Uholka primeval forest in the Ukrainian Carpathians – a keynote area for diversity of forest lichens in Europe

Jiří Malíček*, Zdeněk Palice, Andy Acton, Franz Berger, František Bouda, Neil Sanderson & Jan Vondrák

Abstract: Malíček, J., Palice, Z., Acton, A., Berger, F., Bouda, F., Sanderson, N. & Vondrák, J. 2018. Uholka primeval forest in the Ukrainian Carpathians – a keynote area for diversity of forest lichens in Europe. – Herzogia **31**: xxx–xxx.

One of the largest European primeval forests, Uholka-Shyrokyi Luh in the Ukrainian Carpathians, has received increased attention in recent years. In spring 2015 we explored the lichen biota in the southern part of the reserve. Species richness of epiphytic and epixylic lichens presented in this paper far exceeds all numbers achieved in other Central European old-growth forests. In total, 370 lichenized and lichen-allied fungi and 30 lichenicolous fungi were recorded. We focussed on forest lichens on organic substrata, inorganic substrata were largely ignored. Species composition in the Uholka forest includes many rare taxa and typical old-growth forest species: e.g. *Cetrelia* spp., *Gyalecta* spp., *Leptogium saturninum, Lobaria pulmonaria, Ricasolia amplissima, Sclerophora farinacea, S. pallida, Thelopsis flaveola* and *T. rubella*. *Opegrapha fumosa*, *Pyrenula chlorospila* and *P. dermatodes* represent oceanic species that are very rare outside Western Europe. *Biatora longispora, Calicium montanum, Menegazzia subsimilis, Micarea perparvula, Ochrolechia trochophora, Pyxine sorediata, Ramonia luteola* and *Thelotrema suecicum* are examples of phytogeographically remarkable or generally very rare lichens. Thirty lichenized and ten lichenicolous fungi are new to Ukraine, including *Biatora bacidioides* and *Pertusaria macounii* not previously reported from Europe.

Zusammenfassung: Malíček, J., Palice, Z., Acton, A., Berger, F., Bouda, F., Sanderson, N. & Vondrák, J. 2018. Der Urwald Uholka in den ukrainischen Karpaten – ein Hotspot für die Diversität von Waldflechten in Europa. – Herzogia **31**: xxx–xxx.

Im Frühling 2015 wurde die Flechtenflora in einem der größten europäischen Naturwälder, dem Uholka-Shyrokyi Luh in den ukrainischen Karpaten, untersucht, dem in den letzten Jahren erhöhte Aufmerksamkeit gewidmet wurde. Der dort angetroffene Artenreichtum der epiphytischen und epixylen Flechten übertrifft zahlenmäßig alle vergleichbaren zentraleuropäischen Naturwälder bei weitem. Insgesamt wurden 370 epiphytische Flechten und flechtenähnliche Pilze sowie 30 lichenicole Pilze festgestellt. Der Schwerpunkt lag in der Erfassung der Flechten auf organischen Substraten, andere Substrate wurden weitgehend vernachlässigt. Die Artenliste enthält zahlreiche sehr seltene Taxa und viele Altwaldzeiger, wie verschiedene *Cetrelia* und *Gyalecta* Arten, *Leptogium saturninum, Lobaria amplissima, L. pulmonaria, Sclerophora farinacea, S. pallida, Thelopsis flaveola* und *T. rubella*. *Opegrapha fumosa, Pyrenula chlorospila* und *P. dermatodes* sind ozeanische Arten, die außerhalb Westeuropa sehr selten vorkommen. *Biatora longispora, Calicium montanum, Menegazzia subsimilis, Micarea perparvula, Ochrolechia trochophora, Pyxine sorediata, Ramonia luteola* und *Thelotrema suecicum* sind Beispiele für phytogeografisch bemerkenswerte bzw. generell sehr selten gefundene Arten. 30 lichenisierte und 10 lichenicole Pilze sind neu für die Ukraine, *Biatora bacidioides* und *Pertusaria macounii* sind Erstnachweise für Europa.

Key words: *Biatora bacidioides*, biodiversity, Carpathian Biosphere Reserve, lichen inventory, lichenized and lichenicolous fungi, *Pertusaria macounii*, Uholka-Shyrokyi Luh, Ukraine.

* Corresponding author

Introduction

Biodiversity and its conservation is currently considered as a key issue in policy and management of all natural resources (Mace et al. 2012, Gao et al. 2014). The highest biodiversity among terrestrial biomes is associated with forests (Loo 2009). However, most woodlands in Europe today are planted monocultures, often planted non-native trees, with very low biodiversity. Primeval forests have become rare and are one of the most endangered habitats. Lichens are one of the most diverse groups of organisms in European forests.

Surprisingly little information is available on lichen diversity in Central European old-growth forests, although woodlands are one of the hot spots of these organisms. An overview of such studies has been published by Vondrák et al. (2015). Additional detailed inventories have recently been published (e.g. Malíček & Palice 2015, Vondrák et al. 2016, Groner 2016). We decided to explore the lichen biota in one of the largest European primeval forest Uholka-Shyrokyi Luh (c. 30 km NE of Khust) in the Ukrainian Carpathians. The locality had already been surveyed for lichen diversity by Dymytrova et al. (2013) who listed numerous old-growth forest lichens that indicated a potentially high diversity. In addition to obtaining interesting lichen-floristic data, we planned the field trip to test new methods for recording lichen diversity data in comparison with the approach employed in a previous study (Dymytrova et al. 2013); these results will be published in a separate paper.

Methods

Surveyed area

Uholka-Shyrokyi Luh (10383 ha) is a part of the Carpathian Biosphere Reserve, which was certified by UNESCO in 1992. In 2007, forests of Uholka-Shyrokyi Luh, together with nine smaller primeval forest remnants in Ukraine and Slovakia, were added to the World Heritage List under the name “Primeval Beech Forests of the Carpathians”. The protected area consists of two parts of similar size: the administrative unit of Uholka, adjacent to the villages Velyka Uholka and Mala Uholka, and the unit of Shyrokyi Luh.

The primeval forest in the Uholka has been protected since 1958 and currently covers 4729 ha. Its core zone, subject to natural processes without any intervention, occupies 3246 ha. The massif consists mainly of flysch formations of the Cretaceous and Paleogene periods, with overlaying Jurassic limestone, calcareous conglomerates, marls and sandstone. According to our observations, limestone outcrops are occasionally present at lower altitudes (up to about 900 m) and form up to 60 m high cliffs and contain numerous karst caves. Flysh forming the bedrock at upper altitudes does not form any distinct outcrops.

The mean annual temperature measured at the meteorological station in Uholka at 430 m altitude is 7.7 °C (averages for the years 1990–2010). The mean annual precipitation from 1980–2010 was 1134 mm, 50–60 % of which fell from May to October.

Commarmot et al. (2013) collated information about the woodland structure of the primeval beech forest of Uholka-Shyrokyi Luh. It is described as rather dense, with trees of various sizes and only small gaps in the canopy and a high amount of standing and lying deadwood (163 m^3/ha) of all decay classes. Most woodlands are more or less pure beech forests. They form a continuous belt from 400 m a.s.l. up to the upper timber line (1250–1350 m). However, the upper forest line is 100–200 m lower than it would be without the intense livestock pasturing practised for centuries on the mountain meadows. In Uholka, on average 12 trees per hectare with a DBH of 80 cm or more are present. The largest tree measured was an elm with a DBH of 150 cm; the largest *Fagus sylvatica* trees reached 140 cm in diameter. Beech in this area may reach an age of 450 to 500 years. The average number of dead standing trees is on average 30 per ha.

We surveyed a 2300 ha part of the protected forest area, on the southern slopes of Mt Menchul (Fig. 1) between 400–1300 m altitudes. The area is divided by numerous valleys with water-courses and ridges. The whole area is dominated by *Fagus sylvatica*. Additional tree species were almost exclusively associated with stream/river valleys, steep rocky slopes or limestone ridges. These included *Acer platanoides, A. pseudoplatanus, Carpinus betulus, Tilia platyphyllos* and *Ulmus glabra*. Marginal parts are not primeval forest as their structure has been influenced by stock grazing and logging in the past. Locally, some areas are still subject to stock grazing and woodland management today. Nevertheless, most of the locality and the core area is considered to be genuine primeval forest without significant human impact.

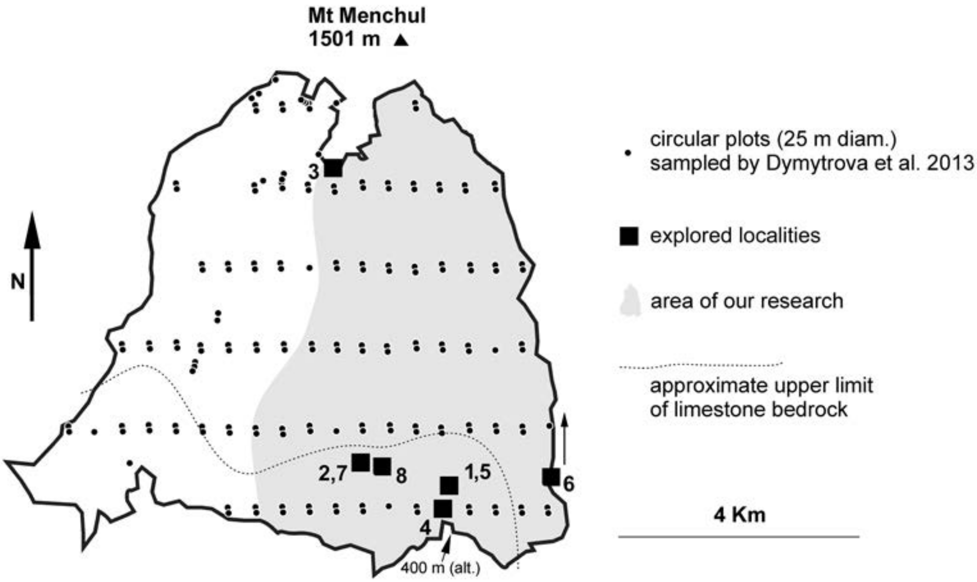

Fig. 1. Surveyed area and eight localities in the Uholka primeval beech forest.

Field work

Our field research in May 2015 lasted eight days; four days were devoted to an overall lichen diversity survey, another four days involved surveys in plots. Data for the overall survey were collected usually at well accessible places, such as river valleys and at the marginal zone of the reserve. The four 1 ha plots were selected subjectively at places with expected high lichen diversity, for example sites with old trees and natural canopy gaps, large amounts of dead wood, a high diversity of tree species and areas with accessibility of canopy lichens due to fresh wind throws. The work was performed by seven experienced lichenologists (the authors) as a competitive survey sensu Vondrák et al. (2016). We used 1 ha plots to facilitate comparison with other such plots that have previously been recorded thorough the Europe (mostly unpublished results by Malíček, Palice & Vondrák).

The main aim was to record the full spectrum of epiphytic and epixylic lichens, as well as facultatively lichenized and lichen-allied fungi. Namely, we recorded also species with an unclear degree of lichenization (*Lithothelium*, *Naetrocymbe*, *Ramonia*, *Thelocarpon*), calicioid fungi (*Chaenothecopsis*, *Microcalicium*, *Mycocalicium*, *Stenocybe*) as good indicators of forest continuity (e.g. SELVA 1994), and non-lichenized members of frequently lichenized genera (*Anisomeridium*, *Arthonia*, *Naetrocymbe*). We also collected some lichenicolous fungi, fungi similar to lichens and saxicolous lichens (the latter not included here). To increase the reliability and credibility of our diversity data, vouchers were collected for almost all species, and most species were repeatedly collected; vouchers are deposited in the herbarium PRA (Z. Palice and J. Vondrák), PRM (F. Bouda – FB) and in the personal herbaria of the other authors (Appendix 1).

