Chapter 5
Lichen Biota of the Czech Republic

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Abstract A basic overview of the current state of knowledge on the lichen biota in the Czech Republic is provided. Lichens of particular interest, e.g. those described from this country, globally rare species and endangered bioindicators are dealt with in more detail. Important lichenological localities in this country are briefly mentioned. Biogeographical aspects of Czech lichen biota are discussed and examples of various biogeographical elements given. Changes in abundance, especially of epiphytic lichens, both on a long time scale and in recent years, are evaluated, especially in relation to the latest national Red List of lichens. The phenomenon of recent recolonization and gradual spread of nitrophilous and previously rare or new acidophilous lichens is outlined.

5.1 Introduction

The Czech Republic is a lichenologically rather well known area, although bryophytes and vascular plants are much better explored in this country. This is mainly because of the still unresolved taxonomy of many groups of lichens. In addition, many lichens are small, easily overlooked and impossible to identify in the field, and many new records result from accidental ex situ discoveries in herbarium collections.

In the latest Czech lichen checklist (Liška and Palice 2010) 1526 species are listed. The landlocked position of the Czech Republic, the absence of high mountains and the rarity of limestone outcrops at high altitudes preclude the occurrence of a potentially more diverse lichen biota. In spite of that the number of lichens is comparable to that recorded in Slovakia and Poland, both countries with recently updated checklists (Guttová et al. 2013; Fałtynowicz and Kossowska 2016). In Central Europe the richest lichen biotas by far are those of Austria (Hafellner and Türk 2016) and Germany (Wirth et al. 2013), where the number of species exceeds 2300 and 2100, respectively. This is apparently due to the significant number of species in the Alps and larger area of Germany.

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According to Liška and Palice (2010) a notable part (~37%) of the Czech lichen biota is threatened (IUCN Red List categories CR, EN and VU) and 9% of previously recorded species are now extinct (RE category). Not currently threatened lichens (NT and LC categories) comprise ~24% of the total. The very high percentage of species classified as DD (data deficient, ~22%) and taxonomically unresolved and dubious NE taxa (not evaluated, ~7%) clearly indicate that the knowledge of this country's lichen biota is still insufficient. In particular many crustose species are poorly known. Interestingly, more than 100 lichen taxa are recorded only from one locality in the Czech Republic, even when dubious taxa (NE) are excluded. Crustose microlichens constitute about three quarters of the total number of the lichens in this country, while only each fourth lichen taxon is a macrolichen. Making up almost half of the total number, saxicolous lichens are the largest ecological group and the majority of the questionable taxa (NE) come from rocky substrates. The percentage of epiphytes (including lignicoles) slightly exceeds one third of the lichens and approximately every sixth lichen may be ranked among terricolous or epibryophytic species.

5.2 Pecularities of the Czech Lichen Biota in the European Context

Diverse geology, geomorphology and preservation of endangered ecosystems make the Czech Republic suitable for various ecological groups of lichens. Some of them are narrow niche-specialists adapted to specific environmental and microclimatic conditions, and show specific substrate requirements (ultramafic rocks, lime-enriched silicate rocks in open high-mountain habitats), being in some cases vicariants of more widespread species (see e.g. Guttová et al. 2014). Although these rare lichens may be relatively distinct and easily identifiable, some of them seem to be very local, being recorded only a few times globally. Such rarities in the Czech lichen biota include *Diploschistella athalloides*, *Gyalecta sudetica*, *Harpidium rutilans*, *Porpidia nadvornikiana* (see Vězda and Liška 1999), *Psorotichia taurica* (Czeika et al. 2004) and *Solenopsora liparina* (Fig. 5.1e; Guttová et al. 2014).

A good example of a specialist lichen is the crustose *Porpidia nadvornikiana* (Fig. 5.1a) confined to serpentinite rocks (see Fig. 1.7 in Chap. 1, this book, for distribution of serpentinite). It is a globally rare species, recorded so far only in

Fig. 5.1 (continued) sandstone outcrops above the Křinice rivulet in the Bohemian Switzerland National Park; (**c**) *Lobaria amplissima*, a critically endangered species in the Czech Republic surviving on the last veteran trees in the humid forest area west of Modrava, Šumava Mts; (**d**) *Arctoparmelia centrifuga*, a glacial relict occurring on boulder fields on Mt. Luč in the Šumava Mts, which is probably the largest locality for this species in Central Europe outside the Alps; (**e**) *Solenopsora liparina*, a lichen confined to serpentinite outcrops with its northenmost known European locality near Raškov in northern Moravia; (**f**) *Lobaria pulmonaria*, a rapidly declining species of lichen typical of old-growth forests with the richest Czech population near Modrava in the Šumava Mts; (**g**) *Cladonia stellaris*, a rare boreal species in Central Europe occurring in relictual habitats; serpentinites near the Želivka water reservoir in central Bohemia. Photo credits: P. Uhlík (a, b, g), F. Bouda (c, d, f) and J. P. Halda (e)

