia, normally abundant pycnidia up to 0.3 mm diam., typical spot test reactions and presence of alectorialic acid.

Discussion

According to our data, 61 species of lichenicolous fungi have been recorded from Latvia. *Acolium inquinans* mentioned by Āboliņa and Vimba (1959), who described it as ‘a parasitic lichen, growing on thalli of other lichens’, has been excluded since it is a lichenized species that lacks a lichenicolous habit (Tibell 1999). Specimen on which the record was based is lacking, therefore it is impossible to check its identity. Furthermore, Piterāns (1982) did not mention *A. inquinans* in his list of Latvian lichens and Āboliņa et al. (2015) described the species as an epiphytic lichen; therefore, it can be assumed that the aforementioned report was based on misidentification. Specimens of *Biatoropsis usnearum* reported by Motiejūnaitė et al. (2006) (both on *Usnea subfloridana*) are housed in the herbaria of the Institute of Botany, Nature Research Centre (BILAS) and University of Tartu (TU); the BILAS specimen and DAU specimens were checked in accordance with the description of *B. usnearum* (s. str.) given by Millanes et al. (2016), so it is assumed that only one species of *Biatoropsis* is known from Latvia.

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References

Āboliņa, A., Piterāns, A. and Bambe, B. 2015. Lichens and bryophytes in Latvia. Checklist. Latvijas Valsts mežzinātnes institūts ‘Silava’. – DU AA Saule, in Latvian.

Āboliņa, A. and Vimba, E. 1959. Latvijas PSR Mežu ķērpju un sūnu noteicējs. – Latvijas valsts izdevniecība, in Latvian.

Alstrup, V., Kocourková, J., Kukwa, M. et al. 2009. The lichens and lichenicolous fungi of south Greenland. – Folia Cryptog. Estonica 46: 1–24.

Bendiksby, M. and Timdal, E. 2013. Molecular phylogenetics and taxonomy of *Hypocenomyce* sensu lato (Ascomycota: Lecanoromycetes): extreme polyphyly and morphological/ecological convergence. – Taxon 62: 940–956.

Czarnota, P. and Kukwa, M. 2010. New and noteworthy lichenized and lichenicolous fungi from Latvia. – Bot. Lithuan. 16: 21–27.

Eichler, M., Cezanne, R., Diederich, P. et al. 2010. New or interesting lichens and lichenicolous fungi from Belgium, Luxembourg and northern France. XIII. – Bull. Soc. Nat. Luxemb. 111: 33–46.

Esslinger, T. L. 2007. A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. – North Dakota State Univ., Fargo.

Flakus, A., Ahti, T., Kukwa, M. et al. 2008. New and interesting records of *Cladonia* and their lichenicolous fungi from the Andean cloud forest in Bolivia. – Ann. Bot. Fenn. 45: 448–454.

Hafellner, J., Petutschnig, W., Taurer-Zeiner, C. et al. 2005. Über einige bemerkenswerte Flechtenfunde in Kärnten, hauptsächlich in den Gurktaler Alpen. – Carinthia II. 195: 423–440.

Hardman, A., Stone, D. and Selva, S. B. 2017. Calicioid lichens and fungi of the Gifford Pinchot and Okanogan-Wenatchee National Forests in Washington, U.S.A. – Opusc. Philolichenum 16: 1–14.

Harris, R. C. and Lendemer, J. C. 2010. A review of *Lecania croatica* (syn. *Catillaria croatica*) in North America. – Opusc. Philolichenum 8: 41–49.

Hodkinson, B. P. 2009. A first assessment of lichen diversity for one of North America's 'Biodiversity Hotspots' in the Southern Appalachians of Virginia. – Castanea 75: 126–133.

Istomina, N. B. and Likhacheva, O. V. 2010. The preliminary list of lichens of the Pskov Region (Russia). – Nov. Sist. Nizs. Rast. 44: 171–199, in Russian.

Kukwa, M., Łubek, A., Szymczyk, R. et al. 2012. Seven lichen species new to Poland. – Mycotaxon 120: 105–118.

Malta, N. 1926. Die Kryptogamenflora der Sandstein in Lettland. – Acta Hort. Bot. Univ. Latv. 1: 13–32.

Mereschkowski K. S. 1913. Spisok lishainikov Pribaltijskogo kraja. – Uchenyje zapiski Kazanskogo Universiteta 30: 1–62, in Russian.

Millanes, A. M., Diederich, P., Westberg, M. et al. 2016. Three new species in the *Biatoropsis usnearum* complex. – Herzogia 29: 337–354.

Moisejevs, R. 2015. Some new to Latvia lichens and allied fungi. – Acta Biol. Univ. Daugavp. 15: 285–292.

Moisejevs, R. 2017. New lichens and allied fungi for Latvia. – Folia Cryptog. Estonica 54: 9–12.

Moisejevs, R. and Degtjarenko, P. 2017. Four species of saxicolous lichenized fungi new to Latvia. – Bot. Lithuan. 23: 68–70.

Motiejūnaitė, J. 2017. Supplemented checklist of lichens and allied fungi of Lithuania. – Bot. Lithuan. 23: 89–106.

Motiejūnaitė, J. and Piterāns, A. 1998. Materials on lichens and allied fungi of Ķemeri National Park (Latvia). – Bot. Lithuan. 4: 187–196.

Motiejūnaitė, J. and Grochowski, P. 2014. Miscellaneous new records of lichens and lichenicolous fungi. – Herzogia 27: 193–198.

Motiejūnaitė, J., Suija, A., Lõhmus, P. et al. 2006. New or noteworthy lichens, lichenicolous and allied fungi found during the 16th Symposium of Mycologists and Lichenologists in Latvia. – Bot. Lithuan. 12: 113–119.

Motiejūnaitė, J., Berglund, T., Czarnota, P. et al. 2012. Lichens, lichenicolous and allied fungi found in Asveja Regional park (Lithuania). – Bot. Lithuan. 18: 85–100.

Motiejūnaitė, J., Chesnokov, S. V., Czarnota, P. et al. 2016. Ninety-one species of lichens and allied fungi new for Latvia with a list of additional records from Kurzeme. – Herzogia 29: 143–163.

Mrak, T., Mayrhofer, H. and Batič, F. 2004. Contributions to the lichen flora of Slovenia XI. Lichens from the vicinity of Lake Bohinj (Julian Alps). – Herzogia 17: 107–127.

Nordin, A., Moberg, R., Tønsberg, T. et al. 2011. Santesson's checklist of Fennoscandian lichen-forming and lichenicolous fungi. Ver. 29 April 2011. <http://130.238.83.220/santesson/home.php>, accessed 6 May 2018.

Orange, A., James, P. W. and White, F. J. 2001. Microchemical methods for the identification of lichens. – British Lichen Society, London.

Piterāns, A. 1982: Lishainiki Latvii. – Zinatne, in Russian.

Piterāns, A. 2001. Checklist of the lichens of Latvia. – Latvijas Veģetācija 3: 5–45.

Printzen, C. 1995. Die Flechtengattugn *Biatora* in Europa. – Bibl. Lichenol. 60: 1–275.

Randlane, T., Saag, A. and Suija, A. 2016. Lichenized, lichenicolous and allied fungi of Estonia. Ver. December 31, 2016. <http://esamba.bo.bg.ut.ee/checklist/est/home.php>, accessed 29 July 2018.

Santesson, R. and Tønsberg, T. 1994. *Arthrorhaphis aeruginosa* and *A. olivaceae*, two new lichenicolous fungi. – Lichenologist 26: 295–299.

Śliwa, L. and Kukwa, M. 2008. *Calicium pinastri* (Lichenized Ascomycota), a lichen species new to Poland. – Pol. Bot. J. 53: 189–191.

Śliwa, L. and Kukwa, M. 2012. New distribution data for sterile crustose lichens in the Polish Tatra Mts and its surroundings. – Pol. Bot. J. 57: 259–278.