List of localities

Valley of the Velyka Uholka River, c. 0.7 km NNE of last houses in the village, steep slopes on limestone bedrock with a mixed forest dominated by *Fagus sylvatica* and *Carpinus betulus*, other deciduous trees intermixed, 48°15'03"N, 23°41'47"E, alt. c. 500 m, 13.5.2015.

Mixed broad-leaved forest on a steep limestone rocky ridge c. 0.9 km WNW of Molochnyi kamin Cave, 48°15'22"N, 23°39'41"E, alt. 800 m, 16.5.2015.

Beech forest influenced by a summer grazing on a ridge 1.5 km SW of Mt Menchul (1501 m), 48°17'52"N 23°39'59"E, alt. 1200 m, 17.5.2015.

Beech forest with *Corylus avellana, Carpinus betulus* and several other trees in the valley of the Velyka Uholka River, c. 0.3 km NE from last houses in village, limestone bedrock, 48°14'43"N, 23°41'39"E, alt. 430 m, 19.5.2015.

Valley of the Velyka Uholka River, from the last houses in the village up to c. 2 km into the reserve, surrounding slopes and hills with dominated by beech forest, alt. 400–700 m, 12.5.2015.

Upper margin of the primeval beech forest from the point 48°15'22"N, 23°42'47"E up to the locality no. 3, alt. 800–1300 m, 12.5.2015.

Mixed broad-leaved forests on limestone ridges E of the locality no. 2, alt. 700–800 m, 15.5.2015.

Beech forest in the valley of the Kamenskyi strumok stream, 48°15'25–33", from 23°39'52"E to 23°40'11"E, alt. 700–750 m, 18.5.2015.

Species identification and molecular barcoding

We identified the collected material mostly by standard techniques (examination under the light microscope, spot/UV reactions) and thin-layer chromatography (TLC) using solvent systems A, B', C, following (ORANGE et al. 2010). Our appraisals of critical specimens/species and results of TLC analyses are described in Appendix 2. Specimens ambiguously identified by morphological and chemical characters or specimens that did not fit a description of any known species were sequenced for nrITS and/or mtSSU DNA loci. We employed the NCBI's BLAST website (JOHNSON et al. 2008; http://blast.ncbi.nlm.nih.gov/Blast.cgi) to confirm their identity or at least to place them into a genus. Species not certainly identified were excluded from the final list (apart from two taxa). We recorded at least ten species, for which no name was available and they may therefore represent undescribed species. They are excluded from this paper except for two distinctive taxa – *Bacidia albogranulosa* and *Japewia* sp.). Both of them have been briefly described and commented on in previous publications (VONDRÁK et al. 2015, VONDRÁK et al. 2016).

Fig. 2. Solitary *Fagus sylvatica* trees along the tree line (locality no. 6) harbour rich epiphytic communities, including many rare macrolichens. Photo by F. Berger.

Fig. 3. Old beech forest, influenced by grazing, in the marginal part of the Uholka forest (locality no. 3) – the richest site for epiphytes. Photo by J. Malíček.

Results

The list of recorded species comprises 418 taxa. They are represented by lichens (358 species), lichen-allied and non-lichenized calicioid fungi (12 species), lichenicolous fungi (30 species) and other non-lichenized fungi similar to lichens that are often studied by lichenologists (18 species). 331 species are reported from trees and shrubs, and 88 from wood. Epiphytic and epixylic lichens, including lichen-allied fungi, comprise 370 species. Thirty lichenized and ten lichenicolous species are new for Ukraine: *Agonimia flabelliformis*, *Alyxoria ochrocheila*, *Arthonia biatoricola*, *A. helvola*, *Bacidina etayana*, *Biatora bacidioides*, *B. longispora*, *B. mendax*, *B. pontica*, *Calicium montanum*, *Chalara lobariae*, *Dactylospora homoclinella*, *Gyalecta croatica*, *Gyalideopsis helvetica*, *Lecanora exspersa*, *Lecidella subviridis*, *Lithothelium hyalosporum*, *Menegazzia subsimilis*, *Merismatium heterophractum*, *Micarea anterior*, *M. deminuta*, *M. perparvula*, *M. soralifera*, *Normandina acroglypta*, *Opegrapha fumosa*, *O. thelotrematis*, *Pertusaria macounii*, *Phoma lobariae*, *Pseudosagedia byssophila*, *Psoroglaena stigonemoides*, *Pyrenula chlorospila*, *Rhymbocarpus neglectus*, *Rinodina malangica*, *Scoliciosporum schadeanum*, *Sphinctrina leucopoda*, *Taeniolella toruloides*, *Verrucaria hegetschweileri*, *Vezdaea retigera*, *Xenonectriella septemseptata* and *Xylographa trunciseda*. Three species (*Biatora radicicola*, *Lecanora stanislai*, *L. substerilis*) have been recently described and Ukrainian specimens were a part of the paratype material (Printzen et al. 2016, Guzow-Krzemińska et al. 2017, Malíček et al. 2017).

Comments on rare, poorly known and phytogeographically remarkable species

Bacidia albogranulosa ined.

This sterile sorediate species closely resembles several members of the genus *Lepraria* in its morphology and ecology. It produces atranorin and occurs on trees with higher bark pH (e.g. *Acer*). In the study area, we collected it on rough bark of an ancient *Fagus*. It seems to be widespread in Central European old-growth forests, especially at lower elevations, but there is only one published record (as "nomen ineditum") is from the Czech Republic (Vondrák et al. 2016). *Bacidia albogranulosa* is related to *B. rubella* according to nrITS and mtSSU data. It should be formally described in future years.

Vouchers: FB s.n. (PRM), JM 8166 (hb. Malíček), ZP 19366, 19392, JV 14081 (PRA).

Biatora bacidioides Printzen & Tønsberg

This lichen is characterized by greyish apothecia resembling *Biatora beckhausii* (absent in our material), containing bacidioid ascospores (16–47 × 2–4 µm), Sedifolia-grey pigment in the exciple and subhymenium, light yellowish green, punctiform to rarely coalescing soralia and argopsin and gyrophoric acid (soralia Pd+ orange/red, C+ red) as major secondary metabolites (Printzen & Tønsberg 2003). In the field, it may be easily misidentified for *B. chrysantha* or *B. efflorescens*, which occur in similar habitats; however, the content of both argopsin and gyrophoric acid preclude a misidentification. The same combination of metabolites is found in *B. fallax*, *B. kodiakensis* and *B. printzenii* (Printzen & Tønsberg 2003, Printzen et al. 2016), but those species differ morphologically (even when sterile) or by their distribution. *Biatora bacidioides* was up to now known only from *Picea orientalis* forests of north-eastern Turkey (Printzen & Tønsberg 2003). Our specimens were collected on bark as well as on bryophytes overgrowing bark of *Fagus* and *Carpinus*. Identification was confirmed by molecular nrITS and mtSSU data. New for Europe.

Vouchers: JM 8178 (hb. Malíček), ZP 19221, 19295, 19304, 19324, 19619, 19685 (PRA).

Biatora longispora (Degel.) Lendemer & Printzen

This species macroscopically resembles *B. helvola*, from which it differs in longer and narrower ascospores (12.5–26.0 × 3–5 µm) and in the absence of secondary metabolites. *Biatora longispora* displays a large discontinuous distributional range, but it is a rare species confined to humid woodland areas.

It has been reported from mountain ranges of the southeastern USA, the Caucasian region (north-eastern Turkey, Armenia, Adygea Republic), East Asia (Sakhalin, Korea) and W Europe (Pyrénées Atlantiques) (Printzen & Otte 2005, Gasparyan & Sipman 2016, Printzen et al. 2016). In the Uholka forest, it occurs on the trunks of young *Fagus* in river valleys.

Vouchers: JM 8178, 8293 (hb. Malíček), ZP 19307, 19308, 19626, JV 13957, 13958 (PRA).

***Japewia* sp.**

This brownish sorediate crust resembles *Placynthiella dasaea* and has previously been recorded as *Placynthiella* cf. *dasaea* (Vondrák et al. 2015). Apothecia are not known. An unknown fatty acid (A4, B'4-5, C4) was detected by TLC in samples JM8238 and ZP19774. According to molecular data, the species belongs to the genus *Japewia*. It can be very easily overlooked and based on our unpublished data it is probably a widespread corticolous lichen on acidic bark of broad-leaved trees at higher elevations. The new species should be formally described in future years.

Vouchers: JM 8238 (hb. Malíček), ZP 19774, JV 14134 (PRA).

Micarea perparvula (Nyl.) Coppins & Printzen

M. perparvula is a poorly known inconspicuous species. The thallus is inapparent, containing the Sedifolia-grey pigment; apothecia black, up to 0.2 mm in diam., with the Elachista-brown pigment (K-, C-); ascospores are simple or very rarely 1-septate. It occurs on a rotting wood and has been so far reported from USA and the type locality in France (Coppins 2008). In the Uholka, one specimen of this *Micarea* was collected on a lying trunk in a very wet river valley. The specimen was compared to a voucher from Italy (see below) identified by B. Coppins.

Voucher: ZP 19314 (PRA). **Additional record:** Italy: Calabria, Aspromonte National Park, Gambarie, along road at border of national park 4.5 km S of village, near a bridge, 38°07'15"N, 15°50'06"E, alt. 1400 m, on wood of *Pinus*, 2012, J. Malíček 6933, I. Frolov & J. Vondrák, det. B. J. Coppins (herb. JM).

Ochrolechia trochophora (Vain.) Oshio

This variable species is characterized by its usually pustulate thallus and often pustulate apothecial margin, algal layer confined mostly to the exciple and the presence of gyrophoric acid in the epihymenium, cortex and apothecial margin. In Europe, it is known from several collections before 1960 in Germany, Poland, Ukraine and Romania (Kukwa 2011). Our single specimen comes from the bark of a sun-exposed *Tilia platyphyllos* on the top of a limestone crest. It was accompanied by a similar taxon, *O. pallescens*.

Voucher: JM 8141 (hb. Malíček).

Opegrapha fumosa Coppins & P.James

The immersed thallus of the species is covered by punctiform to erose, fawn-coloured, C+ red soralia, containing finely granular soredia. *Opegrapha fumosa* is a rare lichen so far known from the British Isles and North America. In Western Europe, it occurs on oaks in ancient woodlands and parklands (Pentecost & James 2009) and long established oakwoods of plantation origin in western Scotland (Acton, personal observations). This very inconspicuous species was collected on *Fagus* at a very humid site in the valley of the Velyka Uholka River. The presence of gyrophoric acid was confirmed by TLC.

Voucher: ZP 19299 (PRA).

Pertusaria macounii (I.M.Lamb) Dibben

This species is very similar to *Pertusaria pertusa*, but its ascospores are grey and contain the *Sedifolia*-grey pigment in the endosperm and epispore (reacting K+ violet). Worldwide, it occurs in North America (Dibben 1980). The records from Asia require verification. The species was included in the key to *Pertusaria* in Thailand (Jariangprasert 2013) but it is absent from the recent checklist of this country (Buaruang et al. 2017). *Pertusaria macounii* is reported here for the first time from Europe. A single specimen was collected on *Carpinus* in the valley of the Velyka Uholka River. We also included here a voucher from *Fagus* in a very humid part of the Czech Republic.

At least in the European material, the amount of the *Sedifolia*-grey pigment in ascospores and the grey colour intensity are variable. Therefore we speculate that *P. macounii* may represent only an extreme morphotype of *P. pertusa*.

Voucher: JV 14091 (PRA). **Additional record:** Czech Republic: W Bohemia, Šumava Mts, Modrava, remnants of old-growth deciduous forest W of Rokytecká slať bog just along the borderline, c. 6.5 km W of Modrava, 49°01'07"N, 13°24'06.5"E, alt. 1085 m, on bark of old *Fagus*, 2016, E. Loskotová, Z. Palice 11015 & O. Peksa, conf. H. T. Lumbsch (PRA).