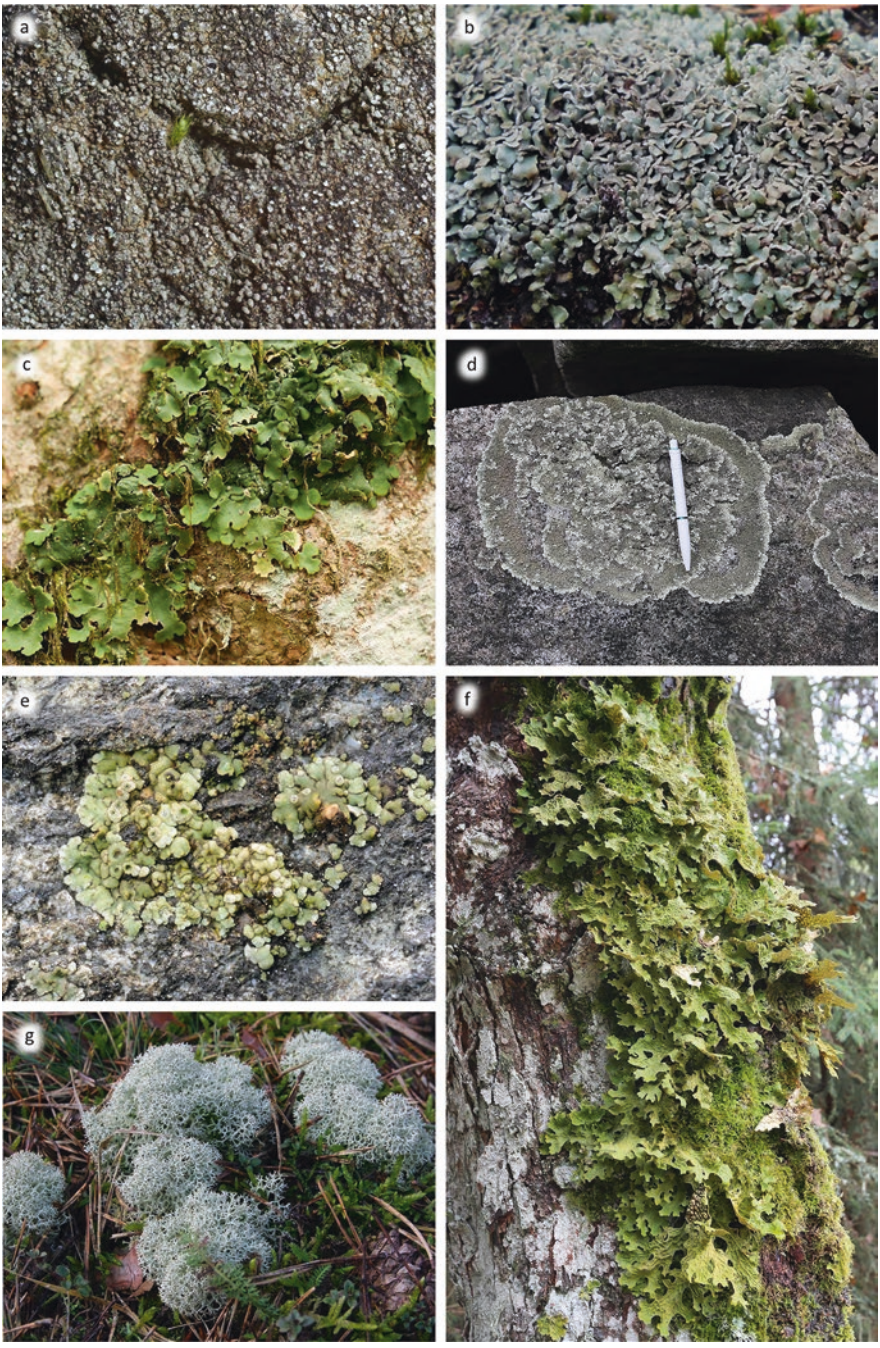

Fig. 5.1 Examples of rare lichens occurring in the Czech Republic (**a**) *Porpidia nadvornikiana*, a globally rare lichen confined to serpentinite outcrops, described from the Czech Republic and not known outside Europe; Dukovanský mlýn near Mohelno in south-western Moravia; (**b**) *Cladonia subcervicornis*, primarily a coastal lichen with only a few inland localities in Central Europe;

Europe and with most records from the Czech Republic, from where it was described by Vězda (1972). Another peculiarity is the rare *Cladonia krogiana* found on ultramafic outcrops (peridotite-gabbro) at the Ranský Babylon site (Žďárské vrchy Mts; Palice, unpubl.). This single species of *Cladonia* producing xanthones was described from Norway as growing on mossy rocks mainly near lakes (Løfall and Timdal 2002), while at the Czech locality it was collected in a relatively dry habitat, a low ultramafic boulder on a hill plateau. This dual ecology is not fully understood but may be attributable to specific properties of ultramafic rocks that sometimes support lichens otherwise known mainly as epiphytes in more humid woodland areas, e.g. *Normandina pulchella*, which is often associated with liverworts of the genus *Frullania*.