Smith, C. W., Aptroot, A., Coppins, B. J. et al. (eds). 2009. The Lichens of Great Britain and Ireland. – British Lichen Society.

Sohrabi, M. and Alstrup, V. 2007. Additions to the lichen mycota of Iran from East Azerbaijan Province. – Mycotaxon 100: 145–148.

Strazdiņa, L., Kluša, J., Leimanis, I. et al. 2017. New bryophyte and fungi records and rarities of Latvia in 2016. – Latvijas Veģetācija 26: 125–150, in Latvian.

Titov, A. 2000. Notes on calicioid lichens and fungi from the Gongga Mountains (Sichuan, China). – Lichenologist 32: 553–569.

Tibell, L. 1975. The Caliciales of boreal North America. Taxonomy, ecological and distributional comparisons with Europe, and ultrastructural investigations in some species. – Symb. Bot. Ups. 21: 1–128.

Tibell, L. 1999. Caliciales. – In: Nordic Lichen flora 1. Bohuslän '5, pp. 20–92.

Tønsberg, T. 2004. Additions to the lichen flora of Great Smoky Mountains National Park. – ATBI Q. 3: 6.

Tsurykau, A. 2017. New or otherwise interesting records of lichens and lichenicolous fungi from Belarus. III. With an updated checklist of lichenicolous fungi. – Herzogia 30: 152–165.

Vimba E.1971. Materials of the 6th symposium of the Baltic republics on mycology and lichenology. – Zinatne, in Russian.

Vondrák, J., Palice, Z., Khodosovtsev, A. et al. 2010. Additions to the diversity of rare or overlooked lichens and lichenicolous fungi in Ukrainian Carpathians. – Chornomorskyi Bot Zhurnal 6: 6–34.

Wirth, V., Hauck, M., von Brackel, W. et al. 2010. Checklist of lichens and lichenicolous fungi in Germany. Ver. #2: 19 January 2011. <www.gwdg.de/~mhauck>, accessed 29 July 2018.

VI

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REVISION OF THE GENUS *CETRELIA* (LICHENISED ASCOMYCOTA) IN LATVIA

Polina Degtjarenko[1,2*], Rolands Moisejevs[2]

[1]University of Tartu, Department of Botany, Lai Str. 40, 51005 Tartu, Estonia
[2]Daugavpils University, Institute of Life Sciences and Technology, Parādes Str. 1a, 5401 Daugavpils, Latvia*
Corresponding author. E-mail: polina.degtjarenko@ut.ee

Abstract

Degtjarenko P., Moisejevs R., 2020: Revision of the genus *Cetrelia* (lichenised Ascomycota) in Latvia. – Botanica, 26(1): 88–94.

All available specimens (98) of the genus *Cetrelia* from Latvia (Northern Europe) in the Herbaria DAU and RIG were revised. *Cetrelia cetrarioides*, *C. olivetorum* and *C. monachorum* were confirmed to occur in the country. The last taxon is new to Latvia. Distribution maps and habitat preferences of all three species in Latvia were presented, and their conservation status was discussed.

Keywords: cetrarioid lichens, *Cetrelia monachorum*, chemotypes, conservation, new record, Parmeliaceae.

INTRODUCTION

The genus *Cetrelia* W.L. Culb. & C.F. Culb. (Parmeliaceae, Lecanorales, Ascomycota) has been described by Culberson & Culberson (1968). The genus is characterised by a large foliose, loosely attached greyish-green thallus with rounded marginal lobes and laminal pseudocyphellae on an upper cortex, at least partly black lower surface with sparse rhizines, ellipsoid ascospores, and atranorin as the main cortical substance with different orcinol depsides and depsidones as diagnostic medullary substances (Culberson & Culberson, 1968, 1976; Obermayer & Mayrhofer, 2007; Mark et al., 2019). The European *Cetrelia* species are characterised by the presence of marginal soralia. In Europe, the *Cetrelia* species are mostly epiphytic and found in old natural or seminatural forests on tree bark or occasionally on mossy rocks (Obermayer & Mayrhoffer, 2007; Kukwa et al., 2012; Degtjarenko et al., 2018). The genus includes 18 currently accepted species (Thell et al., 2012; Randlane et al., 2013), and most species are restricted to eastern and south-eastern Asia (Culberson & Culberson, 1968; Randlane & Saag, 1991). In Europe, only four species are known: *Cetrelia cetrarioides* (Delise) W.L. Culb. & C.F. Culb., *Cetrelia chicitae* (W.L. Culb.) W.L. Culb. & C.F. Culb., *Cetrelia monachorum* (Zahlbr.) W.L. Culb. & C.F. Culb., and *Cetrelia olivetorum* (Nyl.) W.L. Culb. & C.F. Culb. (Culberson & Culberson, 1968; Hawksworth et al., 2008, 2011). The taxonomic affinities of these species have been discussed over the years. Several studies have suggested accepting only one species in the group with four chemotypes, separated according to the major medullary substances, which can be visualised by the standard thin-layer chromatography methods (TLC) (Clerc, 2004; Santesson et al., 2004; Gilbert & Purvis, 2009), while others have considered the different chemotypes as separate species (Randlane & Saag, 1991; Wirth et al., 2013). Recently, Mark et al. (2019) have shown that these chemotypes are correlated with phylogenetic clades. Recognition of the species based on TLC results is, therefore, confirmed to be possible. The *Cetrelia* synthesise specific sets of related substances – chemosyndromes, where the same product may occur in several species, but in different quantities, acting either as a major or a minor compound – specific to its taxonomic affiliation (Culberson & Culberson, 1968). *Cetrelia monacho-*

rum contains imbricaric acid as the major medullary substance and, additionally perlatolic, 4-O-demethylimbricaric, and anziaic acids in minor or trace amounts in the medulla (Obermayer & Mayrhofer, 2007; Kukwa & Motiejūnaitė, 2012). *Cetrelia cetrarioides* contains perlatolic acid as the major and imbricaric acid as minor medullary substance (Obermayer & Mayrhofer, 2007; Kukwa & Motiejūnaitė, 2012). *Cetrelia olivetorum* can be separated from the morphologically similar species *C. cetrarioide*s and *C. monachorum* by a strong sanguineous/red reaction with the spot-test reaction with solution of sodium hypochlorite (C), which is caused by the presence of olivetoric acid in medulla (with trace of anziaic acid and 4-O-de-methylmicrophyllinic acid) (Obermayer & Mayrhofer, 2007; Golubkov et al., 2015). *Cetrelia chicitae* produces alectoronic acid and a-collatolic acid, including physodic acid and 4-O-methylphysodic acid in traces (Obermayer & Mayrhofer, 2007). Also, all discussed *Cetrelia* species contain atranorin in the cortex.

In Latvia, two species, *C. olivetorum* and *C. cetrarioides*, have been recorded and distinguished by morphology and a spot-test reaction with solution of sodium hypochlorite (C) (Āboliņa et al., 2015). In the neighbouring countries, Estonia, Lithuania and Belarus, three species of the genus *Cetrelia* have been confirmed by TLC (Kukwa & Motiejūnaite, 2012; Golubkov et al., 2015; Degtjarenko et al., 2018). To date, no particular chemical studies using TLC and distributional survey of the genus *Cetrelia* have been performed in Latvia. This study aimed to revise the *Cetrelia* taxa from available herbarium material to determine the species, their distribution and habitat preferences according to the European Union Habitats Directive in Latvia.

MATERIALS AND METHODS

The present study was based on herbarium material collected in Latvia from 1957 to 2018. A total of 98 specimens from the Lichenological Herbarium of Daugavpils University (DAU) and the University of Latvia (RIG) were studied. Morphology of the *Cetrelia* specimens was examined using a stereomicroscope. The specimens were tested for lichen substances by thin-layer chromatography (TLC; solvent A) (Orange et al., 2001). Localities of Latvian specimens and their substrates were transcribed from the labels. Distribution maps of the *Cetrelia* species were created using ESRI ArcGIS pro 2.3. (ESRI, 2011).