***Pyrenula* spp.**

The valley of the Velyka Uholka River was a diversity hot-spot for *Pyrenula* species. Apart from the widely distributed *P. laevigata, P. nitida* and *P. niditella*, three rare oceanic/suboceanic species, *P. chlorospila, P. coryli* and *P. dermatodes* were recorded on trunks of *Carpinus betulus* and *Acer pseudoplatanus*. *Pyrenula coryli* has been reported several times from Central Europe as well as from the Carpathians (e.g. Vězda & Liška 1999, Bielczyk et al. 2004, Wirth et al. 2013), but currently, it is considered to be either a very rare taxon or extinct in most countries. *Pyrenula dermatodes* is known in Europe only from the British Isles (Orange 2013) and Ukraine (e.g. Oksner 1956). *P. chlorospila*, a Mediterranean-Atlantic species (Nimis 2016), distributed in Western and Southern Europe (see Orange 2013), is new for Central Europe as well as Ukraine.

Pyxine sorediata (Ach.) Mont.

This widespread, mainly subtropical macrolichen is very rare in Europe with few scattered, mainly historical localities, and with the northernmost record in the Bavarian-Bohemian forest (Nádvorník 1947, see the map in Masson 2008). Recently it was recorded only in the Pyrenees and the Caucasus (Masson 2008). In the Ukrainian Carpathians it was previously recorded three times between 1920 and 1940 (Lynge 1935, Nádvorník 1947).

Voucher: JV 13914 (PRA).

Lichen communities and keynote habitats for nature conservation

Many epiphytic lichens typical of old-growth forests that are generally considered to be rare in Central European countries are widespread through the Uholka reserve – e.g. *Cetrelia monachorum, C. olivetorum, Heterodermia speciosa, Lobaria pulmonaria, Menegazzia terebrata, Normandina pulchella, Sclerophora farinacea* and *Thelopsis rubella*. However, many species are restricted to more or less specific habitats, e.g. low, slowly dying beeches at the timber line, and are present only locally in the reserve. The most valuable lichen communities, i.e. with the highest diversity and abundance of rare species, are situated along the upper tree line, on limestone crests and steep rocky slopes and in humid stream/river valleys. Brief characteristics of these habitats are discussed below.

Mountain forests at the timber line

Beech forests along the tree line are probably the most important hot spot for lichen biodiversity. The communities are rich in macrolichens, including rare cyanolichens such as *Leptogium saturninum, Nephroma parile, N. resupinatum, Peltigera collina, Ricasolia amplissima*. These are most abundant along the upper edge of the forest (at elevations 1000–1300 m), on solitary beeches or groups of them. Such trees are usually old or even partly dead, frequently with rough bark covered by bryophytes. The bases of beeches exposed to a long-lasting snow cover are the habitat for a few mainly subalpine species, known for example from low shrubs in the Alps (e.g. Hinteregger 1994), such as *Caloplaca sorocarpa, Lecanora exspersa* and *Rinodina malangica*. *Catillaria erysiboides, Frutidella furfuracea, Lecanora subintricata, Micarea globulosella* and *Xylographa trunciseda*. These represent a small group of lichens characteristic of high montane coniferous forests; they usually occur on dead wood close to

Fig. 4. *Arthonia cinnabarina* was exclusively collected on *Carpinus betulus* bark at lower elevations. Photo by F. Bouda.

Fig. 5. *Gyalecta truncigena* occurred in the study area on various tree species. Photo by F. Bouda.

Fig. 6. *Nephroma parile* preferred mossy trunks of old beeches in the upper part of the reserve. Photo by F. Bouda.

Fig. 7. *Sclerophora farinacea* – this rare forest lichen is common in the reserve on old and especially dead beeches. Photo by F. Bouda.

the tree line. In several cases, we recorded some primarily saxicolous lichens (e.g. *Acarospora fuscata*, *Aspicilia caesiocinerea*, *L. polytropa*, *Lecidella carpathica*, *Porpidia macrocarpa*, *Protoparmeliopsis muralis*) at the bases of old or wind-exposed trees; these lichens also occupied siliceous stones at the timber line.

Lowland forests in stream/river valleys

In contrast to high elevations, trunks of trees at lower altitudes in the primeval forest are usually not so rich in the lichen species richness and abundance, despite the often greater diversity of tree species (not solely *Fagus*). However, well-lit substrata, such as twigs, branches and upper parts of trunks, can harbour very rich lichens communities, including rare macrolichens (e.g. *Hypotrachyna afrorevoluta*, *Parmotrema* spp.). The lower 2 m section of trunks are covered by a varied mosaic of crustose lichens with a high abundance of genera with trentepohlioid algae, such as *Arthonia*, *Graphis*, *Opegrapha* and *Pyrenula*. The typical lowland species, collected mainly on *Carpinus* and *Fagus*, are represented by *Arthonia atra*, *A. helvola*, *A. ruana*, *Coniocarpon cinnabarinum*, *Inoderma byssaceum* and *Pyrenula nitidella*. The rare lichens *Biatora bacidioides*, *B. longispora*, *B. vernalis*, *Coenogonium luteum*, *Lecanora cinereofusca*, *Megalaria laureri*, *Menegazzia subsimilis*, *Pyrenula laevigata*, *Opegrapha fumosa*, *Pyxine sorediata* and *Thelotrema suecicum* were recorded exclusively in deep stream/river valleys. Wet and shady valleys are important sites for some lignicolous microlichens, for example of the genus *Micarea*, among them several rare species – *M. anterior*, *M. cinerea*, *M. deminuta*, *M. nigella* and *M. perparvula*.

Limestone crests

A third diversity hotspot is situated on limestone crests. These geomorphologically diverse habitats are usually well-lit and with a diverse range of trees. *Quercus petraea* agg., *Tilia platyphyllos*, *Taxus baccata* and *Acer platanoides* are the best examples of phorophytes absent or extremely rare in other forest communities. *Caloplaca herbidella*, *Candelariella reflexa*, *Gyalecta croatica*, *Melaspilea proximella*, *Ochrolechia arborea*, *O. trochophora*, *Pannaria conoplea*, *Pertusaria flavida*, *Pseudosagedia byssophila* and *Verrucaria breussii* are examples of epiphytic lichens recorded exclusively in this forest type.

Discussion

Our lichen diversity survey vs. previous research in the locality

The lichen biota of the Uholka-Shyrokyi Luh was explored by Dymytrova et al. (2013). They used a grid mapping of 171 plots of 500 m^2 in the Uholka unit. They studied epiphytic and epixylic lichens and in each plot at least 5 trees were observed. In total, 161 lichens were recorded, including 6 new species for Ukraine (*Lecanora strobilina*, *Ramonia luteola*, *Rinodina capensis*, *Tetramelas chloroleucus*, *Usnea wasmuthii* and *Wadeana dendrographa*). Although our research did not cover the whole area, but only c. 2300 ha (of 4729 ha), we observed 370 epiphytic and epixylic lichens and lichen-allied fungi. However, we did not record 24 species reported by Dymytrova et al. (2013). Some of these species are undoubtedly rare in the area (e.g. *Buellia schaereri*, *Lecanora strobilina*, *Mycobilimbia carneoalbida*, *Peltigera degenii*, *Pertusaria pustulata*, *Rinodina conradii*, *Usnea ceratina*, *Wadeana dendrographa* and *Xanthomendoza ulophyllodes*), but several species might be incorrectly identified: *Arthonia vinosa* (possible misidentification for *A. didyma* or *A. spadicea*), *Calicium abietinum* (suspicious absence of much commoner *C. glaucellum* in the list), *Haematomma ochroleucum* (a suspected misidentification for *Lecanora thysanophora*, which is common in the area), *Lecanora allophana* (extreme morphotypes of *L. glabrata*), *L. impudens* (very likely represents another sorediate *Lecanora* – *L. exspersa* or *L. substerilis*), *Pyrrhospora quernea* (not expected in the area, likely misidentified for *Lecanora expallens* or *Lecidella subviridis*). Unfortunately, the vouchers are not available for a critical revision. Our species concept of two taxa is different to that reported in Dymytrova et al. (2013): *Lecanora subrugosa* Nyl.

is regarded as a synonym of *L. argentata* (Lumbsch & Feige 1996, Malíček 2014); a lichen identified as *Porina hibernica* from non-oceanic parts of Europe and also from Uholka belong to a separate species, *P. pseudohibernica* (Tretiach 2014). From the remaining species, we did not record *Candelaria concolor*, *Mycobilimbia pilularis*, *Naetrocymbe rhyponta* (as *Arthopyrenia rhyponta*), *Reichlingia leopoldii*, *Rinodina pyrina*, *Tetramelas insignis* (as *Buellia insignis*), *Thelocarpon laureri*, *Usnea dasopoga* and *U. wasmuthii*.

Comparison of Uholka to other Central European old-growth forests

When combined all records of epiphytic and epixylic lichenized and lichen-allied fungi recorded by us and by Dymytrova et al. (2013) in the Uholka forest, i.e. the area of 4729 ha, the total number is 394, including doubtful taxa (as described above). This number exceeds any other diversity data from Central European old-growth and primeval forests (see Table 1). One of the most famous European forests, Białowieża in Poland, is not included in the table because we were unable to get any comparable data from the area of the national park (10500 ha). Cieśliński & Tobolewski (1988) reported altogether 210 species from this area and 345 species from the whole Polish part of Białowieża, including terricolous and saxicolous lichens. Several additional studies with records from the park as well as surrounding forests have been published later (e.g. Czyżewska et al. 2001, Sparrius 2003, Kukwa et al. 2008, *Łubek & Jaroszewicz* 2012), but unfortunately, it was very difficult or impossible to fix their geographical position (in or outside the park as well as the substrate). The total number of lichens known from the national park reaches possibly about 300 species and most of them occur on trees and wood. A similar situation happened in the case of the recent study by Groner (2016). Groner explored the Bödmerenwald in Switzerland, including the adjacent Silberen area. The study comprises 336 epiphytic and epixylic lichens, but it is not possible to extract records only from the forest reserve.

Table 1. An overview of well studied primeval and old-growth forests in Central Europe (including Ukraine and Switzerland) and numbers of reported lichens.

Locality (country)	**Area (ha)**	**No. of epiphytic and epixylic lichens**	**All lichenized and lichen-allied fungi**	**References**
Uholka (UA)	4729	356	370	this paper
Žofínský prales (CZ)	102	220	226	Malíček & Palice (2013)
Rothwald (A)	500	209	213	Türk & Breuss (1994), Bilovitz (2007), Türk (2015)
Stužica (SK)	761	237	242	Vondrák et al. (2015), Pišút & Lackovičová (1992)
Merliwald (CH)	90	191	197	Dietrich (1991)
Stuzhytsa (UA)	2492	218	225	Kondratyuk et al. (1998), Kondratyuk & Coppins (2000), Motiejūnaitė et al. (1999)
Cahnov (UA)	13.5	189	202	Vondrák et al. (2016)

According to the Table 1, localities with the highest species richness usually harbour more than 200 epiphytic and epixylic lichens. However, the diversity is probably underestimated because it is extremely difficult to record the complete spectrum of species, especially in large areas (see for example Vondrák et al. 2016). Recent research considerably increased the known species richness in forest areas precisely surveyed in the past. Numerous additional records were received from the Žofínský prales in the Czech Republic in 2016 (Malíček, Palice & Vondrák, unpublished results) and from the Austrian Rothwald in 2015 and 2016 (Türk, Berger, Breuss & Malíček, unpublished data).