Worth mentioning are also dealpine occurrences of predominantly arctic-alpine crustose species like *Dimelaena oreina* and *Pleopsidium flavum* on outcrops of hard proterozoic silicite at low altitudes of the Bohemian Massif, including in the capital city of Prague.

Endemism is very rare among European lichens. Probably there is no lichen taxon endemic to the Czech Republic, although some species are documented only from their type localities in this country. These include, except several dubious taxa, *Aspicilia serpentinicola* from the Mohelno serpentinite steppe in south-western Moravia, *Polyblastia suzae* from serpentinites near the village of Raškov in northern Moravia (see Vězda and Liška 1999), the epiphytic *Lecanographa aggregata* collected by J. Suza in 1920 on road-side trees near the town of Blansko in central Moravia (Egea and Torrente 1994) or the recently described saxicole *Bacidina flavoleprosa* discovered near the town of Sedlčany in central Bohemia (Czarnota and Guzow-Krzemińska 2012). Further information may be found in the Czech Lichen Type Database (Liška 2016).

Rare epiphytic and epixylic lichens are mainly niche specialists in old-growth forests, which require long forest continuity and are susceptible to forest management. Their rarity may be also partly linked to the migration history of their preferred phorophyte, e.g. *Abies alba*, although recent finds also come from other trees. These include some species of *Biatora*, in Central Europe known only from a few woodland sites, such as the south-western Bohemian occurrences of *B. ligni-mollis* and *B. mendax* (Printzen and Palice 1999; Malíček and Palice 2013).

5.2.1 Biogeographical Patterns

The distribution of lichens depends on a complex set of evolutionary, historical, environmental and ecological factors. Since lichens produce small, easily spreading diaspores, many species have large distribution ranges, hence (sub)cosmopolitan distributions are not rare. Widespread, supposedly Holarctic species often have outlying localities also in high mountains in the tropics or in the Southern Hemisphere. Therefore, applying a strict phytogeographic framework does not appear to be fully appropriate in lichenology. Since many groups of lichens are undercollected, their

records may reflect intense research activity in particular regions, mainly in some parts of Europe and North America, although these species are actually more widespread.

Lichens with **boreal affinities** include mainly epiphytes typical of the boreal forest zone, which are recorded mainly in montane spruce forests or pine mire woodlands in the Czech Republic. Some of these lichens are rare, preferably occurring in old-growth forests (e.g. *Alectoria sarmentosa*, *Lecanactis abietina* and *Mycoblastus sanguinarius*) and some others are widespread across the country since they can grow in spruce plantations (e.g. *Chaenotheca ferruginea* and *Hypocenomyce scalaris*). Examples of relict boreal epiphytic species are *Melanohalea olivacea* and *M. septentrionalis*, recorded mainly on raised bogs in the Šumava Mts before World War II (see Vězda and Liška 1999). While these lichens are occasionally dominant on *Betula* trunks in Fennoscandia, declining relict populations in the Czech Republic were apparently unable to cope with the changing environment, especially with acidic pollution. Indicators of old-growth boreal forest in temperate mountain forests include *Chaenotheca sphaerocephala* and other rarities recorded only recently in the Šumava Mts, such as *Lecidea betulicola* (Palice 1999), *L. coriacea* (Holien et al. 2016) and *Myochroidea porphyrospoda* (Printzen et al. 2008). Also some terricolous boreal species are declining, for example the decorative *Cladonia stellaris* (Fig. 5.1g), no longer present at many of its former sites and currently known only from about two dozen dispersed localities in Bohemia (Fig. 5.2a). A majority of the Czech epiphytic lichens are **temperate broad-leaved forest species**, occurring mainly on the bark of the two dominant trees of these forests, oak (*Quercus* spp.) and beech (*Fagus sylvatica*). Although many generalist epiphytes occur on both oak and beech trees, different microclimates in warmer and drier oak-dominated forests and colder and wetter beech forests account for different assemblages of lichens at least in their understoreys, with the most characteristic lichen species being *Flavoparmelia caperata* in oak forests and *Pyrenula nitida* in beech forests. Notably old-growth forests dominated by beech have the highest diversity of epiphytic lichens (Hofmeister et al. 2016), with beech being the most preferred phorophyte. Forest continuity over several centuries and the range of microhabitats available in the best preserved fir-beech primeval forests account for the uniqueness and extraordinarily high diversity of epiphytic lichens in the Central European context. In these woodlands there are both lichens with oceanic and boreal affinities. Well-preserved old-growth forests in the Boubínský prales (Šumava Mts) and Žofínský prales (Novohradské hory Mts) National Nature Reserves harbour several sensitive macrolichens (e.g. *Lobaria pulmonaria* and *Menegazzia terebrata*) and also rare crustose specialists confined to specific niches such as exposed roots, weathered bark of old trees or decaying wood of standing trees. These crustose species are otherwise only exceptionally found in Central Europe (*Arthonia incarnata*, *Biatora ligni-mollis*, *Cliostomum leprosum* and *Pachyphiale carneola*; Svoboda 2009; Malíček and Palice 2013; Malíček et al. 2014). Unlike some mountain beech and spruce forests, oak forests have been subject to strong human interventions for millenia and subject to marked changes after the cessation of traditional management in the twentieth century. Numerous species of lichen characteristic of oak woodlands have recently