RESULTS AND DISCUSSION

Heretofore, only two species, *Cetrelia olivetorum* and *C. cetrarioides*, had been known in Latvia (Āboliņa et al., 2015), *Cetrelia monachorum* was reported new to Latvia. *Cetrelia cetrarioides* and *C. olivetorum* accounted for 43% and 42% of the examined specimens, respectively. Amongst other *Cetrelia* species in Latvia, *Cetrelia monachorum* appeared to be the rarest – with 15% of the examined specimens. All studied material was sterile (without apothecia).

*Cetrelia cetrarioide*s and *C. olivetorum* were first recorded in Latvia in 1957 (Andrušaitis et al., 1996) in the Numerne Forest near Donikava town. Since then, it has been recorded from other parts of Latvia as well (Piterāns, 2001; Āboliņa et al., 2015). Most collections of the *Cetrelia* are from the north-eastern and central parts of Latvia (Figs 1, 2). There are no records from the western part of the country. The distribution of *C. monachorum* is congruent with the distribution of other *Cetrelia* species (Fig. 3).

The three *Cetrelia* taxa are morphologically very similar, and difficult to distinguish based on morphology alone (Randlane & Saag, 1991; Obermayer & Mayrhofer, 2007; Mark et al., 2019). In our study, twenty-one *C. cetrarioides* specimens were previously determined as *C. olivetorum,* and seven *C. olivetorum* specimens as *C. cetrarioides.* A possible explanation

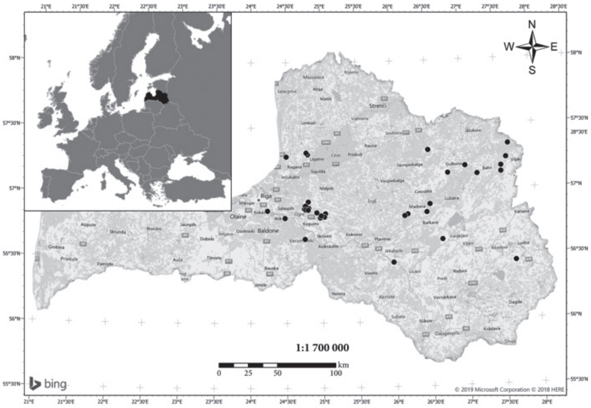

Fig. 1. Map of *Cetrelia cetrarioides* distribution in Latvia (marked with black circles); based on the herbarium collection from 1957 to 2018

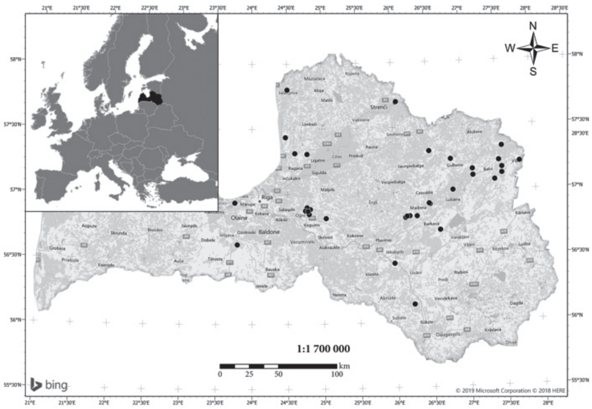

Fig. 2. Map of *Cetrelia olivetorum* distribution in Latvia (marked with black circles); based on the herbarium collection from 1957 to 2018

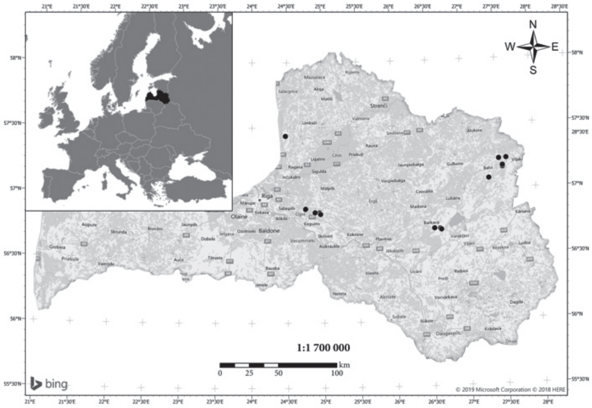

Fig. 3. Map of *Cetrelia monachorum* distribution in Latvia (marked with black circles); based on the herbarium collection from 1957 to 2018

for this might be that *C. olivetorum* and *C. cetrarioides* had been treated in Latvia as one species until 2001 (Piterāns, 2001). Since 2001, the determination of these taxa continued to be mainly based on morphology and spot-test reactions which are unreliable. Fifteen specimens were determined as *C. monachorum* (previously determined as *C. cetrarioides* and *C. olivetorum* and kept in the herbarium collections under *C. cetrarioides* or *C. olivetorum* names). The determination of lichen secondary substances using TLC proved to be a reliable tool to distinguish between these taxa (Obermayer & Mayrhofer, 2007; Kukwa et al., 2012; Mark et al., 2019).

In the continental parts of Europe, the *Cetrelia* species grow mostly in old deciduous or mixed forests, in localities of high humidity (Obermayer & Mayrhoffer, 2007), especially in swamp forests or forests surrounded by a lake or river or on hillsides near lakes or streams (Randlane & Saag, 1991; Kukwa et al., 2012; Kukwa & Motiejūnaitė, 2012). The *Cetrelia* habitat requirements in Latvia according to the European Union Habitats Directive (Auniņš et al., 2013) were based only on 33 recorded specimens from DAU and RIG. Data on habitat requirements according to the EU Habitats Directive were not used for other 65 specimens due to insufficient data on the specimen labels and lack of knowledge on the EU habitat distribution in Latvia. The examined *Cetrelia* specimens were mainly found at the sites, which correspond to the habitat type “Fennoscandian hemiboreal natural old broad-leaved deciduous forests (*Quercus*, *Tilia*, *Acer*, *Fraxinus* or *Ulmus*) rich in epiphytes” (habitat type code “9020”, 31% of the examined records), “Fennoscandian deciduous swamp forests” (habitat type code “9080*”, 24% of the examined records), and “Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*” (habitat type code “91E0*”, 24% of the examined records).

Elsewhere, the *Cetrelia* species usually occur on deciduous trees and are very rarely found on coniferous trees (Obermayer & Mayrhoffer, 2007; Kukwa et al., 2012; Kukwa & Motiejūnaitė, 2012). In Latvia, the *Cetrelia* species prefer mostly *Alnus glutinosa*, *Fraxinus excelsior*, *Populus tremula*, *Tilia cordata*, *Quercus robur* and less frequently *A. incana*, *Betula pendula*, *Corylus avelana*, *Padus avium* and *Picea abies* (Table 1). The habitat preferences for 18 specimens were not recorded on the specimen labels (Table 1).