Substrate preferences

Numbers of recorded lichens on particular substrata (see Table 2) correspond more to the general abundance of single trees in the area then to any substrate preferences. According to Hobi et al. (2015), *Fagus sylvatica* is overwhelmingly dominant in this reserve, forming almost pure stands with less than 3 % of other deciduous species, such as *Acer pseudoplatanus*, *A. platanoides*, *Carpinus betulus*, *Fraxinus excelsior* and *Ulmus glabra*. Although, the lichen species richness on admixtured trees is quite high, especially for *Carpinus* and *Tilia*. Nevertheless, a high lichen diversity has been reported repeatedly on *Fagus sylvatica* from Central European forests (Dymytrova et al. 2014, Malíček & Palice 2015, Vondrák et al. 2015, Hofmeister et al. 2016).

Table 2. Number of lichenized and lichen-allied species recorded from the commonest substrata in the Uholka area, extracted from the table in Appendix 1.

Substrate preferences of epiphytic and epixylic species			
Acer platanoides 55	*Acer pseudoplatanus* 107	*Carpinus betulus* 136	*Fraxinus excelsior* 82
Fagus sylvatica 295	*Tilia* sp. 116	*Ulmus glabra* 35	dead wood 88

Acknowledgements

Alexander Y. Khodosovtsev helped with comments on species new to Ukraine. Thorsten H. Lumbsch confirmed our identification of *Pertusaria macounii* and Helmut Mayrhofer kindly identified several *Rinodina* specimens. Both reviewers helped to improve the manuscript. This work was financially supported by Ministry of Culture of the Czech Republic (DKRVO 2017/09, National Museum, 00023272) and by a long-term research development grant RVO 67985939. The Administration of the Carpathian Biosphere Reserve (Rakhiv, Ukraine) granted permission for our research.

References

Bilovitz, P. O. 2007. Zur Flechtendiversität des „Mariazellerlandes“ und ausgewählter Standorte im Bereich Naßköhr-Hinteralm (Nordalpen, Steiermark). – Mitteilungen des Naturwissenschaftlichen Vereines für Steiermark **136**: 61–112.

Buaruang, K., Boonpragob, K., Mongkolsuk, P., Sangvichien, E., Vongshewarat, K., Polyiam, W., Rangsiruji, A., Saipunkaew, W., Naksuwankul, K., Kalb, J., Parnmen, S., Kraichak, E., Phraphuchamnong, P., Meesim, S., Luangsuphabool, T., Nirongbut, P., Poengsungnoen, V., Duangphui, N., Sodamuk, M., Phokaeo, S., Molsil, M., Aptroot, A., Kalb, K., Lücking, R. & Lumbsch, H. T. 2017: A new checklist of lichenized fungi occurring in Thailand. – MycoKeys **23**: 1–91.

Commarmot, B., Brändli, U.-B., Hamor, F. & Lavnyy, V. 2013. Inventory of the largest primeval beech forest in Europe – a Swiss-Ukrainian scientific adventure. – Birmensdorf, Switzerland: WSL Swiss Federal Research Institute.

Cieśliński, S. & Tobolewski, Z. 1988. Porosty (Lichenes) Puszczy Białowieskiej i jej zachodniego przedpola [Lichens (Lichenes) of the Bialowieza Forest and its western foreland]. – Phytocenosis 1 (N. S.), Suppl. Cartographiae Geobotanicae **1**: 1–116.

Czyżewska, K., Motiejūnaitė, J. & Cieśliński, S. 2001. Species of lichenized and allied fungi new to Białowieża Large Forest (NE Poland). – Acta Mycologica **36**: 13 –19.

Dibben, M. J. 1980. The chemosystematics of the lichen genus *Pertusaria* in North America north of Mexico. – Milwaukee Public Museum Publications in Biology and Geology **5**: 1–162.

Dietrich, M. 1991. Die Flechtenflora des Merliwaldes, Giswil/OW (Zentralschweiz). – Botanica Helvetica **101**: 167–182.

Dymytrova, L., Nadyeina, O., Naumovych, A., Keller, C. & Scheidegger, C. 2013. Primeval beech forests of Ukrainian Carpathians are sanctuaries for rare and endangered epiphytic lichens. – Herzogia **26**: 73 – 89.

Dymytrova, L., Nadyeina, O., Hobi, M. L. & Scheidegger, C. 2014. Topographic and forest-stand variables determining epiphytic lichen diversity in the primeval beech forest in the Ukrainian Carpathians. – Biodiversity and Conservation **23**: 1367–1394.

Gao, T., Hedblom, M., Emilsson, T. & Nielse, A. B. 2014. The role of forest stand structure as biodiversity indicator. – Forest Ecology and Management **330**: 82–93.

Gasparyan, A. & Sipman, H. J. M. (2016): The epiphytic lichenized fungi in Armenia: diversity and conservation. – Phytotaxa **281**: 1– 68.

Groner, U. 2016. Lichens and associated non-lichenized fungi of the Bödmerenwald-Silberen region, Muota Valley, Canton of Schwyz (Switzerland). – Cryptogamica Helvetica **22**: 1–156.

Guzow-Krzemińska, B., Łubek, A., Malíček, J., Tønsberg, T., Oset, M. & Kukwa, M. 2017. *Lecanora stanislai,* a new, sterile, usnic acid containing lichen species from Eurasia and North America. – Phytotaxa **329**: 201–211.

Hinteregger, E. 1994. Krustenflechten auf den *Rhododendron*-Arten (*Rh. ferrugineum* und *Rh. hirsutum*) der Ostalpen unter besonderer Berücksichtigung einiger Arten der Gattung *Biatora*. – Bibliotheca Lichenologica **55**: 1–346.

Hobi, M. L., Commarmot, B. & Bugmann, H. 2015. Pattern and process in the largest primeval beech forest of Europe (Ukrainian Carpathians). – Journal of Vegetation Science **26**: 323 –336.

Hofmeister, J., Hošek, J., Malíček, J., Palice, Z., Syrovátková, L., Steinová, J. & Černajová, I. 2016. Large beech (*Fagus sylvatica*) trees as 'lifeboats' for lichen diversity in central European forests. – Biodiversity and Conservation **25**: 1073 –1090.

Jariangprasert, S. 2013. New taxa and a key to *Pertusaria* species (Pertusariaceae, lichenised Ascomycota) in Thailand. – Maejo International Journal of Science and Technology **7**: 364 –376.

Johnson, M., Zaretskaya, I., Raytselis, Y., Merezhuk, Y., McGinnis, S. & Madden, T. L. 2008. NCBI BLAST: a better web interface. – Nucleic Acids Research **36**: W5 –9.

Kondratyuk, S. Y. & Coppins, B. J. 2000. Basement for the lichen monitoring in Uzhansky national nature park, Ukrainian part of the Biosphere reserve "Eastern Carpathians". – Roczniki Bieszczadzkie **8**: 149 –191.

Kondratyuk, S. Y., Coppins, B. J., Zelenko, S. D., Khodosovtsev, A. Y., Coppins, A. M. & Wolseley, P. A. 1998. Lobarion lichens as indicators of primeval forests in the Ukrainian part of the International Biosphere Reserve "Eastern Carpathians": distribution, ecology, long-term monitoring and recommendations for conservation. – Roczniki Bieszczadzkie **6**: 65 – 87.

Kukwa, M. 2011. The lichen genus *Ochrolechia* in Europe. – Gdańsk: Fundacja Rozwoju Uniwersytetu Gdańskiego.

Kukwa, M., Schiefelbein, U., Czarnota, P., Halda, J., Kubiak, D., Palice, Z. & Naczk, A. 2008. Notes on some noteworthy lichens and allied fungi found in the Białowieża Primeval Forest in Poland. – Bryonora **41**: 1–11.

Lõhmus, P., Leppik, E., Motiejunaite, J., Suija, A., Lõhmus, A. 2012. Old selectively cut forests can host rich lichen communities – lessons from an exhaustive field survey. – Nova Hedwigia **95**: 493 –515.

Loo, J. A. 2009. The role of forests in the preservation of biodiversity. – In: Owens, J. N. & Lund, H. G. (eds). Forests and forest plants. Vol. 3. – UNESCO and EOLSS Publishers Co Ltd.

Łubek, A. & Jaroszewicz, B. 2012. New, rare and noteworthy species of lichens and lichenicolous fungi from Białowieża Forest. – Polish Journal of Natural Sciences **27**: 275 –287.

Lumbsch, H. T. & Feige, G. B. 1996. Comments on the exsiccat "Lecanoroid Lichens" III. – Mycotaxon **58**: 259 –267.

Lynge, B. 1935. Physciaceae. – In: Dr. L. Rabenhorsts Kryptogamen-Flora von Deutschland, Österreich und der Schweiz, Band IX, Abteilung 6, Lieferung 1: 37–188 + 12 Tafeln. – Leipzig: Akademische Verlagsgesellschaft.

Mace, G. M., Norris, K. & Fitter, A. H. 2012. Biodiversity and ecosystem services: a multilayered relationship. – Trends in Ecology and Evolution **27**: 19 –26.

Malíček, J. 2014. A revision of the epiphytic species of the *Lecanora subfusca* group (Lecanoraceae, Ascomycota) in the Czech Republic. – Lichenologist **46**: 489 –513.

Malíček, J., Berger, F., Palice, Z. & Vondrák, J. 2017. Corticolous sorediate *Lecanora* species (Lecanoraceae, Ascomycota) containing atranorin in Europe. – Lichenologist **49:** 431– 455.

Malíček, J. & Palice, Z. 2013. Lichens of the virgin forest reserve Žofínský prales (Czech Republic) and surrounding woodlands. – Herzogia **26**: 253 –292.

Malíček, J. & Palice, Z. 2015. Epifytické lišejníky Jilmové skály na Šumavě [Epiphytic lichens of the locality Jilmová skála in the Šumava Mts]. – Bryonora **56**: 56 –71.

Masson, D. 2008. Découverte de cinq espèces rares de macrolichens dans les Pyrénées occidentales françaises: une présence relictuelle? – Cryptogamie, Mycologie **29**: 35 – 61.

Motiejūnaitė, J., Zalewska, A., Kukwa, M. & Fałtynowicz, W. 1999. New for Ukraine or interesting lichens and allied fungi from the Regional Landscape Park "Stuzhytzia". – Ukrainian Botanical Journal **56**: 596 – 600.

Nádvorník, J. 1947. Physciaceae Tschécoslovaques. – Studia Botanica Čechoslovaca **8**: 69 –124.