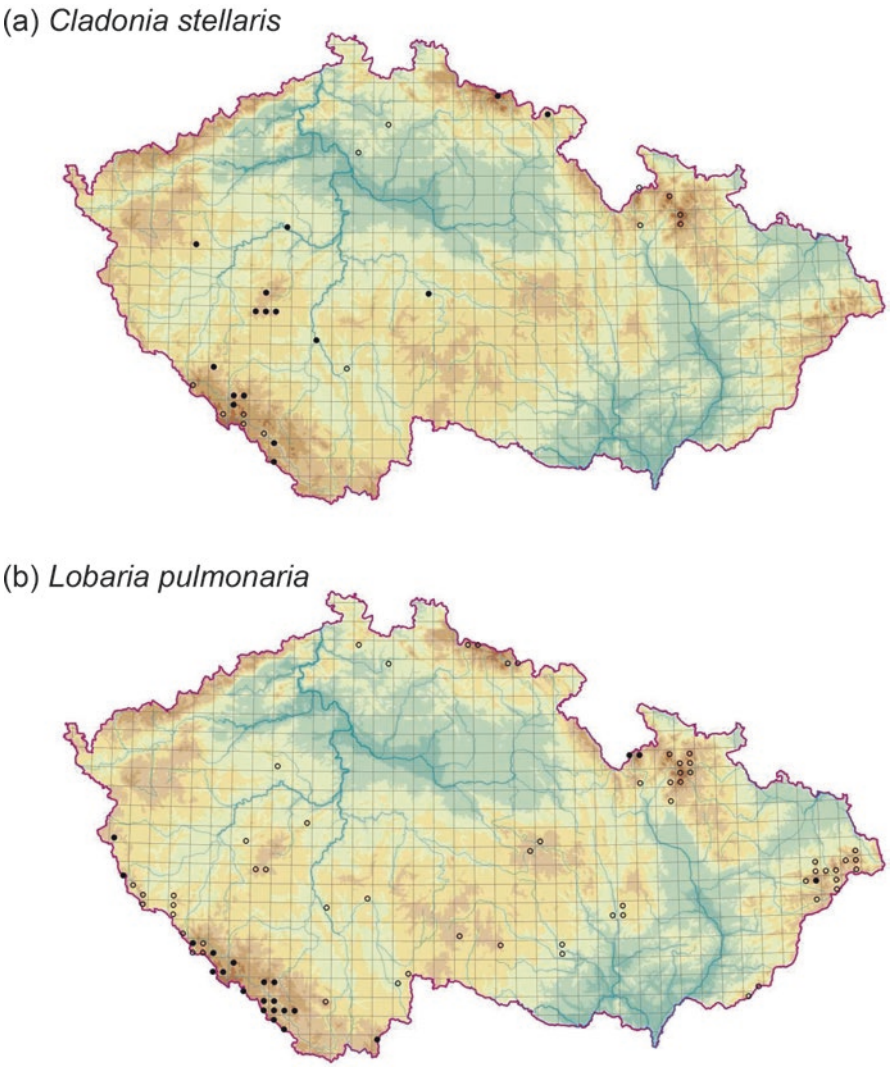

Fig. 5.2 Distribution of two rare macrolichen species in the Czech Republic: (**a**) *Cladonia stellaris* and (**b**) *Lobaria pulmonaria. Empty circles* refer to the records from the period 1900–1989 only, *full circles* to the records since 1990 (data were extracted from the NDOP database of the Nature Conservation Agency of the Czech Republic and reliable literature sources; the maps were prepared by O. Hájek)

declined in abundance or become extinct (Svoboda et al. 2011). The lichens favouring oaks are also disadvantaged by the low buffering capacity of their bark (Frahm et al. 2009). Despite this, less fragmented lowland floodplain forests (e.g. upstream of the confluence of the Dyje and Morava rivers in southern Moravia) and wooded middle and lower parts of the valleys in the southern part of the Bohemian Massif