In the Baltic countries, the *Cetrelia* species are rare and threatened. In Estonia, *C. olivetorum* and *C. cetrarioides* are considered as endangered (EN) and *C. monachorum* as critically endangered (CR; Lõhmus et al., 2019). In Lithuania, all species of the genus *Cetrelia* are considered as EN (Jurga Motiejūnaitė pers. comm.). In Fennoscandia, for example, in Sweden, *C. olivetorum* s. lat. is treated as CR (Nordin et al., 2011; Artfakta, 2019), and in Finland, *C. olivetorum* – as EN (Hyvärinen et al., 2019). In neighbouring Belarus, *C. olivetorum* and *C. monachorum* are treated as EN, and *C. cetrarioides* – as CR (Bely et al., 2014). *Cetrelia olivetorum* is classified in Category I of the Latvian Red Data Book; the assessment of status was based on only seven herbarium specimens and one historical record (Andrušaitis et al., 1996). The status of newly reported *C. monachorum* has not been

Table 1. Substrate requirements for *Cetrelia cetrarioides*, *Cetrelia monachorum* and *Cetrelia olivetorum* in Latvia; based on the herbarium collection from DAU and RIG

Substrate	*C. cetrarioides*	*C. monachorum*	*C. olivetorum*	Total
Alnus glutinosa	13	4	12	29
Alnus incana	2	1	1	4
Betula spp.	2	0	1	3
Corylus avelana	0	0	1	1
Populus tremula	2	0	3	5
Fraxinus excelsior	11	2	7	20
Picea abies	1	0	0	1
Tilia cordata	1	3	5	9
Quercus robur	0	3	3	6
Padus avium	1	1	0	2
Unknown	8	2	8	18

determined yet. *C. olivetorum* is also included into the Legislative List (Rules of Ministry Cabinet) of Legally Protected Lichens in Latvia (Regulations, 2013). For the current species, micro-reserves of up to 30 ha might be established. The assessment of a threat status of Latvian *Cetrelia* species based on IUCN system (Standards…, 2006) has not been performed yet. Further work needs to be carried out to assess the threat status of all three *Cetrelia* species in Latvia according to the IUCN system and reconsider their conservation status for the Latvian Legislative List of Legally Protected Lichens. It is also recommendable to include *C. olivetorum*, *C. monachorum* and *C. cetrarioides* into a species monitoring system (Baroniņa, 2017) to estimate the size of species populations and potential threats for all three species.

Record new to Latvia

Cetrelia monachorum **(Zahlbr.) W.L. Culb. & C.F. Culb.**

C. monachorum is morphologically similar to other sorediate species of the genus *Cetrelia* and is characterised by the presence of (mainly) marginal soredia. The soralia of *C. monachorum* are often coarse and irregular in shape with soredia usually exceeding 40 µm in diam. On the upper part of cortex, typically small and raised pseudocyphellae are found, sometimes associated with large ones, the lower cortex often lacks pseudocyphellae (Culberson & Culberson, 1968, 1976; Obermayer & Mayrhofer, 2007). Morphologically similar sorediate *Cetrelia* species (*C. cetrarioides*, *C. chicitae* and *C. olivetorum*) are distinguished from *C. monachorum* by their different content secondary metabolites profile (Obermayer & Mayrhofer, 2007; Randlane & Saag, 1991; Mark et al., 2019). The species is known in the following European countries: Austria (Obermayer & Mayrhofer, 2007), Belarus (Golubkov et al., 2015), Bosnia-Herzegovina (Bilovitz & Mayrhofer, 2011), the Czech Republic (Obermayer & Mayrhofer, 2007), Estonia (Degtjarenko et al., 2018), France, Germany, Italy (Obermayer & Mayrhofer, 2007), Lithuania (Kukwa & Motiejūnaite, 2012), Montenegro (Obermayer & Mayrhofer, 2007; Knezevic & Mayrhofer, 2009), Norway (Obermayer & Mayrhofer, 2007), Poland (Kukwa et al., 2012), Portugal (Llimona & Hladun, 2001), Romania (Obermayer & Mayrhofer, 2007), Russia (European part, Tver Oblast, Stepanchikova et al., 2011), Slovakia, Slovenia, (Obermayer & Mayrhofer, 2007), Spain (Barbero et al., 1995), Sweden (Nordin et al., 2011), Switzerland (Obermayer & Mayrhofer, 2007), Ukraine (Kondratyuk et al., 2003), the United Kingdom (Obermayer & Mayrhofer, 2007). It is also known from the Republic of Armenia, the Republic of Azerbaijan (Sohrabi et al., 2007), China (Wei, 1991), Georgia (Obermayer & Mayrhofer, 2007; Sohrabi & Alstrup, 2007), Hawaii (Elix & McCarthy, 1998), India (Mishra & Upreti, 2015), Japan (Kurokawa, 2003), North American mainland (Obermayer & Mayrhofer, 2007), and from the Asian part of Russia (Urbanavichus & Andreev, 2010).

Specimens examined. Ogres distr., Suntažu Forest, forest square – 88, forest site 5, on unknown substrate, 16 Oct. 2002, I. Grīsle (RIG15910). Viļakas distr., Žīguru Forest, forest square – 504, forest site 2, on *A. glutinosa*, 2 Oct. 2012, V. Lārmanis (RIG16132).

Ogres distr., Suntažu Forestry, forest square – 256, forest site 12, on *A. glutinosa*, 16 Oct. 2002, I. Grīsle (RIG15925). Ogres distr., Suntažu Forestry, forest square – 79, forest site 8, on *A. incana*, 16 Oct 2002, I. Grīsle (RIG15917). Balvu distr., Kupravas Forest on *T. cordata*, 3 Oct. 1996, A. Piterāns (RIG14313). Balvu distr., Tilža, Dominava Forest of high humidity on *F. excelsior*, 13 Aug. 1957, A. Piterāns (RIG2038). Balvu distr., Kupravas Forest on *T. cordata*, 3 Oct. 1996, A. Piterāns (without number). Ogres distr., Suntažu Forestry, forest square – 274, forest site 10 on unknown substrate, in 2002, I. Grīsle (RIG15905). Ogres distr., Suntažu Forestry, forest square – 157, forest site 8, on *A. glutinosa*, 1 Dec. 2002, I. Grīsle (RIG15908). Madonas distr., Barkavas Rural Municipality, on *Q. robur*, 22 May 1997, A. Piterāns (RIG15353). Madonas distr., on *Q. robur*, 22 May 1997, A. Piterāns (RIG15352). Madonas distr., Nature 'Barkavs ozolu audze', *Q. robur* forest, 22 May 1997, A. Piterāns (RIG15245). Balvu distr., Vīksnas Rural Municipality, Nature Reserve 'Kupravas liepu audze', *T. cordata* forest, 26 May 1976, A. Piterāns (RIG15244). Salacgrīvas distr., 2 km to the east of Mustkalni town, on *A. glutinosa* in alluvial swamp forest (91E0*), 1 July 2017, R. Moisejevs (DAU600000477). Krimulda distr., about 3 km of Lēdurga town to the east, on *F. excelsior*, in old-growth broadleaved forest dominated by *Q. robur*, 19 Sep. 2016, R. Moisejevs (DAU600000476).

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REFERENCES

Āboliņa A., Piterāns A., Bambe B., 2015: Lichens and bryophytes in Latvia: Checklist. – Salaspils.

Andrušaitis G., Vimba E., Piterāns A., 1996: Latvian Red Data Book. Rare and extinct plant and animal species. Mushrooms and lichens, 1. – Rīga.

Artfakta, 2019: ArtDatabanken, SLU. https://artfakta.se/rodlistan [Accessed 14 August, 2019].

Auniņš A., Lārmanis V., Rove I., Rūsiņa S., Laime B. (eds), 2013: European Union Protected Habitats in Latvia. – Riga.

Barbero M., Etayo J., Gómez-Bolea A., 1995: Chemotypes of *Cetrelia cetrarioides* s. l. (Lichenes) in the Iberian Peninsula. – Cryptogamic Botany, 5: 28–30.

Baroniņa V., 2017: Augu monitoringa metodika Natura 2000 teritorijās. www.daba.gov.lv/upload/File/DOC.../MET_2017_augi_N2000_un_arpus.docx [Accessed 14 August, 2019].

Bilovitz P.O., Mayrhofer H., 2011: Epiphytic lichen mycota of the virgin forest reserve Rajhenavski Rog (Slovenia). – Herzogia, 24(2): 315–324.

Bely P., Golubkov V., Tsurykau A., Sidorovich E., 2014: The lichen genus *Cetrelia* in Belarus: distribution, ecology and conservation. – Botanica Lithuanica, 20 (2): 69–76.

Clerc P., 2004: Les champignons lichénisés de Suisse. – Cryptogamica Helvetica, 19: 1–320.

Culberson W.L., Culberson C.F., 1968: The lichen genera *Cetrelia* and *Platismatia* (Parmeliaceae). – Washington.