Nimis, P. L. 2016. The lichens of Italy. A second annotated catalogue. – Trieste: EUT – Edizioni Università di Trieste.
Orange, A. 2013. British and other pyrenocarpous lichens. – Wales: Department of Biodiversity and Systematic Biology, National Museum of Wales.
Orange, A., James, P. W. & White, F. J. 2010. Microchemical methods for the identification of lichens. – London: The British Lichen Society.
Oksner, A. M. 1956. Flora of the lichens of Ukraine. – Kiev: Academy of Sciences of the Ukrainian SSR. [in Ukrainian]
Pentecost, A. & James, P. 2009. *Opegrapha* Ach. (1809). – In: Smith, C. W., Aptroot, A., Coppins, B. J., Fletcher, A., Gilbert, O. L., James, P. W. & Wolseley, P. A. (eds). The Lichens of Great Britain and Ireland. Pp. 631–647. – London: The British Lichen Society.
Pišút, I. & Lackovičová, A. 1992. Flechten der Staatlichen Natur-Reservation Stužica (Gebirge Bukovské vrchy, Ostslowakei). – Biológia, Bratislava **47**: 549–559.
Printzen, C., Halda, J. P., McCarthy, J. W., Palice, Z., Rodriguez-Flakus, P., Thor, G., Tønsberg, T. & Vondrák, J. 2016. Five new species of *Biatora* from four continents. – Herzogia **29**: 566–585.
Printzen, C. & Otte, V. 2005. *Biatora longispora*, new to Europe, and a revised key to European and Macaronesian *Biatora* species. – Graphis Scripta **17**: 56–61.
Printzen, C. & Tønsberg, T. 2003. Four new species and three new apothecial pigments of *Biatora*. – Bibliotheca Lichenologica **86**: 133–145.
Selva, S. B. 1994. Lichen diversity and stand continuity in northern hardwoods and spruce-fir forests of northern New England and western New Brunswick. – Bryologist **97**: 424–429.
Sparrius, L. B. 2003. Contribution to the lichen floras of the Białowieża Forest and the Biebrza Valley (Eastern Poland). – Herzogia **16**: 155–160.
Tretiach, M. 2014. *Porina pseudohibernica* sp. nov., an isidiate, epiphytic lichen from central and south-eastern Europe. – Lichenologist **46**: 617–625.
Türk, R. 2015. Flechten im Wildnisgebiet Dürrenstein. – Silva Fera **4**: 26–40.
Türk, R. & Breuss, O. 1994. Flechten aus Niederösterreich I. Steirisch-niederösterreichische Kalkalpen. – Verhandlungen der Zoologisch-Botanischen Gesellschaft in Österreich **131**: 79–96.
Vondrák, J., Malíček, J., Palice, Z., Coppins B. J., 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**: 619–626.
Vondrák, J., Malíček, J., Šoun, J. & Pouska, V. 2015. Epiphytic lichens of Stužica (E Slovakia) in the context of Central European old-growth forests. – Herzogia **28**: 104–126.

Manuscript accepted: 15 January 2018.

Communicated by: Helmut Mayrhofer

Addresses of the authors

Jiří Malíček, Institute of Botany, Academy of Sciences of the Czech Republic, Zámek 1, 252 43 Průhonice, Czech Republic. E-mail: jmalicek@seznam.cz

Zdeněk Palice, Institute of Botany, Academy of Sciences of the Czech Republic, Zámek 1, 252 43 Průhonice, Czech Republic & Charles University in Prague, Faculty of Sciences, Department of Botany, Benátská 2, 128 01 Praha 2, Czech Republic.

Andy Acton, Dailnamac, Taynuilt, Argyll, PA35 1HZ, Scotland, United Kingdom.

Franz Berger, Kopfing 130, 4794, Austria.

František Bouda, National Museum, Department of Mycology, Cirkusová 1740, Horní Počernice, 193 00 Praha 20, Czech Republic.

Neil Sanderson, 3 Green Close, Woodlands, Southampton, SO40 7HU, United Kingdom.

Jan Vondrák, Institute of Botany, Academy of Sciences of the Czech Republic, Zámek 1, 252 43 Průhonice, Czech Republic & Department of Botany, Faculty of Science, University of South Bohemia, Branišovská 31, 370 05, České Budějovice, Czech Republic

Appendix 1. List of recorded species at eight sites in the Uholka forest in 2015, including literary records by Dymytrova et al. (2013). Substrate abbreviations: Apl – *Acer platanoides*, AP – *Acer pseudoplatanus*, CA – *Corylus avellana*, CB – *Carpinus betulus*, FE – *Fraxinus excelsior*, FS – *Fagus sylvatica*, QU – *Quercus*, SA – *Sorbus aucuparia*, SN – *Sambucus nigra*, TIL – *Tilia* and UG – *Ulmus glabra*. Vouchers are indicated by initials of the authors and amounts of specimens collected by each researcher. Species marked by an asterisk (*) are new to Ukraine. Herbaria vouchers with the asterisk indicate confirmation by TLC analysis. The nomenclature follows Hafellner & Türk (2016) and Wirth et al. (2013) in case of taxa missing in the former studies. Species absent from both publications are provided by author initials. Frequencies of species published by Dymytrova et al. (2013) are divided into three categories: + – rare (present on < 3 % of studied plot), ++ – scattered (3–15 %) and +++ – common (> 15 %).

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Absconditella lignicola	1	1	1	1	1				FS, log, snag	FrB2, JM, JV3, ZP3	
Acarospora fuscata						1			FS (trunk bases)	JV	
Acrocordia gemmata	1	1		1	1		1	1	Apl, AP, CB, FE, FS, QU, TIL	FB, JM, JV3, NS3, ZP8	+++
Agonimia allobata	1	1		1	1		1		Apl, FE, log, snag	AA, JM, JV4, NS, ZP3	+
Agonimia borysthenica Dymytrova, Breuss & S.Y.Kondr.	1			1					FS	ZP2	
**Agonimia flabelliformis*	1				1				log	ZP	
Agonimia opuntiella				1					log	AA	
Agonimia repleta		1	1	1	1				Apl, FE, FS	AA, JV3, ZP2	+
Agonimia tristicula	1	1	1	1			1		Apl, AP, FE, FS, QU, TIL, UG, snag (often on mosses)	FrB, JM2, JV3, ZP4	+
**Alyxoria ochrocheila*			1		1				FS, CB (wood in hollow)	JM, ZP	
Alyxoria varia	1	1	1	1	1				AP, CB, FE, FS, UG, snag (FS)	FB, JV2, NS, ZP8	++
Amandinea punctata	1	1	1		1				Apl, AP, CB, FS, TIL, UG, snag	JV, NS2, ZP	++
Anaptychia ciliaris		1	1			1			Apl, FS, TIL (also twigs)		++
Anisomeridium biforme	1			1	1				CB, FE, FS, UG	FB, NS, ZP	++
Anisomeridium macrocarpum		1		1					AP, FE, FS, TIL (trunk bases)	AA, FrB, JV3, ZP	
Anisomeridium polypori	1	1		1	1				AP, Apl, CA, CB, FE, FS, TIL, UG, snag (FS)	FrB2, JV4, NS5, ZP8	
Arthonia atra				1					CB, FS	ZP2	
Arthonia didyma	1	1	1	1	1		1		Apl, AP, CB, FS, TIL	AA, FB, JM, JV5, NS2, ZP5	+
**Arthonia helvola*	1			1					CB, FS	AA2, FB, FrB, ZP	
Arthonia mediella		1	1			1			CB, FS	JM, JV2, ZP4	
Arthonia punctiformis	1								CA	AA	
Arthonia radiata	1	1	1	1	1	1			Apl, CA, CB, FS, TIL, UG	JM, JV3, NS2, ZP	++

species	1	2	3	4	5	6	7	8	substrate	vouchers	Dymytrova et al. (2013)
Arthonia ruana	1			1	1				AP, CA, CB, FE, FS, TIL, UG	FB, JM2, JV6, NS2, ZP2	++
Arthonia spadicea	1	1		1	1				CA, CB, FE, FS, TIL	JV, NS, ZP4	
Arthonia vinosa											++
Arthothellium spectabile	1	1		1	1				CB, FS	FB, FrB, JM2, JV3, NS2, ZP5	
Arthrorhaphis grisea				1					FS (root, associated with *Baeomyces rufus*)	ZP	
Aspicilia caesiocinerea			1			1			FS (trunk bases)	JV, ZP	
Bacidia albogranulosa ined.	1			1					FS	FrB*, JM*, JV, ZP2*	
Bacidia arceutina					1				FS	FB	
Bacidia circumspecta	1	1	1	1		1		1	FS, TIL	AA, FB2, JM2, JV4, NS, ZP7	
Bacidia fraxinea				1					FS, UG	JM	
Bacidia incompta				1	1	1			FS	JV3	
Bacidia laurocerasi					1				CB	ZP	
Bacidia pycnidiata Czarnota & Coppins					1				log	FrB	
Bacidia rosella	1	1			1				Apl, AP, CB, FS, TIL	JV	+
Bacidia rubella	1	1	1	1			1		Apl, AP, CB, FE, FS, QU, TIL, UG	ZP	++
Bacidia subincompta	1	1	1	1	1				Apl, AP, CB, FE, FS, TIL, UG	AA, FrB, JM, JV2, NS2, ZP2	
Bacidia vermifera			1	1		1			FS	JM2, JV2, ZP	
Bacidina delicata			1						FS	JV	
**Bacidina etayana*	1								wood of snag	FrB	
Bacidina mendax Czarnota & Guz.-Krzem.	1				1				FS	JM	
Bacidina phacodes		1	1		1		1		FS (sometimes in hollows), polypore	FB, FrB, JM2, JV3, ZP2	+
Bacidina sulphurella	1	1	1	1	1				CA, CB, FS, TIL, UG, log	AA, FrB, JV2, ZP2	
Baeomyces rufus			1	1					CB (roots), FS (roots)	JM, ZP	
Biatora albohyalina			1						FS	ZP	
**Biatora bacidioides* Printzen & Tønsberg	1			1	1				CB, FS (also bryophytes)	JM, ZP6*	
Biatora beckhausii			1		1				CB, FS	ZP2	
Biatora chrysantha			1		1	1			FS (also bryophytes)	JM, JV5*, ZP4*	
Biatora efflorescens		1	1		1	1			CB, FS	AA, FrB, JM2, JV2, ZP2*	+
Biatora globulosa		1	1		1		1		AP, Apl, FS, TIL, UG, QU	AA, JM, JV2, ZP2, NS	
**Biatora longispora* (Degel.) Lendemer & Printzen	1			1	1				FS	AA, JM2, JV2, ZP3	

species	1	2	3	4	5	6	7	8	substrate	vouchers	**Dymytrova et al. (2013)**
***Biatora mendax**	1			1	1		1		CB, FS, TIL	AA, FrB2, JM2, JV, NS2, ZP5	
Biatora ocelliformis	1		1	1	1				AP, CA, CB, FS	AA, FB, FrB2, JM, JV4, ZP5	
**Biatora pontica*	1	1		1	1			1	AP, CA, CB, FS, TIL, UG	FB, FrB, JM2, JV*, NS, ZP10*	
Biatora radicicola Printzen, Palice & J.P.Halda			1			1			FS (foot / roots)	FrB, JM, JV3, ZP2	
Biatora vernalis	1			1	1			1	CB, FE, FS, snag (mosses)	AA, FB3, FrB4, JM, JV3, NS2, ZP7	++
Biatoridium monasteriense	1	1	1		1		1		Apl, AP, FE, FS, SN, TIL, UG	FrB, JM2, JV4, NS, ZP	+
Bilimbia sabuletorum		1	1		1				Apl, FE, FS, QU (often mosses)	AA, JM, JV, NS, ZP2	+
Bryoria fuscescens			1			1			FS	JV	+
Bryostigma apateticum	1	1	1	1	1				AP, CA, CB, FS, SN	AA, FrB2, JM3, JV2, ZP3	
Buellia disciformis	1	1	1	1	1	1		1	CB, FS, TIL	FB, JM3, JV5, ZP5	++
Buellia erubescens			1						FS	JV	
Buellia griseovirens	1	1	1	1	1		1		AI, Apl, AP, CB, FE, FS, TIL (also twigs), snag	FB, JV, NS2, ZP	++
Buellia schaereri											+
Calicium abietinum											+
Calicium glaucellum		1					1		QU, snag	FrB, JM	
**Calicium montanum*							1		snag (QU)	JV, NS	
Calicium salicinum		1	1			1			FS, TIL, snag	NS2	
Calicium trabinellum							1		snag (QU)	FrB, JV	
Caloplaca cerina			1			1			FS		+
Caloplaca cf. *cerinelloides*	1	1							FE (twig)	AA	
Caloplaca herbidella		1					1		TIL	FB, JV2	
Caloplaca lucifuga							1		TIL	JV	
Caloplaca monacensis			1			1			FS	JM3, JV, ZP	
Caloplaca obscurella		1	1						AP, FS	AA, ZP2	
Caloplaca sorocarpa			1			1			FS (trunk bases)	AA, FrB2, JM, JV2, ZP2	
Caloplaca stillicidiorum		1	1				1		FS, TIL (mosses)	FrB	+
Caloplaca substerilis			1						FS	ZP	
Caloplaca turkuensis			1						FS (trunk bases)	JV, ZP2	
Candelaria concolor											+