(e.g. Vltava and Oslava rivers) harbour a surprisingly high diversity of crustose lichens. They have been underexplored for a long time and recent surveys yielded unexpected discoveries such as *Arthonia pruinata*, *Bactrospora dryina*, *Bacidia auerswaldii*, *Buellia violaceofusca* and *Dendrographa decolorans*, all species that were either considered extinct or were newly recorded for this country (Malíček et al. 2014; Šoun et al. 2015; Vondrák et al. 2016). Lichen biota in lowland forests suffers from overall eutrophication. What is more, several species are confined to the rough bark of old oak trees; some of them (e.g. *Calicium quercinum*, *Lecanographa amylacea* and *L. lyncea*) have not been observed for almost a century and are considered extinct in many Central European countries.

Lichens with oceanic affinities generally have large discontinuous distribution ranges and tend to occur patchily, being confined only to sites with relatively stable humidity and temperature; in addition, more southerly distributed taxa occur only at sites with mild winters. Permanent high humidity may locally compensate for an otherwise unsuitable macroclimate. Molecular markers helped to identify a sterile specimen of the predominantly coastal epiphytic species *Caloplaca ulcerosa* living on shaded limestone rocks in the foothills of the Šumava Mts (Vondrák et al. 2009b). *Pilophorus strumaticus*, an unmistakable macrolichen occurring on wet siliceous rocks, was traditionally considered a typical example of an oceanic Northern European endemic (Dahl 1998). However, it was unexpectedly discovered on hardly accessible rock-walls in the Labský důl valley in the Krkonoše Mts (Halda et al. 2011). For both species these are the only Central European and at the same time most continental records. Similarly, glacial cirques in the Šumava Mts with lakes and stable and permanently wet microclimate support predominantly coastal species that only exceptionally occur inland, such as *Rinodina interpolata*, which was found on a rock-wall at Černé Lake (Palice 1999).

Most lichens with oceanic affinities in the Czech Republic occur in northern Bohemian sandstone landscapes. The rare *Bunodophoron melanocarpum* is known only from this area, now surviving only in the Adršpach-Teplice Rocks. There are isolated populations of the epiphytic microlichens *Micarea pycnidiophora* and *Phaeographis inusta*, and the mainly coastal macrolichen *Cladonia subcervicornis* (Fig. 5.1b) in Saxon-Bohemian Switzerland (Palice et al. 2007).

Lichens with Mediterranean affinities occur mainly in dry areas of central and northern Bohemia and southern Moravia, e.g. in the Bohemian Karst and the Pavlov Hills, the valleys of the lower stretches of the Berounka and Vltava rivers, and on the volcanic hills in the České středohoří Mts. Terricolous and saxicolous lichens with Mediterranean affinities were surveyed by Suza (1937, 1943), who mentions several characteristic taxa, like the terricolous *Fulgensia fulgens*. Interestingly, some calcicolous taxa have a restricted distribution within the Czech Republic, being known only from its Carpathian part. The best examples are *Lecanora pruinosa*, *Psora vallesiaca* and *Toninia toninioides*, all recorded only on the Jurassic limestone rocks on Kotouč hill near Štramberk in north-eastern Moravia (Suza 1943), which is the westernmost outpost of their Carpathian distribution. The remnants of their habitat on the south-facing slopes of Kotouč hill were destroyed by limestone quarrying after World War II and all three species became extinct there. Also occurrences of

some calcicolous lichens in the Moravian Karst that are absent from Bohemia, e.g. *Toninia taurica* (Peksa 2008a), may be interpreted as outposts of their Carpathian range (Peksa 2008a). Several species of the families *Teloschistaceae* and *Candelariaceae* with mainly Mediterranean distributions probably reach their northern distribution limits in the Czech Republic, Germany and Slovakia; this applies to e.g. *Caloplaca inconnexa* (Vondrák et al. 2007), *C. austrocitrina* (Vondrák et al. 2009a), *C. emilii*, *C. interfulgens* (Vondrák et al. 2013), *C. xerica*, *Candelariella plumbea* and *C. viae-lacteae* (Malíček et al. 2014).

Continental steppe elements are few, including mainly terricolous lichens with scattered records of them occurring in dry and warm areas in Central Europe that are the westernmost limits of their distribution ranges. The most favourable conditions for these species are in south-eastern Moravia and in the České středohoří Mts in northern Bohemia. Many of them are associated with loess, e.g. *Gyalidea asteriscus* (Suza 1936) and *Rinodina terrestris* (Vězda 1970). Jurassic limestone rocks in the Pavlov Hills in southern Moravia are the only known site in the Czech Republic for *Xanthoria papillifera* (Malíček et al. 2014).