Culberson W.L., Culberson C.F., 1976: Chemosyndromic variation in lichens. – Systematic Botany, 1(4): 325–339.

Degtjarenko P., Jüriado I., Lõhmus P., 2018: New Estonian records: Lichenized fungi. – Folia Cryptogamica Estonica, 55: 151–154.

Elix J.A., Mc Carthy P.M., 1998: Catalogue of the lichens of the smaller Pacific Islands. – Bibliotheca Lichenologica, 70: 1–361.

ESRI, 2011: ArcGIS Desktop, Release 10. – Redlands.

Gilbert O.L., Purvis O.W., 2009: *Cetrelia* W.L. Culb. & C.F. Culb. (1968). – In: Smith C.W., Aptroot A., Coppins B.J., Fletcher A., Gilbert O.L., James P.W., Wolseley P.A. (eds), The lichen flora of Great Britain and Ireland: 296–297. – London.

Golubkov V., Matwiejuk A., Bely P., Tsurykau A., 2015: Revision of the genus *Cetrelia* (Lecanorales, Ascomycota) in the Białowieża Forest (Belarussian part). – Steciana, 19(3): 123–132.

Hawksworth D.L., Blanco O., Divakar P.K., Ahti T., Crespo A., 2008: A first checklist of parmelioid and similar lichens in Europe and some adjacent territories, adopting revised generic circumscriptions and with indications of species distributions. – The Lichenologist, 40(1): 1–21.

Hawksworth D.L., Divakar P.K., Crespo A., Ahti T., 2011: The checklist of parmelioid and similar lichens in Europe and some adjacent territories: additions and corrections. – The Lichenologist, 43(6): 639–645.

Hyvärinen E., Juslén A., Kemppainen E., Uddström A., Liukko U-M. (eds), 2019: The 2019 Red List of Finnish Species. – Helsinki.

Knezevic B., Mayrhofer H., 2009: Catalogue of the lichenized and lichenicolous fungi of Montenegro. – Phyton, 48(2): 283–328.

Kondratyuk S.Y., Popoval P., Lackovičovšút A., Pišút J., 2003: A catalogue of eastern Carpathians lichens. – Kiev.

Kurokawa S. (ed.), 2003: Checklist of Japanese lichens. – Tokyo.

Kukwa M., Motiejūnaitė J., 2012: Revision of the lichen genera *Cetrelia* and *Punctelia* (Lecanorales, Ascomycota) in Lithuania with implications for their conservation. – Herzogia, 25(1): 5–14.

Kukwa M., Pietnoczko M., Czyżewska K., 2012: The lichen family Parmeliaceae in Poland. II. The genus *Cetrelia*. – Acta Societatis Botanicorum Poloniae, 81(1): 43–52.

Llimona X., Hladun N., 2001: Checklist of the lichens and lichenicolous fungi of the Iberian Peninsula and Balearic Islands. – Bocconea, 14: 5–58.

Lõhmus P., Marmor L., Jüriado I., Suija A., Oja E., Degtjarenko P., Randlane T., 2019: Red List of Estonian lichens: revision in 2019. – Folia Cryptogamica Estonica, 56: 63–76.

Mark K., Randlane T., Thor G., Hur J.S., Obermayer W., Saag A., 2019: Lichen chemistry is concordant with multilocus gene genealogy in the genus *Cetrelia* (Parmeliaceae, Ascomycota). – Fungal Biology, 123(2): 125–139.

Mishra G.K., Upreti D.K., 2015: The lichen genus *Cetrelia* (Parmeliaceae, Ascomycota) in India. – Phytotaxa, 236(3): 201–214.

Nordin A., Moberg R., Tønsberg T., Vitikainen O., Dalsätt Å., Myrdal M., Snitting D., Ekman S., 2011: Data from: Santesson's Checklist of Fennoscandian Lichen-forming and Lichenicolous Fungi. Ver. 29 April 2011. http://130.238.83.220/santesson/home.php [Accessed 14 August, 2019].

Obermayer W., Mayrhofer H., 2007: Hunting for *Cetrelia chicitae* (lichenized Ascomycetes) in the eastern European Alps (including an attempt for a morphological characterization of all taxa of the genus *Cetrelia* in Central Europe). – Phyton, 47(1–2): 231–290.

Orange A., James P.W., White F.J., 2001: Microchemical methods for the identification of lichens. – London.

Piterāns A., 2001: Checklist of the lichens of Latvia. – Latvijas Veģetācija, 3: 5–45.

Randlane T., Saag A., 1991: Chemical and morphological variation in the genus *Cetrelia* in the Soviet Union. – The Lichenologist, 23(2): 113–126.

Randlane T., Saag A., Thell A., Ahti T., 2013: Third world list of cetrarioid lichens - in a new databased form, with amended phylogenetic and type information. – Cryptogamie Mycologie, 34(1): 79–84.

Regulations, 2013: Regulations Regarding the Establishment and Management of Micro-reserves, Their Conservation, as well as Determination of Micro-reserves and Their Buffer Zones. https://likumi.lv/ta/en/en/id/253746 [Accessed 14 August, 2019].

Santesson R., Moberg R., Nordin A., Tønsberg T., Vitikainen O., 2004: Lichen-forming and lichenicolous fungi of Fennoscandia. – Uppsala.

Sohrabi M., Ahti T., Urbanavichus G., 2007: Parmelioid lichens of Iran and the Caucasus Region. – Mycologia Balcanica, 4(1–2): 21–30.

Standards and Petitions Working Group, 2006: Guidelines for Using the IUCN Red List Categories and Criteria: Version 6.1. Prepared by the Standards and Petitions Working Group for the IUCN SSC Biodiversity Assessments Sub-Committee in July 2006. http://app.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf [Accessed 14 August, 2019].

Stepanchikova I., Kukwa M., Notov A., Himelbrant D., 2011: Novye dannye o lixenoflore Tverskoj oblasti. – Vestnik TvGU, Biologija i ekologija, 23: 137–142.

Thell A., Crespo A., Divakar P.K., Kärnefelt I., Leavitt S.D., Lumbsch H.T., Seaward M.R., 2012: A review of the lichen family Parmeliaceae – history, phylogeny and current taxonomy. – Nordic Journal of Botany, 30(6): 641–664.

Urbanavichus G., Andreev M., 2010: A checklist of lichen flora of Russia. – St. Petersburg.

Wei J.C., 1991: An enumeration of lichens in China. – Beijing.

Wirth V., Hauck M., Schultz M., 2013: Die Flechten Deutschlands, 1. – Stuttgart.

CETRELIA GENTIES (LICHENIZUOTI AUKŠLIAGRYBŪNAI) REVIZIJA LATVIJOJE

Polina Degtjarenko, Rolands Moisejevs

Santrauka

Buvo patikrinti visi DAU ir RIG herbariumuose laikomi *Cetrelia* pavyzdžiai (iš viso 98), surinkti Latvijoje. Inventorizacija patvirtino, kad šalyje aptinkamos trys *Cetrelia* genties rūšys: *Cetrelia cetrarioides*, *C. olivetorum* ir *C. monachorum*. Pastaroji rūšis yra nauja Latvijos lichenobiotai. Straipsnyje pateikiami visų trijų rūšių paplitimo žemėlapiai bei jų buveinės Latvijoje, aptariamas rūšių apsaugos statusas.

VII

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SOME NEW TO LATVIA LICHENS AND ALLIED FUNGI

Rolands Moisejevs

Moisejevs R. 2015. Some new to Latvia lichens and allied fungi. *Acta Biol. Univ. Daugavp., 15 (2): 285 – 292.*

The paper presents data on five lichenized, lichenicolous and saprobic fungus species that are new to Latvia. *Chaenothecopsis pusiola, Scytinium teretiusculum, Microcalicium ahlneri, M. disseminatum* and *Pilophorus cereolus* were found in Vidzeme region in year 2015. Of them, *Scytinium teretiusculum* and *Pilophorus cereolus* are rare in all Baltic States.