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Candelariella efflorescens	1	1	1	1		1			Apl, AP, CB, FE, FS, snag	JM2, JV2	
Candelariella reflexa s.str.		1					1		FE, QU	FB, JM, JV	
Candelariella vitellina						1			FS (trunk bases)	JV	
Candelariella xanthostigma	1	1	1	1		1			AP, FE, FS, TIL, FS, snag	FrB, JV, ZP5	+++
Catillaria erysiboides			1						log	AA, FrB, JV, ZP	
Catillaria nigroclavata	1	1		1	1		1		AP, CB, FE, FS, TIL (twig)	FrB, JM, JV2, ZP	
Catinaria atropurpurea		1	1						FS, log, snag	AA, JV2, ZP2	
Cetrelia cetrarioides					1				AP, FS	JV2*, ZP*	++
Cetrelia chicitae		1	1		1				FS, TIL	JV2*, ZP*	
Cetrelia monachorum	1	1	1	1	1	1	1		CB, FE, FS, TIL, UG	FrB*, FB, JM4*, JV3*, ZP2*	
Cetrelia olivetorum	1	1	1	1	1				AP, FE, FS (branch)	FrB*, JM, ZP2*	+
Chaenotheca brachypoda	1		1	1	1				FS, UG, snag		
Chaenotheca furfuracea	1		1	1	1				CB, FS (hollows at base)		
Chaenotheca gracilenta	1			1	1				CB, FS, snag (often hollows at base)	JM, JV	
Chaenotheca trichialis	1		1		1				snag, CB		
Chaenotheca xyloxena			1						FS, snag	JM	
Chaenothecopsis debilis		1			1				FS, snag	JV, NS	
Chaenothecopsis pusilla	1	1		1					snag	AA, JM2, NS2	
Cheiromycina petri					1				CB	ZP	
Chromatochlamys muscorum			1			1			FS	JV, NS, ZP2	
Cladonia chlorophaea agg.	1	1	1			1			CB, FS, TIL, log		+
Cladonia coniocraea	1	1	1	1		1			Apl, CB, FS, log	JM	+++
Cladonia fimbriata	1	1	1	1	1				CB, FS, TIL, log, AP		++
Cladonia macilenta			1						FS		
Cladonia pyxidata			1			1			CB, FS	JM, JV	
Cladonia subulata			1			1			FS	JV*	
Cliostomum griffithii			1						FS	FrB*	
Coenogonium luteum	1			1					CB	NS	+
Coenogonium pineti	1	1	1	1	1				CB, FS, log, snag	NS, ZP3	++
Collema flaccidum		1	1	1	1	1	1		Apl, FE, FS, QU, TIL	AA, FB, JM2, JV2, ZP3	++
Collema nigrescens		1	1			1			TIL, FS	FB, JM	

species	1	2	3	4	5	6	7	8	substrate	vouchers	DYMYTROVA et al. (2013)
Coniocarpon cinnabarinum	1			1	1				CB	FB, JV, NS	
Cresporhaphis wienkampii	1								UG	JV2	
Cryptodiscus gloeocapsa				1					epiphytic mosses		
Dictyocatenulata alba	1		1	1					CB, FS (usually trunk bases)	FB, FrB, JM, ZP4, JV2	+
Diploschistes muscorum			1			1			FS (partly on *Cladonia* squamules)	JV	
Evernia divaricata						1			QU		
Evernia prunastri	1	1	1	1		1			CB, FS, TIL (often twigs)		+
Fellhanera bouteillei			1	1					FS, log		
Fellhanera gyrophorica				1					FS	JV	
Flavoparmelia caperata	1	1	1	1	1				CB, FE, FS, TIL (also twigs)	ZP, FrB	+
Frutidella furfuracea (Anzi) M.Westb. & M.Svenss.			1						FS	JM*, JV, ZP*	+
Fuscidea arboricola	1	1	1				1		FS, CB	JM*, JV*, NS, ZP	
Fuscidea cyathoides	1	1							Apl, FS	JV2, ZP	
Graphis scripta	1	1	1	1	1				AP, CA, CB, FE, FS, TIL, UG	AA, ZP9	+++
**Gyalecta croatica* Zahlbr.							1		TIL, FS	NS	
Gyalecta flotowii	1			1	1			1	AP, FS, UG	FB, FrB2, JM, JV2, NS, ZP4	+
Gyalecta herculina (Rehm) Baloch, Lumbsch & Wedin	1	1	1			1	1	1	Apl, AP, CB, FE, FS	AA, FB, FrB, JM, JV5, NS, ZP5	+++
Gyalecta truncigena	1	1			1		1		AP, Apl, FE, FS, TIL, UG	AA, FB2, JM3, JV4, NS, ZP7	+
Gyalecta ulmi							1		QU	JV	
**Gyalideopsis helvetica*			1						FS	ZP	
Haematomma ochroleucum											+
Halecania viridescens	1	1							FS, TIL (twigs)	JM, ZP	
Hazslinszkya gibberulosa	1	1	1		1		1		AP, FS, TIL	AA, JV3, NS, ZP	++
Heterodermia speciosa	1	1	1	1	1				FS, FE, FS, TIL (often twigs)	FrB, JM, JV, ZP	++
Hypocenomyce scalaris			1						FS		
Hypogymnia farinacea		1	1				1		FS, TIL		
Hypogymnia physodes	1	1	1	1	1				FS, TIL (also twigs)	ZP	+++
Hypogymnia tubulosa	1	1	1	1	1				FE, FS, TIL (often twigs)		++
Hypotrachyna afrorevoluta	1	1		1	1		1		CB, FS (also twigs)	FB, FrB, JM, JV2, ZP2*	
Hypotrachyna revoluta				1					CB (also twigs)	JV	+

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Imshaugia aleurites							1		snag (QU)	FrB, ZP	
Inoderma byssaceum (Weigel) Gray				1	1				CB, FS	FB, JV2, ZP2, NS	
Japewia sp.			1			1			FS	JM*, ZP*, JV3*	
Lathagrium auriforme		1					1		Apl, FE, FS, QU	FB, JM, JV2, ZP2	
Lecania croatica	1	1	1	1	1				AP, CA, CB, FE, FS, UG, *Lonicera*	AA, FB, FrB, JM3, ZP	
Lecania cyrtella			1						FS (dry bark of lying trunk), snag	FrB, ZP	
Lecania cyrtellina	1		1				1		FS	FB, JM2	
Lecania naegelii					1				FS (twig)	FB	
Lecanora albella				1		1			CB, FS	JV	
Lecanora albellula			1						FS (foot), log, snag	AA, ZP	
Lecanora allophana											++
Lecanora cf. *anopta*			1						log	ZP2*	
Lecanora argentata	1	1	1	1	1		1		Apl, AP, CB, FE, FS	FrB, JV2, NS4, ZP4	+++
Lecanora carpinea s.str.		1	1		1				FE, FS, TIL, CB	JM, JV, NS	++
Lecanora chlarotera		1	1				1		FS, TIL	JM, JV	++
Lecanora cinereofusca	1			1	1				CB, FS, AP	FB, FrB, JM2, NS, ZP2*	
Lecanora ecorticata J.R. Laundon s.l.	1			1					AP, FS	JM2*, ZP*	
Lecanora expallens	1	1	1	1			1		CB, FS	JV	
**Lecanora exspersa*			1			1			FS	JM*, JV2*, ZP2*	
Lecanora glabrata	1	1	1	1	1	1	1		Apl, CB, FS, TIL	JM3*, JV3, NS, ZP5	+++
Lecanora impudens											+
Lecanora intricata						1			FS (bark at base & exposed wood)	JV	
Lecanora intumescens		1	1			1	1		CB, FS, TIL	AA, JM, JV3, NS, ZP3*	+
Lecanora leptyrodes		1	1	1	1	1			AI, CB, FE, FS, snag	AA, FB, JM3, JV2, ZP5	+
Lecanora phaeostigma			1						FS, snag	JV, ZP, FrB	
Lecanora polytropa		1	1			1			FS, TIL (trunk bases)	JM*, JV2, NS, ZP3*	++
Lecanora pulicaris	1	1	1	1	1				AI, CB, FE, FS, TIL, (often twigs)	FB, JV3, NS, ZP3	++
Lecanora saligna		1	1			1			FS, snag, log	JM, JV2, ZP3*	
Lecanora stanislai Guzow-Krzem., Łubek, Malíček & Kukwa	1								FS	JM*	
Lecanora strobilina											+

species	1	2	3	4	5	6	7	8	substrate	vouchers	Dymytrova et al. (2013)
Lecanora subintricata			1						snag	JV*, NS	
Lecanora substerilis Malíček & Vondrák	1	1		1	1		1		AP, CB, FS	FrB2, JM4*, JV2*, ZP2*	
Lecanora symmicta	1			1	1				CB, FS (often twigs)	AA, JM, JV, ZP	+
Lecanora thysanophora	1	1	1	1	1				AP, CB, FS, UG	JM2*, JV*, ZP3*	
Lecanora varia		1	1			1			FS, TIL (also twigs)	JV	
Lecidea erythrophaea	1		1	1	1				AP, CB, FS	FrB, JV, NS, ZP6	
Lecidea turgidula			1						FS (wood in hollow trunk), snag	FrB, ZP2	
Lecidella carpathica			1			1			FS (trunk bases)	JV, ZP	
Lecidella elaeochroma (incl. *L. achristotera*)	1	1	1	1	1	1	1		AI, Apl, CB, FE, FS, TIL	FB, FrB2, JV4, NS, ZP4	+++
Lecidella flavosorediata	1	1	1	1			1		AP, FE, FS, TIL (also twigs)	JM2*, JV, ZP*	
**Lecidella subviridis* s.l.	1	1		1			1		FS	JM3*, JV3*, ZP3*	
Lepra albescens	1	1	1	1	1				Apl, CB, FE, FS, TIL	JV5	++
Lepra amara	1	1	1	1	1		1		AP, Apl, CB, FE, FS, TIL (also twigs)	ZP*, JV2	++
Lepraria eburnea		1							TIL	ZP*	
Lepraria elobata			1						FS	JM2*, JV*	
Lepraria finkii	1	1	1	1	1	1			Apl, AP, CA, CB, FE, FS, QU, TIL, UG, snag	JV6*, NS2, ZP5*	++
Lepraria incana	1	1	1						FS, snag		
Lepraria membranacea						1			FS		
Lepraria rigidula	1	1	1	1	1				CB, FE, FS, UG, log	JM3*, JV4, ZP*	
Lepraria vouauxii	1	1	1	1	1		1		Apl, CB, FE, FS, QU, TIL, UG	FrB2, JM, JV2*, ZP4*	
Leproplaca chrysodeta	1	1		1	1				CB, FE, FS, snag	JV, ZP	
Leptogium cyanescens		1		1	1				AP, FE, FS, TIL	AA, FrB, JM, ZP	
Leptogium saturninum		1	1		1	1	1		FE, FS, TIL	FB, JM2, JV, ZP	++
**Lithothelium hyalosporum*	1								AP, FS	JV, ZP	
Lobaria pulmonaria	1		1	1	1	1			AP, CB, FE, FS		+++
Lopadium disciforme	1	1	1		1				CB, FS	JV, ZP	+
Megalaria laureri	1			1	1				CB, FS	FB, FrB, JM, JV4, NS, ZP2	+
Melanelixia glabra		1	1				1		FE, FS, TIL	AA	++
Melanelixia glabratula	1	1	1	1	1				AP, Apl, CB, FS, TIL (often twigs), snag	FrB2, NS, ZP3	+++
Melanelixia subargentifera							1		TIL		+++