Most **arctic-alpine lichens** are saxicolous and terricolous species, which occur in the Czech Republic mainly in the Sudetes Mts. Some high-mountain species are also found in other mountain ranges. *Arctoparmelia centrifuga* (Fig. 5.1d), for instance, is known from a few sites on the summits of the Krkonoše Mts and there is a large population (perhaps one of the richest in Central Europe) on Mt. Luč in the Šumava Mts (Černohorský 1961). This lichen is considered to be a glacial relict in Central Europe (Wirth et al. 2013). Some high-mountain elements occur also in the Brdy Mts in central Bohemia, especially on cold boulder fields, where *Brodoa intestinifomis*, *B. atrofusca* (Peksa 2008b) and *Miriquidica deusta* (Malíček et al. 2015) are recorded, the latter being known in this country only from this area. The most prominent arctic-alpine lichens are mentioned in the next subchapter.

5.3 Sites of Particular Lichenological Interest in the Czech Republic

The majority of the lichenologically unique localities are in the Sudetes Mts. A particularly remarkable site is the **Obří důl** valley (Riesengrund) in the Krkonoše Mts, which encompasses glacial cirques and the smaller famous sites **Čertova zahrádka** (Teufelsgärtchen) and **Rudník** (Kiesberg). Obří důl is *locus classicus* for several distinct species discovered and described by Julius Flotow and Gustav Körber in the mid-nineteenth century and Eugen Eitner at the beginning of the twentieth century. *Gyalecta friesii* (Koerber 1855), a rare boreal species, was apparently extirpated at its type locality because the humid old-growth forest, its typical habitat, was largely destroyed. There are no recent records of this species in the Alps, and viable populations are known only in northern Eurasia. *Sporodictyon cruentum* is an example of a more widespread amphibious lichen described from this locality (Körber 1853). The

Obří důl valley is rich geologically: it includes crystalline limestones, on which *Collema undulatum* was found and described (Flotow 1850), as well as metamorphic metal-rich rocks providing niches for specific assemblages of ferrophilous lichens. This also applies to two species described by Eitner (1911) from the abandoned mine area at Rudník, namely *Rhizocarpon pycnocarpoides*, recently once again recognized as taxonomically distinct (Westberg et al. 2015), and *Lecanora subaurea*, which was originally described by Eitner as *L. aurea*. Mt. **Sněžka** (Schneekoppe, Śnieżka), the highest mountain in the country (1603 m), hosts the richest populations of several arctic-alpine species in the Czech Republic, such as *Alectoria nigricans*, *Allantoparmelia alpicola*, *Flavocetraria cucullata* and *F. nivalis*. The rare arctic-alpine terricolous calciphilous species *Caloplaca nivalis* was described from the Sněžka slopes facing the Obří důl valley (Körber 1853), where patches of base-rich rocks occur. Five specialized lichenicolous lichens with reduced thalli that are usually confined to a single crustose host lichen are so far known in the Czech Republic only from Mt. Sněžka; they are *Caloplaca epithallina*, *C. magni-filii*, *Lecanora latro*, *Protoparmelia phaeonesos* and *Rhizocarpon pusillum* (see Vězda and Liška 1999; Vondrák et al. 2007). The wind-exposed, nutrient-enriched schist outcrop **Petrovy kameny** (Peterstein) in the Hrubý Jeseník Mts harbours several lichens that are not recorded elsewhere in the country (*Anaptychia bryorum*, *Fulgensia schistidii*, *Melanohalea infumata* and *Phaeophyscia kairamoi*) or only rarely in the nearby Velká kotlina cirque (*Acarospora badiofusca* s. str., *Caloplaca ammiospila*; Suza 1933; Vondrák and Malíček 2015). Likewise the sheltered lime-enriched schist outcrops on Mt. **Studénková hole** (Brünnelheide) are unique, being the only site in the country for *Gyalecta sudetica* (type locality), *Porina mammillosa* and *Leucocarpia biatorella* (see Vězda and Liška 1999; Peksa 2008a).

Although the serpentinite area near **Mohelno** in south-western Moravia is not extraordinarily rich in lichens, it is one of the most unique lichenological localities in Central Europe. Three accepted species were described from this site: *Aspicilia serpentinicola* (known only from this site), *Acarospora suzae* and *Psorotichia moravica*. This locality hosts also other globally rare species such as *Gyalidea asteriscus*, *Harpidium rutilans*, *Lecanora laatokkaensis* and *Toninia cinereovirens*.