Key words: lichenized fungi, lichenicolous fungi, non-lichenized fungi.

Rolands Moisejevs. Daugavpils University, Institute of Life Sciences and Technology, Daugavpils University, Parādes str.1a., LV-5401, e-mail: rolands.moisejevs@biology.lv.

INTRODUCTION

Lichens are poorly studied group of organisms in Latvia. Current total number of lichen and allied fungus species found in Latvia is the smallest in Baltic States – 682 in total (Motiejūnaitė et al., in prep.). During last 25 year new records of lichens and allied fungi were reported as a fieldwork result of the Symposia of Baltic Mycologists and Lichenologists (Motiejūnaitė & Piterāns 1998, Motiejūnaitė et al. 2006, Czarnota & Kukwa 2010), by visiting lichenologists from other countries (Sundin & Thor 1990, Motiejūnaitė & Grochowski 2014), local ecological studies (Plociņa 2007, Mežaka 2009, Mežaka et al. 2008, 2009, 2012), and some targeted lichen diversity studies (Piterāns et.al. 2005, 2006). Current paper supplements data on biota of lichens and allied fungi in Latvia and expands knowledge on distribution of some rare and understudied species.

MATERIAL AND METHODS

Specimens of lichenized and allied fungi were collected by the author of present paper in year 2015, in two Natura 2000 and one industrial forest territories in Vidzeme region (Fig 1.). Collected specimens were identified using the routine lichenological methods (Smith et al. 2009). Specimens were examined under stereomicroscope Nicon SMZ 800. Watermounted hand-made cross sections were examined under light transmission microscope Nicon Eclipse E100. Measurements of ascospores and other structures were made in water. For determination of collected specimens following references were employed: Ahti & Steinross (2013), Jørgensen (2007), Smith et al. (2009) , Tibell (1999). The nomenclature of taxa mainly follows Nordin et al. (2011). Some specimens were compared with the collections at the herbarium of the Institute of Botany, Nature Research Centre, Vilnius (BILAS). Species distribution in neighboring countries (except Russia) is provided. Non-lichenized fungi are marked with (+) and lichenicolous fungi with (#).All lichen specimens that are presented in this paper are deposited at the Herbarium of Daugavpils University, Institute of Life Sciences and Technology, Laboratory of Botany (DAU).

Study site

Vidzeme is situated in northeast part of Latvia and occupies area of 25 683 km^2 (including Riga and Pieriga districts), with highest population in the districts of Riga, Jūrmala, Valmiera and Cēsis. (Turlājs 2011). There are 7 Nature Parks, 4 Protected Landscape Areas, 1 Biosphere Preserve, 1 National Park and over 70 Nature Preserves. (Dabas aizsardzības pārvalde 2015). The region is bordered by Riga Gulf in the west. Highest areas above the sea level are Vidzemes and Alūksnes uplands with highes points „Gaiziņkalns" 311,6 m and „Dēliņkalns" 271,5. Largest river in Vidzeme is Gauja with total lenth of 452 km and catchment area over 7.700 km^2 in Latvia. Sandstone outcrops are found along the banks and in the catchment of the river (Turlājs 2011).

Climate of Vidzeme region is mainly formed by Atlantic cyclones that bring air masses and precipitation from west and northwest. Average temperature in January ranges between -7 and -3 °C , in July +16 and +18°C. Average yearly precipitation ranges between 600 and 850 mm, snow cover remains for 80–110 days (Turlājs 2011).

A number of forest and outcrop habitat types included into Annex I of European Union Habitat Directive are found in the region, such as 6530 *Fennoscandian wooded meadows, 9010 *Western taiga, 9020 *Fennoscandian hemiboreal natural old broad-leaved deciduous forests rich in epiphytes, 9050 Fennoscandian herb-rich forests with *Picea abies*, 9080 *Fennoscandian deciduous swamp woods, 9160 Sub-Atlantic and medio-European oak forests, 9180 *Tilio-Acerion* forests of slopes, screes and ravines, 91E0 *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*, 91D0 Bog woodland, 8220 Siliceous (sandstone) rocky slopes with chasmophytic vegetation, 8210 Calcareous rocky slopes with chasmophytic vegetation and some others (Lārmanis 2013, Rēriha 2013).

RESULTS AND DISCUSSION

All refered specimens were collected during the year 2015 in Vidzeme. *Chaenothecopsis pusiola,*

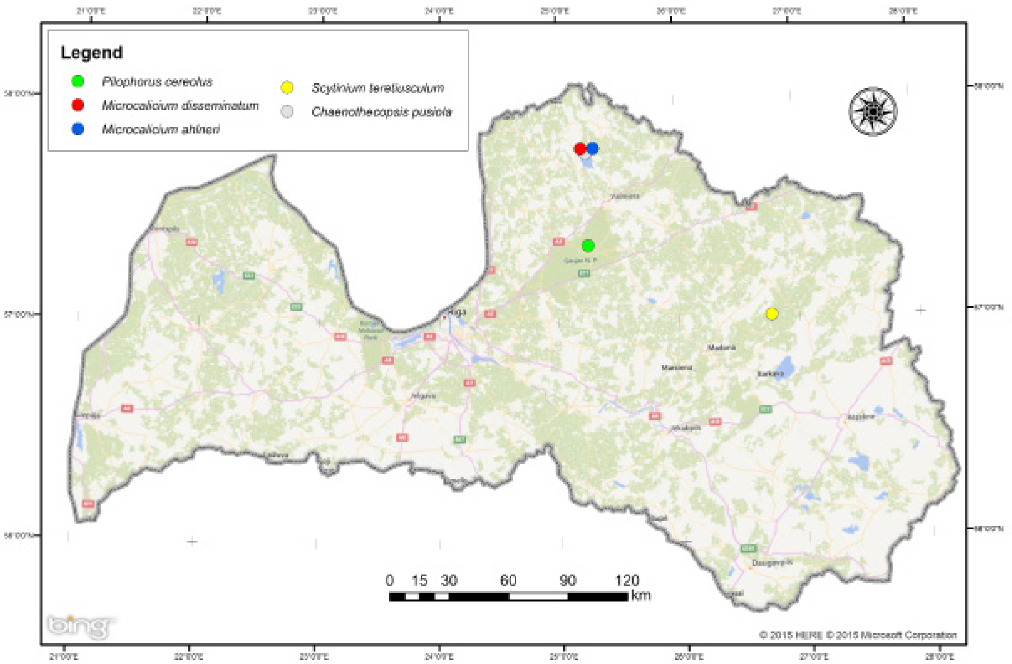

Fig 1. Study areas.

Scytinium teretiusculum, Microcalicium ahlneri, Microcalicium disseminatum, Pilophorus cereolus are reported here for the first time in Latvia. Of the five newly recorded species, *Scytinium teretiusculum* and *Pilophorus cereolus* are rare and red-listed in adjacent countries whenever they are known (Randlane & Saag 2000, Randlane et al. 2008, Rašomavičius 2007).

SPECIES LIST

+ ***Chaenothecopsis pusiola*** (Ach.) Vain.

Morphology: Apotecia 0,3-0,55 mm tall, head 0,16- 0,2 mm diam. Ascospores 6-7x 2-2,4 µm, 1-septate, septum pale. Excipulum K+ bright red.

Species distribution and ecology: Widely distributed in boreal and montane zones of N.Hemisphere, occurs on lignum of conifers, less often on lignum of deciduous trees (Tibell 1999) . Species is known from Lithuania and Estonia (Motiejūnaitė 1999; Lõhmus 1998).

Material examined: Latvia, Valmieras region, Burtnieku district, Nature preserve „Vidusburtnieks", (57°46'N, 25°14'E). On decaying *Quercus* wood in old shaded woodland with high humidity. .May 16, 2015. (DAU Nr. 027004001)

Scytinium teretiusculum **(Wallr.) Otálora et al.**

Morphology: Thallus dark grey. Lobes 0,3-0,8x 0,1-0,2 mm. Isidia long, cylindrical 40- 65 µm diam and 0,6-0,8 mm long. Apotecia in Latvian material not found.