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Melanelixia subaurifera	1	1	1	1		1			Apl, FE, FS, TIL (also twigs)	JM	++
Melanohalea elegantula	1	1	1	1			1		CB, FE, FS, TIL	FrB, JV4, NS, ZP2	++
Melanohalea exasperata	1				1				FS (twigs)		
Melanohalea exasperatula	1	1	1		1				CB, FS (twigs)		+
Melaspileella proximella		1					1		AP, QU, TIL	AA, JM, JV4, ZP5	
**Menegazzia subsimilis*				1	1				CB, FS	JV2, ZP	
Menegazzia terebrata	1	1	1	1	1				AP, CB, FS, TIL (often in canopy)	JM, ZP2	+
**Micarea anterior*	1								log	ZP	
Micarea botryoides	1			1					snag	ZP2	
Micarea byssacea		1		1					log	AA2	
Micarea cinerea	1								log	ZP	
**Micarea deminuta*				1					log	FrB, ZP	
Micarea denigrata			1						log	JV	
Micarea globulosella			1						FS	AA, JM*, ZP	
Micarea lithinella				1					FS (root)	ZP	
Micarea melaena							1		snag (QU)	JV	
Micarea micrococca	1	1	1	1	1				AP, CB, FS, UG, log	AA, JM2*, JV2, ZP4	
Micarea misella	1		1	1	1				FS, log, snag	FrB, JV2, ZP5	
Micarea nigella	1								wood	AA, ZP	
Micarea peliocarpa			1						wood	AA	
**Micarea perparvula* (Nyl.) Coppins & Printzen	1								wood	ZP	
Micarea prasina	1	1	1	1			1		AP, FS, UG, log, snag	AA, ZP*	
**Micarea soralifera* Guzow-Krzem., Czarnota, Łubek & Kukwa				1	1				log	FrB*, ZP*	
Microcalicium arenarium				1					FS (root)	ZP	
Multiclavula mucida	1		1	1					log	NS2	+
Mycobilimbia carneoalbida											+
Mycobilimbia epixanthoides		1			1				FE, TIL (often bryophytes)	AA, JM2, ZP*, NS	+
Mycobilimbia pilularis											+
Mycobilimbia tetramera			1			1			FS (also bark mosses)	FrB, JV	
Mycocalicium subtile	1	1	1	1	1		1		snag	FrB2, JM2, JV2, NS3	

species	1	2	3	4	5	6	7	8	substrate	vouchers	Dymytrova et al. (2013)
Myriolecis sambuci			1			1			FS, snag	FrB, JM, JV, NS, ZP4	+
Naetrocymbe punctiformis		1	1			1			FS, TIL	JV4, ZP	+
Naetrocymbe rhyponta											+
Nephroma parile			1			1			FS	JM2	++
Nephroma resupinatum			1			1			FS	JV, FrB	+
Nephromopsis laureri			1			1			FS	JV2	
**Normandina acroglypta*		1		1	1				FS (mosses), TIL	JV, FrB, ZP*	
Normandina pulchella	1	1	1	1	1	1	1		CB, FE, FS, QU, TIL (also twigs)	ZP	
Ochrolechia alboflavescens			1						FS	AA, JM*	
Ochrolechia androgyna agg.	1	1	1	1			1		AP, FE, FS, TIL, snag	JM, JV4, ZP2*	+
Ochrolechia arborea		1			1		1		CB, FS, TIL	FrB, JM, ZP	
Ochrolechia microstictoides							1		snag	JV*	
Ochrolechia pallescens		1	1			1	1		Apl, CB, FS, TIL	JM, JV4	+
Ochrolechia szatalaensis		1	1						Apl, CB, FS	JV*, ZP2*	
Ochrolechia trochophora							1		TIL	JM*	
Ochrolechia turneri		1	1	1					Apl, FE, FS, TIL	FB, JM*, JV3*, NS	
**Opegrapha fumosa* Coppins & P.James	1								FS	ZP*	
Opegrapha niveoatra	1	1		1	1				Apl, FE, FS	FrB, JV	
Opegrapha trochodes	1	1		1	1				AP, CB, FE, FS, UG	AA, FrB2, JM, JV3, NS, ZP4	
Opegrapha vermicellifera	1	1		1	1				AP, CB, FE, FS, UG	JM, ZP	+
Pannaria conoplea		1							TIL	FB, JV	
Parmelia saxatilis (incl. *P. ernstiae, P. serrana*)	1	1	1	1	1				FE, FS, TIL (often twigs)	FrB3, ZP*	++
Parmelia submontana	1		1	1	1				FS (also twigs)	FrB, NS	++
Parmelia sulcata	1	1	1	1	1				CB, FE, FS, TIL (often twigs), snag	ZP2	+++
Parmeliella triptophylla		1	1	1	1		1		Apl, CB, FE, FS, QU, TIL	FB, JM2, JV, ZP5	+
Parmelina pastillifera	1	1	1	1		1			AP, CB, FE, FS, TIL (also twigs)	ZP	++
Parmelina tiliacea		1	1	1		1			Apl, CB, FS, TIL (also twigs)	ZP2	++
Parmeliopsis ambigua		1	1	1		1			AP, FS, TIL, snag		++
Parmeliopsis hyperopta			1			1			FS		+
Parmotrema arnoldii	1				1				FS	FrB, JM	
Parmoterma crinitum				1			1		CB, FS (also twigs), TIL	JV2	

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Parmotrema perlatum	1			1	1				CB, FS (also twigs)	FrB2, JV2, ZP*	
Peltigera collina			1		1	1			FS	JM, FB	+
Peltigera degenii											+
Peltigera praetextata	1	1	1	1	1	1			Apl, AP, FE, FS, QU, TIL (usually bases), CB	JV	++
Pertusaria coccodes		1	1				1		Apl, CB, FS, TIL	JM, JV, ZP	
Pertusaria constricta				1	1		1		CB, FE, FS	FrB, JV, ZP2	+
Pertusaria coronata		1	1			1	1		CB, FE, FS, TIL	FB, JV4, ZP2	+
Pertusaria flavida		1					1		FS, TIL	JM, JV	
Pertusaria leioplaca	1	1	1	1	1		1		Apl, CB, FS, TIL, CA	JM, JV4, NS, ZP4	++
**Pertusaria macounii* (I.M.Lamb) Dibben				1					CB	JV	
Pertusaria pertusa	1	1	1	1		1		1	AP, CB, FS	FS, JM2, JV3, NS, ZP3	++
Pertusaria pustulata											+
Pertusaria pupillaris	1	1		1	1				AP, CB, FS, UG	JM, ZP	
Pertusaria trachythallina	1			1	1				CB, FS	FrB*, JV2*	
Phaeophyscia chloantha		1	1		1				CB, FS	FB	
Phaeophyscia endophoenicea	1	1	1	1			1		Apl, AP, CB, FS, TIL (also twigs)	JV, ZP2	++
Phaeophyscia nigricans			1						FS		
Phaeophyscia orbicularis	1	1	1	1	1				Apl, AP, CA, FE, FS (twigs)	ZP	+
Phaeophyscia pusilloides					1				FS	FrB	
Phlyctis agelaea		1		1	1				Apl, CB, FS	FrB, JV, ZP2	
Phlyctis argena	1	1	1	1	1				AP, Apl, CA, CB, FE, FS, QU, TIL, UG	JV, NS, ZP3	+++
Physcia adscendens	1	1	1	1		1			AP, CB, FS (often twigs)	JV	+
Physcia aipolia		1	1		1				FE, FS (twigs)	JV	
Physcia dubia			1						FS		
Physcia stellaris		1		1	1				FS, TIL	JV	
Physcia tenella	1	1	1	1	1				CB, FS, TIL (often twigs)		
Physconia detersa			1						FS	FrB, ZP	++
Physconia distorta		1	1		1				FS, TIL		+
Physconia enteroxantha			1		1				FS		+
Physconia grisea		1							TIL		
Physconia perisidiosa		1	1			1			AP, FE, FS	JM, ZP	+

species	1	2	3	4	5	6	7	8	substrate	vouchers	DYMYTROVA et al. (2013)
Piccolia ochrophora	1	1	1	1	1		1		Apl, FE, FS, SN, UG, AP	FrB2, JM, JV	+
Placynthiella dasaea			1	1					log, snag	FrB*, ZP*	
Placynthiella icmalea	1	1	1			1			FS, log, snag	JV*, ZP2*	
Platismatia glauca	1	1	1	1		1			AP, TIL, FS (often twigs)		++
Pleurosticta acetabulum						1			FS		
Polycauliona polycarpa			1		1				FS		
Porina leptalea	1	1	1	1				1	AP, CA, CB, FS, TIL	FB, JM, JV4, NS, ZP11	+
Porina pseudohibernica Tretiach	1	1	1	1	1		1		AP, FS, QU, TIL, UG	AA3, JV2, ZP2, NS	+
Porpidia macrocarpa (incl. *P. nigrocruenta*)			1			1			FS	AA2, JV4, ZP	
Protoparmeliopsis muralis						1			FS (trunk bases)	JV	
Pseudevernia furfuracea	1	1	1	1	1				AP, FS, TIL (twigs)		+++
Pseudosagedia aenea	1	1	1	1	1				AP, CA, CB, FS, TIL	FrB, JV3, NS	++
**Pseudosagedia byssophila*							1		TIL	NS	
Pseudoschismatomma rufescens	1	1	1	1			1		Apl, AP, CA, CB, FE, FS, QU, TIL	JV4, NS, ZP	+
Psoroglaena abscondita	1	1	1						log	JV	
Psoroglaena dictyospora		1		1					snag, log	JV, ZP2	
**Psoroglaena stigonemoides*				1					FS	ZP	
Punctelia jeckeri	1			1	1				FS		
Punctelia subrudecta	1	1		1	1		1		FS, TIL (also twigs)	JV, ZP3	
Pycnora sorophora							1		snag (QU)		
**Pyrenula chlorospila* Arnold	1								AP	JM	
Pyrenula coryli	1			1					CB	JV2, NS	
Pyrenula dermatodes (Borrer) Schaer.	1			1					CB	JV2	
Pyrenula laevigata	1			1	1				CB, FE, FS	AA, FB2, JM2, JV3, ZP2	+
Pyrenula nitida	1	1	1	1	1		1		Apl, AP, CB, FS	ZP4	+++
Pyrenula nitidella	1				1				CB, FE	JV, NS	
Pyrrhospora quernea											+
Pyxine sorediata				1					CB (branch)	JV	
Ramalina farinacea	1	1	1	1	1				Apl, AP, CB, FS, TIL (also twigs)	ZP2	+++
Ramalina fastigiata		1	1			1			CB, FE, FS, TIL	JV, ZP	++
Ramalina fraxinea			1						FS		+