Remnants of old-growth deciduous forest surrounding the raised-bog area **Modravské slatě** (Weitfäller Filze) near Modrava village in the Šumava Mts harbour luxuriant suboceanic epiphytic assemblages with high proportions of lichens with a cyanobacterial photobiont. Already in the early twentieth century this locality was known to be unique (Hilitzer 1925). Thanks to high precipitation (close to the highest values in the Czech Republic), high air humidity with numerous foggy days, its topography and long forest continuity, this area hosts very rich epiphytic assemblages similar to those in lichen-rich oceanic Western European woodlands. This site was the last known locality of the sensitive native woodland indicator *Usnea longissima* (Hilitzer 1924) and it is also the country's last refuge for some critically endangered macrolichens, namely *Lobaria amplissima* (Fig. 5.1c) (Liška et al. 1996). The most viable population of *Lobaria pulmonaria* (Fig. 5.1f), an indicator of old-growth forests, produces apothecia at this site.

5.4 Effects of Environmental Changes on Lichen Biota

The decline in rare sensitive lichens was already notified by Anders (1935), who recorded their disappearance and extirpation in northern Bohemia. Suza (1944) and Kuťák (1952) reported the decline and local extinctions of some old-growth forest lichens in the Žďárské vrchy Mts and the Krkonoše Mts, respectively. The gradual disappearance of the sensitive forest species *Lobaria pulmonaria* is documented by Liška and Pišút (1990). Although this species declined dramatically in abundance during the twentieth century, eventually being known only from the Šumava Mts, Novohradské hory Mts and Králický Sněžník Mts, recent intensified field research resulted in its rediscovery in the Český les Mts in western Bohemia and on Mt. Kněhyně in the Moravskoslezské Beskydy Mts (Fig. 5.2b).

Several sensitive species may have been declining in abundance already during the eighteenth and nineteenth centuries. This applies to the most sensitive old-growth forest species and to some Mediterranean or high-mountain lichens that are at their distributional and ecological limits in the Czech Republic. For instance, *Solorina crocea*, a species of arctic-alpine snow-patches is known only from nineteenth century records from Mt. Sněžka in the Krkonoše Mts and Mt. Studénková hole in the Hrubý Jeseník Mts (Koerber 1855; Suza 1933).

Acidic air pollution by sulphur dioxide peaked in this country in the 1970s and 1980s. It was especially detrimental to epiphytes (Anděl and Černohorský 1978; Liška 1994). In the most polluted areas in northern Bohemia and Silesia and in industrial centres lichens have almost disappeared, leaving behind "lichen deserts". Acidification also caused changes in the pH values of bark of phorophytes and even in less affected areas a shift in substrate preference was noted e.g. for the rare old-growth forest species *Biatora fallax* (Printzen and Palice 1999) or the common epiphyte *Lecanora pulicaris* (Malíček 2014). Among the terricolous and epibryophytic lichens the most striking decline was that of the cephalodiate macrolichens capable of fixing nitrogen. *Stereocaulon tomentosum*, a conspicuous lichen on acidic sandy soils, namely in heathlands (see Suza 1946) used to be "locally frequent" (Černohorský et al. 1956), but is now considered extinct in this country. Cephalodiate members of *Peltigera* (*P. aphthosa*, *P. leucophlebia* and *P. venosa*) are close to extinction in the Czech Republic and currently only known from a few sites in the Šumava Mts, Krkonoše Mts, Králický Sněžník Mts and Hrubý Jeseník Mts.

Acidifying emissions in Europe have been declining substantially since 1990 (European Environment Agency 2015) but in forests close to some industrial centres the effects of acidification are still discernible in their impoverished lichen biota in which the "weedy" *Lecanora conizaeoides* is dominant. This is also supported by traditional forestry practices preferring spruce (*Picea abies*) plantations. Since the decline in sulphur dioxide emissions, nitrogen has become the predominant acidifying agent (Moldanová et al. 2011) and dry nitrogen deposits may also support the increase of nitrophytic species (Frahm et al. 2009). A persisting issue is the non-declining ammonium emissions and dust from traffic, agriculture and other local sources. This has resulted in striking changes in the epiphytic lichen biota during the

past decades, mainly in a continuous increase of nitrophytes in open landscape, such as in parks and on roadside trees, which are often covered by *Xanthoria parietina*. Also nitrophytic crustose species such as *Bacidina neosquamulosa* or *Candelariella efflorescens* agg. have increased remarkably in these habitats.