Species distribution and ecology: Europe, Macaronesia, N. and C. America, Asia. Corticolous on coarse-barked trees, especially *Populus tremula* or *Juniperus*. (Gilbert & Jørgensen 2009, Jørgensen 2007). Species known from Lithuania and Estonia (Motiejūnaitė et.al. 2005; Randlane & Saag 1999).

Material examined: Latvia, Lubānas region, Daukstas district**,** About 5km West off Lubāna

Fig 2. Old woodland from study area.

City (57°1’N 26°46’E). Broad-leaved forest with *Populus tremula*. On trunk of *Tillia cordata*. Old shaded woodland with high humidity (Fig 2). July 22, 2015 (DAU Nr. 064007001).

+ ***Microcalicium ahlneri*** Tibell (Fig 4.)

Morphology: Apotecia 0,4-0,5 mm tall. Stalk black, head narrowly conical. Ascospore mass green-black with sclerotized hyphae. Ascospores 5-6,5x 2-2,4 µm.

Species distribution and ecology: Known in Europe, N. America, Asia. On decorticated stumps heavily attacked by brown rot fungi, usually of *Pinus sylvestris,* more rarely on lignum of *Picea abies*, and occasionally on oak wood. Mainly in humid locations (Tibell 1999). Recorded from Lithuania and Estonia (Motiejūnaitė 2007; Randlane & Saag 1999).

Material examined: Latvia, Valmieras region, Burtnieku district, Nature preserve „Vidusburtnieks” , (57°46’ N 25°14’E). On decaying wood of *Quecus robur*. Old shaded woodland with high humidity.May 16, 2015 (DAU Nr. 143001001) .

Microcalicium disseminatum (Ach.) Vain. (Fig. 5)

Morphology: On thalli of *Chaenotheca trichialis* (Ach.) Th. Fr. Apotecia 0,1-0,3 mm diam., 0,1-0,2 tall, sessile. True exciple aeruginose in section, K+ brown. Ascospores 11-13x 3-3,7 µm, 1- to 3-septate.

Species distribution and ecology: Reported from Europe, N. America, Asia. On lignum and bark of both decidous trees and conifers in moderately shaded situations. Often parasitic on calicioid lichens, particularly Chaenotheca species. Also on free-living algal colonies and apparently also occurring saprobically on wood (Tibell 1999). Species known from Lithuania and Estonia. (Motiejūnaitė 2003; Randlane & Saag 1999).

Material examined: Latvia, Valmieras region, Burtnieku district, Nature preserve „Vidusburtnieks”,(57°46’ N 25°14’E). On trunk

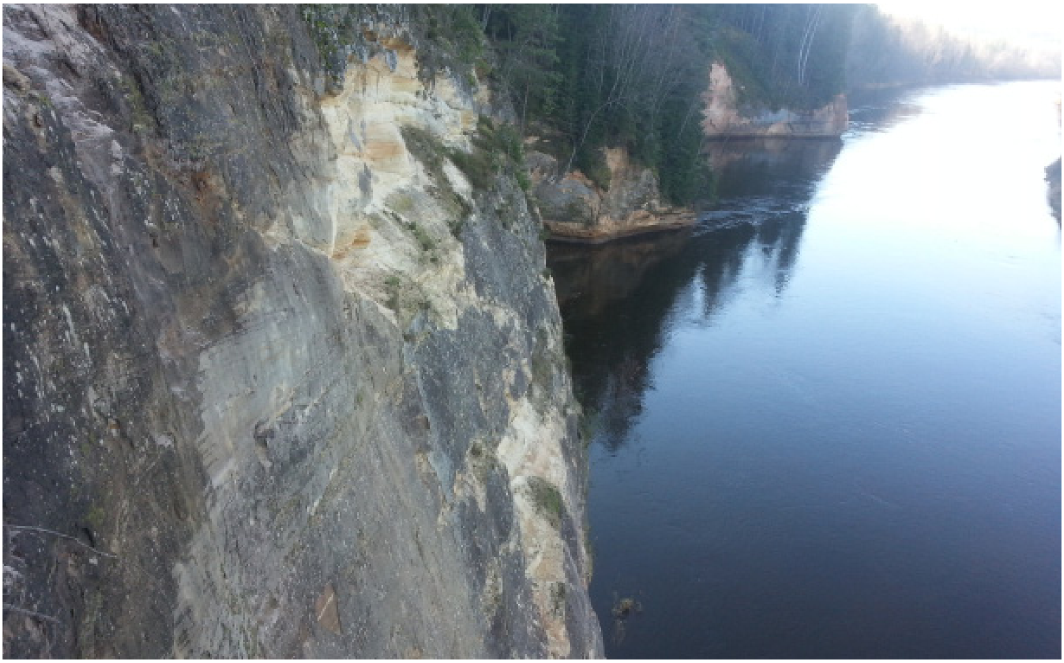

Fig. 3. Habitat of *Pilophorus cereolus.*

Fig. 4. *Microcalicium ahlneri.*

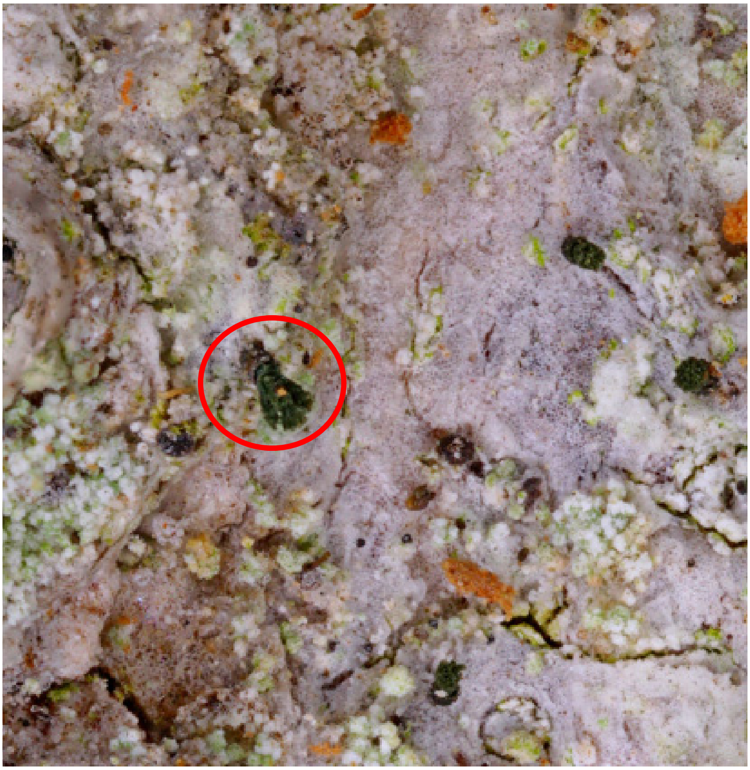

Fig 5. *Microcalicium disseminatum.*

of *Quecus robur*. Old shaded woodland with high humidity. May 16, 2015. (DAU Nr. 143002001)

***Pilophorus cereolus* (Ach.) Hellb.**

Morphology: Crustose, thallus minutely granular, containing soredia and cephalodia. Cephalodia with *Nostoc.* Pseudopodetia 3-5,7 mm high, containing black pycnidia at apices. K+ yellow.

Species distribution and ecology: Reported from Scandinavia, Estonia and Central Europe, Greenland, W and E coast of North America. Grows on siliceous stones and rocks in very shaded, moist places. (Ahti & Stenroos 2013). *P. cereolus* is rare in Baltic region and was found only in Estonia previously (Randlane et al. 2008). In Estonia species is red-listed.