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Ramalina pollinaria agg.	1	1	1	1		1			Apl, CB, FE, FS, QU, TIL	ZP*	+++
Ramonia interjecta	1				1				SN	FrB, JV	
Ramonia luteola		1	1						Apl, FS	AA, JM, JV, ZP	+
Reichlingia leopoldii											+
Rhizocarpon polycarpum						1			FS (trunk bases)	JV	
Ricasolia amplissima			1			1			FS		+
Rinodina albana			1						FS	ZP3	
Rinodina capensis			1						FS, log	JM, JV, NS	+
Rinodina conradii											+
Rinodina efflorescens	1	1	1	1	1	1	1		AP, CB, FS	AA, JM3, JV4*, ZP6*	
Rinodina griseosoralifera			1	1		1			FS, snag	AA, JM2, JV*, ZP2	
**Rinodina malangica*			1						FS (foot)	JM, JV, ZP	
Rinodina orculata			1						FS (trunk bases)	JM, JV	
Rinodina pyrina											+
Rinodina sophodes	1	1				1	1		FS, TIL (twigs)	JV3	+
Rinodina subparieta (Nyl.) Zahlbr.	1	1	1		1		1		CB, FS (also twigs)	JV2, ZP3	
Rinodina trevisanii			1						FS	ZP	
Ropalospora viridis	1	1		1	1				AP, CB, FE, FS	FrB, JM*, JV*, ZP3*	+
Sclerophora farinacea	1		1	1	1				FE, FS, UG (often dead trees)	AA, FB, FrB2, JM2, JV7, NS, ZP4	
Sclerophora pallida	1	1		1			1		FS	JM2, NS	+
Scoliciosporum chlorococcum		1	1						FS, log, snag	JV	++
Scoliciosporum sarothamni	1	1	1	1		1			CB, FS, TIL (twigs)	JV, ZP	
**Scoliciosporum schadeanum*	1				1				AP, CB, FS (fallen branch)	ZP4	
Scoliciosporum umbrinum	1	1	1	1		1			AP, CB, FE, FS, TIL	AA, FB, FrB, JM, JV3, NS2, ZP6	++
Scytinium lichenoides				1	1				FS	ZP	+
Scytinium pulvinatum	1	1		1			1		Apl, AP, FE, FS, QU	JM2, JV, ZP2	
Scytinium teretiusculum	1	1	1	1	1		1		Apl, FE, FS, QU, log	AA, FB, JV5, ZP	
Steinia geophana	1	1	1	1	1				log, snag	JM, JV2, NS2, ZP5	
Stenocybe pullatula	1								FS (twig)	AA	+
Strangospora pinicola			1			1			FS (also exposed wood)	JV	
Strigula glabra	1	1							CB	FB, NS	

species	1	2	3	4	5	6	7	8	substrate	vouchers	Dymytrova et al. (2013)
Strigula stigmatella	1	1		1	1				CB, FE, FS, TIL (also exposed roots)	AA, FrB, JM, JV3, ZP3	+
Tephromela atra							1		TIL	JV	
Tetramelas chloroleucus			1						FS	JV2, ZP	+
Tetramelas insignis											+
Thelocarpon epibolum	1		1	1					log	JV2, NS2, ZP	
Thelocarpon laureri											+
Thelocarpon lichenicola		1		1					log	AA, JV, FrB	
Thelopsis flaveola	1	1							Apl, FS, TIL	JM2, ZP2	
Thelopsis rubella	1	1	1	1	1		1		AP, CB, FS, TIL	FB2, FrB, JM2, JV4, ZP6	++
Thelotrema lepadinum	1			1	1				CB, FE, FS, TIL, UG	FrB, JV, ZP3	++
Thelotrema suecicum	1			1	1				AP, CA, CB	FrB, JV2, ZP3	
Toensbergia leucococca			1						FS	FrB, JV, NS	
Trapelia corticola		1							log	JM	
Trapeliopsis flexuosa		1	1	1		1			FS, TIL, snag	JV2, ZP	+
Trapeliopsis granulosa			1						log		
Trapeliopsis pseudogranulosa			1						FS	AA	
Trapeliopsis viridescens		1							log	JV	
Tuckermannopsis chlorophylla			1			1			FS		+
Usnea barbata		1	1						AP, FS, TIL (often twigs)	JM, ZP	
Usnea ceratina											+
Usnea dasopoga											+
Usnea hirta			1						FS (also twigs)	JV	
Usnea perplexans			1						FS	JM	+
Usnea subfloridana			1			1			FS	JM*	+
Usnea wasmuthii											+
Varicellaria hemisphaerica	1	1	1				1		FS	FrB, ZP	
Verrucaria breussii		1							QU	ZP	
**Verrucaria hegetschweileri* (Nägeli) Nyl.			1						FS (trunk bases)	ZP, JV4	
Verrucaria viridigrana				1	1				log, FS (snag with bark)	FrB, ZP3	
**Vezdaea retigera*				1					wood of snag	ZP	
Violella fucata	1	1	1	1	1				CB, FS (also twigs)	JV	+

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Vulpicida pinastri			1			1			FS		++
Wadeana dendrographa (Nyl.) Coppins & P.James											+
Xanthomendoza fulva			1			1			FS, snag	JV2, NS, ZP	
Xanthomendoza ulophyllodes											+
Xanthoria parietina			1	1	1				FS (canopy)		+
**Xylographa trunciseda*			1						log	JM*	
Zwackhia viridis	1	1		1	1				Apl, AP, CB, FE, FS	AA, JM, JV4, NS2, ZP5	++
lichenicolous fungi											
Abrothallus bertianus De Not.	1		1	1					*Melanelixia glabratula*	FrB2, JV	
**Arthonia biatoricola* Ihlen & Owe-Larss.			1		1				FE, FS (on *Lecania croatica, Biatora chrysantha*)	ZP2	
Briancoppinsia cytospora (Vouaux) Diederich, Ertz, Lawrey & van den Boom	1		1						*Parmelia*	FrB2	
**Chalara lobariae* Etayo			1						*Lobaria pulmonaria*	FrB	
**Dactylospora homoclinella* (Nyl.) Hafellner			1						*Lecanora sp.*	FrB	
Dactylospora lobariella (Nyl.) Hafellner			1						*Lobaria pulmonaria*	FrB	
Dactylospora parasitica (Flörke) Arnold			1						*Pertusaria*	FrB	
Homostegia piggotii (Berk. & Broome) P.Karst.			1						*Parmelia saxatilis*	FrB	
Intralichen christiansenii (D.Hawksw.) D.Hawksw. & M.S.Cole			1						*Lecanora leptyrodes*	FrB	
Intralichen lichenum (Diederich) D.Hawksw. & M.S.Cole			1						*Lobaria pulmonaria*	FrB	
Lichenochora weillii (Werner) Hafellner & R.Sant.			1						*Physconia*	AA	
Lichenoconium erodens M.S.Christ. & D.Hawksw.			1						*Parmelia saxatilis*	FrB	
Lichenodiplis lecanorae (Vouaux) Dyko & D.Hawksw.			1						*Lecanora*	FrB	
Lichenostigma maureri Hafellner			1						*Parmelia saxatilis*	FrB	
**Merismatium heterophractum* (Nyl.) Vouaux				1					*Biatora* sp.	FrB	
**Opegrapha thelotrematis* Coppins				1					*Thelotrema lepadinum*	FrB	
Phaeopyxis punctum (A.Massal.) Rambold, Triebel & Coppins			1						*Cladonia* squamules	AA	
**Phoma lobariae* Diederich & Etayo			1						*Lobaria pulmonaria*	FrB	

species	1	2	3	4	5	6	7	8	substrate	vouchers	DYMYTROVA et al. (2013)
**Rhymbocarpus neglectus* (Vain.) Diederich & Etayo			1						*Lepraria*	FrB	
**Sphinctrina leucopoda* Nyl.				1					*Pertusaria pertusa*	JM	
Sphinctrina turbinata (Pers.) De Not.					1				*Pertusaria leioplaca*	FrB	
Stigmidium microspilum (Körb.) D.Hawksw.					1				*Graphis scripta*		
Taeniolella punctata M.S.Christ. & D.Hawksw.		1	1	1					*Graphis scripta*	NS	
**Taeniolella toruloides* Heuchert & Diederich				1	1				*Thelotrema lepadinum*	FrB2	
Tremella lichenicola Diederich	1			1					*Violella fucata*	FrB	
Tremella lobariacearum Diederich & M.S.Christ.			1		1				*Lobaria pulmonaria*	FrB	
Trichonectria anisospora (Lowen) van den Boom & Diederich	1								*Hypogymnia physodes*	FrB	
Unguiculariopsis acrocordiae (Lowen) van den Boom & Diederich		1		1			1		*Acrocordia gemmata*	FrB, JM2, ZP	
Vouauxiella lichenicola (Linds.) Petr. & Syd.	1		1						*Lecanora pulicaris*	FrB, ZP	
**Xenonectriella septemseptata* (Etayo) Etayo & van den Boom					1				*Melanelixia glabratula*	FrB	
other non-lichenized fungi											
Bertia moriformis (Tode) De Not.	1								log	ZP	
Capronia moravica (Petr.) E.Müll., Petrini, P.J.Fisher, Samuels & Rossman			1						log	AA	
Cryptocoryneum condensatum (Wallr.) E.W.Mason & S.Hughes	1								CA	ZP	
Cryptodiscus foveolaris (Rehm) Rehm		1	1	1					log, FS (wood in hollow trunk)	AA, FrB2, ZP2	
Cryptodiscus pallidus (Pers.) Corda			1						log	AA	
Cryptodiscus pini (Romell) Baloch, Gilenstam & Wedin					1				wood of QU snag	FrB	
Durella connivens (Fr.) Rehm	1								log	ZP	
Durella melanochlora (Sommerf.) Rehm			1						log	ZP	
Exarmidium inclusum (Pers.) Aptroot	1		1						log	AA, JM, ZP2	
Glonium lineare (Fr.) De Not.		1							log, snag	AA	
Hyalotrochophora lignatilis (Thaxt.) Finley & E.F.Morris				1					log	FrB	

species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**substrate**	**vouchers**	**Dymytrova et al. (2013)**
Kirschsteiniothelia aethiops (Sacc.) D.Hawksw.			1						FS	ZP	
Kirschsteiniothelia recessa (Cooke & Peck) D.Hawksw.			1						FS	JV	
Lophiostoma corticola (Fuckel) E.C.Y.Liew, Aptroot & K.D.Hyde					1				FS	ZP	
Mniaecia jungermanniae				1					log	NS, ZP, FrB	
Mycowinteria muriformis Aptroot					1				log	AA	
Perididiothelia fuliguncta	1	1			1				TIL	AA	
Stictis radiata (L.) Pers.	1			1	1				CA, FS, TIL, log	JM, JV2	

Appendix 2. Gen Bank accession numbers of newly produced sequences used for the molecular barcoding.

Species	Voucher	nrITS	mtSSU
Biatora bacidioides	ZP 19221	MG773663	MG773673
Biatora bacidioides	ZP 19685	MG773664	MG773674
Biatora bacidioides	JM 8178	–	MG773674
Biatora efflorescens	ZP 19334	MG773665	MG773676
Biatora longispora	ZP 19307	MG773667	MG773678
Biatora pontica	JM 8269	MG773666	MG773677
Bryostigma apateticum	JV 13925	MG773662	MG773672
Caloplaca monacensis	JM 8255	MG773668	MG773679
Caloplaca sorocarpa	JV 14274	MG773658	–
Caloplaca substerilis	ZP 19680	–	MG773691
Caloplaca turkuensis	JV 14380	MG773657	–
Japewia sp.	JM 8238	MG773669	MG773680
Lecanora cf. *anopta*	ZP 20047	–	MG773687
Lecanora exspersa	JM 8235	KY548036	KY502450
Lecanora exspersa	JV 14118	KY548058	–
Lecanora intumescens	JM 8203	KY548039	KY502443
Lecanora pulicaris	JV s.n.	–	KY502434
Lecanora stanislai	JM 8168	–	MG773681
Lecanora substerilis	JM 8111	–	KY502448
Lecanora substerilis	JM 8162	–	KY502447
Lecanora substerilis	JM 8209	KY548037	KY502449
Lecanora thysanophora	JM 8272	–	KY502442
Lecidella subviridis s.l.	ZP 19343	–	MG773682
Lecidella subviridis s.l.	ZP 19309	–	MG773683
Lecidella subviridis s.l.	JV 13940	–	MG773684
Lepra amara	ZP 19422	MG773671	–
Melaspileella proximella	JV 14226	MG773655	MG773692
Melaspileella proximella	JV 14359	MG773656	–
Mycobilimbia epixanthoides	JM 8199	MG773670	MG773685