An interesting phenomenon is the **(re)colonization** of former "lichen deserts" and lichen-impoverished landscapes after desulphurization of coal power plants in the early 1990s, especially in western Bohemia. Lichen recolonizers were noted by lichenologists soon after 2000 but the observations were only published quite recently (e.g. Steinová et al. 2013; Šoun et al. 2015). The empty niches are reoccupied by assemblages of ecologically and biogeographically rather diverse species growing mainly on well-lit sites on branchlets of shrubs (e.g. *Prunus spinosa* and *Crataegus* spp.) in pastureland or on twigs of larch trees in plantations. In addition to generalists, such as *Evernia prunastri*, *Hypogymnia physodes* and *Parmelia sulcata*, both lichens with suboceanic (e.g. *Hypotrachyna revoluta*) and boreal distributions (e.g. *Evernia divaricata*, *E. mesomorpha* and *Hypogymnia bitteri*) may spread side by side, and these assemblages include even numerous nitrophilous species (e.g. *Melanelixia subaurifera* and *Xanthoria polycarpa*). Some of the colonizers with suboceanic distributions (e.g. *Flavoparmelia soredians* and *Punctelia borreri*) are assumed to have spread from Western Europe (Steinová et al. 2013; Šoun et al. 2015). (Re)expansion is documented also for predominantly foliicolous lichens that were until recently known mainly from the Šumava Mts or were even missing (Palice 1999; see also Vězda and Liška 1999). An example is a lichen known also from the tropics, *Fellhanera bouteillei*, which is native to humid lowland sites. This historically sparsely recorded species was last reported in 1947 and rediscovered at the beginning of the twenty-first century. Recently it spread into various parts of the Czech Republic including Prague, formerly heavily polluted areas in central and northern Bohemia, and at high altitudes in the Šumava Mts (Malíček and Palice 2013) and the Krkonoše Mts. It is thus tempting to attribute this expansion to global warming. Similar gradual spread is also recorded for mosses of the family *Orthotrichaceae* (Kučera et al. 2012). However, some changes in the epiphytic lichen biota are too fast and recent for a full understanding and some even may turn out to be episodic.

Probably no lichens are unequivocally known to be alien in Europe (Essl and Lambdon 2009), and even the widespread toxitolerant *Lecanora conizaeoides* might have been native to Central Europe regardless of its extensive spread over much of the continent since the 1950s. Dozens of presumably native calciphilous lichens have adapted to man-made substrates like mortar, concrete, bricks and roof-tiles. Some species in these habitats belong to the most common ubiquitous lichens, which usually are recorded on calcareous rock outcrops. They may switch also to secondarily base-enriched siliceous rocks (e.g. gravestones) and to dust-impregnated wood. Examples of widespread ubiquitous lichens are *Acarospora moenium*, *Caloplaca decipiens*, *Lecanora dispersa* and *L. muralis*. The high dispersal potential of lichens and their ability to occupy transient habitats is documented by unexpected finds in antropogenic habitats of the rare high-mountain species *Rinodina castanomelodes* (concrete at high altitudes on Mt. Sněžka, Krkonoše Mts; Vondrák

et al. 2006) and *Placidiopsis oreades* (sedimentation basin at the foothills of the Adršpach-Teplice Rocks at an altitude of 500 m; Peksa 2009). In Central Europe both species are otherwise known only from the Alps and Tatra Mts.

5.5 Changes in Our Knowledge of the National Lichen Biota

Lichenofloristic research has experienced a renaissance in the Czech Republic during the last few years, which is mirrored e.g. by additions of more than 100 new species records for the country since issuing the latest version of the Czech lichen checklist (e.g. Malíček and Palice 2013; Malíček et al. 2014; Vondrák et al. 2016). Irrespective of the fact that several taxa were also merged or excluded (e.g. Malíček 2014; Svoboda et al. 2014), to date the number of lichen species recorded in the Czech Republic has exceeded 1630. Surprisingly, most new records are represented by non-cryptic morphospecies identifiable also by non-molecular means. Some DD and NE taxa are currently studied by specialists and new results are to be published in the next few years, therefore the percentage of DD and NE species is likely to be reduced substantially. Intensive field research and targeted search for RE taxa at their former localities since 2010 has yielded records of approximately 30 species of the total of 138 listed by Liška and Palice (2010); hence the percentage of RE species has decreased to 6–7% of the total number of lichens. Also the status of several recolonizers ranked as CR in the Red List (Liška and Palice 2010), including *Evernia divaricata*, *E. mesomorpha*, *Hypogymnia bitteri*, *Nephromopsis laureri* and *Usnea scabrata*, will need to be reconsidered. These species, most of them primarily related to old-growth boreal forests, seem to be adaptive recolonizers in other habitats (e.g. Steinová et al. 2013).

During the last twelve years ten new species were described (based on holotypes) from the Czech Republic: *Agonimia flabelliformis*, *Aspicilia serpentinicola*, *Bacidia pycnidiata*, *Bacidina flavoleprosa*, *Biatora radicicola*, *Caloplaca emilii*, *C. microstepposa*, *C. soralifera*, *C. substerilis* and *Lecania leprosa* (Czarnota and Coppins 2006; Vondrák and Hrouzek 2006; Reese Næsborg 2008; Czarnota and Guzow-Krzemińska 2012; Guzow-Krzemińska et al. 2012; Nordin 2013; Vondrák et al. 2013; Frolov et al. 2016; Printzen et al. 2016). Given the recent boost in lichenological research in this country, new discoveries and significant modifications of the national list of lichens are to be expected in the near future.

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