Material examined: Latvia, Cēsu region, Priekuļu district, Gauja National Park, Ērģeļu (Ērgļu) Klintis, (57°21'N 25°15'E). On sandstone outcrops, about 2-3 m from the base (Fig 3).. April 17, 2015 (DAU 144001001)

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REFERENCES

Ahti T., Stenroos S. 2013. Piloporus. – In: Ahti T., Stenroos S., Moberg R. (eds) Nordic Lichen Flora. Vol.5. Nordic Lichen Society. Bohuslän ´5, Uddevalla. Pp. 87–89.

Anonymous. MK. Noteikumi Nr. 940. http://likumi.lv/doc.php?id=253746 [05.09.2015]

Czarnota P. & Kukwa, M. 2010. New and noteworthy lichenized and lichenicolous fungi to Latvia. *Botanica Lithuanica*, 16: 21–27.

Dabas aizsardzības pārvalde. 2015. http://daba.gov.lv/public/lat/iadt/vidzemes_pr_novados/ [09.09.2015]

Gilbert O. L., Jørgensen, P. M. (2009) Leptogium (Ach.) Gray. In: Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. & Wolseley, P. A. (eds). 2009. The lichens of Great Britain and Ireland. – London: British Lichen Society. Pp. 541–551.

Jørgensen P. M. 2007. Collemataceae. In: Nordic Lichen Flora Vol.3. Nordic Lichen Society. Bohuslän ´5, Uddevalla. Pp. 14–42.

Lārmanis V.(2013.) Meža biotopi. Grām.: Auniņš, A. (red.) Eiropas Savienības aizsargājamie biotopi Latvijā. Noteikšanas rokasgrāmata. 2. papildināts izdevums. Rīga, Latvijas Dabas fonds, Vides aizsardzības un reģionālās attīstības ministrija. Pp. 275–306.

Lõhmus P. 1998. List of Estonian calicioid lichens and fungi. *Folia Cryptog. Estonica,* 32: 43–46.

Mežaka A., Brūmelis G., Piterāns A., Printzen C. 2012. Distribution of *Lepraria* in relation to tree substratum and deciduous forest type (*Lepraria* in deciduous forests). – *Annales Botanici Fennici,* 49: 162–170.

Mežaka A., Strazdiņa L., Brūmelis G., Piterāns A. 2008. Epifītu flora un ekoloģija Dārznīcas pilskalnā. *Latvijas Veģetācija,* 16: 19–34.

Mežaka A., Strazdiņa L., Madžule L., Liepiņa L., Znotiņa V., Brūmelis G., Piterāns A. , Hultengren S. 2009. Bryophyte and lichen flora in relation to habitat characteristics in

Moricsala nature reserve, Latvia. *Latvijas Veģetācija,* 18: 65–88.

Motiejūnaitė J. 1999. Checklist of lichens and allied fungi of Lithuania. *Botanica Lithuanica,* 5(3): 251-269.

Motiejūnaitė J., Suija A., Lõhmus P., Kuznetsova E., Tõrra T., Prigodina-Lukošienė I., Piterāns A. 2006. New or noteworthy lichens, lichenicolous and allied fungi found during the 16th Symposium of Mycologists and Lichenologists in Latvia. *Botanica Lithuanica,* 12(2): 113–119.

Motiejūnaitė J. 2007. Lichenized, lichenicolous and allied fungi of Žemaitija National Park (Lithuania). *Herzogia*, 20: 179–188.

Motiejūnaitė J., Andersson L., 2003. Contribution to the Lithuanian flora of lichens and allied fungi [Papildomi duomenys apie Lietuvos kerpių ir su jomis susijusių grybų florą]. *Botanica Lithuanica,* 9(1): 71–88.

Motiejūnaitė J., Chesnokov S. V., Czarnota P., Gagarina L.V., Frolov I., Himelbrant D., Konoreva L. A., Kubiak D., Kukwa M., Moisejevs R., Stepanchikova I., Suija A., Tagirdzhanova G., Thell A., Tsurykau A. Ninety one species of lichens and allied fungi new for Latvia with a list of additional records from Kurzeme. (in prep.)

Motiejūnaitė J., Grochowski P. 2014. Miscellaneous new records of lichens and lichenicolous fungi. *Herzogia,* 27: 193–198.

Motiejūnaitė J., Piterāns A. 1998. Materials on lichens and allied fungi of Ķemeri National Park (Latvia). *Botanica Lithuanica,* 4: 187–196.

Motiejūnaitė J., Stončius D., Kukwa M., 2005. Contribution to the Lithuanian flora of lichens and allied fungi. II *Botanica Lithuanica*, 11(1): 41–49.

Motiejūnaitė J., Suija A., Lõhmus P., Kuznetsova E., Tõrra T., Prigodina-Lukošienė I., Piterāns A. 2006. New or noteworthy lichens, lichenicolous and allied fungi found during the 16th Symposium of Mycologists and Lichenologists in Latvia. *Botanica Lithuanica* 12(2): 113–119.

Nordin A., Moberg R., Tønsberg T., Vitikainen O., Dalsätt Å., Myrdal M., Snitting D., Ekman S. 2011. Santesson's Checklist of Fennoscandian Lichen-forming and Lichenicolous Fungi. Ver. April 29 2011. http://130.238.83.220/santesson/home.php [30.08.2015].

Piterāns A. 1981. Ķērpji un to aizsardzība. Latvijas PSR floras aizsardzības aktuālās problēmas. Rīga, 49. - 52.

Piterāns A. 1991. Slīteres rezervāta ķērpju flora [Lichens of the Slitere Nature Reserve]. *Jaunākais mežsaimniecībā,* 33: 27. - 32.

Piterāns A. 2001. Latvijas ķērpju konspekts. *Latvijas veģetācija,* 3: 5-46.

Piterāns A., Laime B., Žeiviniece A., Berga I. 2005. Lichens in Užava Nature Reserve. *Acta Biologica Universitatis Daugavpiliensis,* 5(2): 109–112.

Piterāns A., Žeiviniece A.,Berga I. 2006. LU Botānikas un ekoloģijas katedras ķērpju herbārijs. *Latvijas Universitātes raksti,* 693: 249–252.

Plociņa J. 2007. Monitoring of woodland meadow management using epiphytic lichens. – In: 4th International Conference "Research and conservation of biological diversity in Baltic region". Daugavpils, 25–27 April, 2007. Book of abstracts. Pp. 88. Daugavpils: Daugavpils University Academic Press "Saule".

Randlane T., Saag A. (eds) 1999. Second checklist of lichenized, lichenicolous and allied fungi of Estonia. *Folia Cryptog. Estonica,* 35: 1–132.

Randlane T., Saag A. 2000. Biogeographical survey of Estonian lichen flora, with reference to conservation strategies. *For. Snow Landsc. Res.,* 75 (3): 381–390.

Randlane T. Jüriado A. Suija P. Lõhmus, E. Leppik 2008. Lichens in the new Red List of Estonia. *Folia Cryptog. Estonica,* Fasc., 44: 113–120.

Rašomavičius V. (ed.). 2007. Lietuvos Raudonoji Knyga. Leidykla, Lutute. Pp. 19.

Rēriha I. (2013.) Iežu atsegumu biotopi. Grām.: Auniņš, A. (red.) Eiropas Savienības aizsargājamie biotopi Latvijā. Noteikšanas rokasgrāmata. 2. papildināts izdevums. Rīga, Latvijas Dabas fonds, Vides aizsardzības un reģionālās attīstības ministrija. Pp. 245.–254.

Tibell L. 1999. Caliciales. In: Nordic Lichen Flora Vol.1. Nordic Lichen Society. Bohuslän ´5, Uddevalla, 20–94 pp.Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. & Wolseley, P. A. (eds). 2009. The lichens of Great Britain and Ireland. – London: British Lichen Society.

Sundin R.,Thor G. 1990. Some lichens from Latvia. *Graphis Scripta,* 3: 20–23.

Turlājs, J. 2011. Latvijas ģeogrāfijas atlants. – Rīga: Karšu izdevniecība "Jāņa sēta".

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