Changes in distribution of rare and threatened lichens in the Czech Republic II

JIŘÍ LIŠKA[1], ZDENĚK PALICE[1,4], RADEK DĚTINSKÝ[2] AND JAN VONDRÁK [3]

Liška J., Palice Z., Dětinský R. & Vondrák J. 2006. Changes in distribution of rare and threatened lichens in the Czech Republic II. In: Lackovičová A., Guttová A., Lisická E. & Lizoň P. (eds.), Central European lichens – diversity and threat, p. 241 – 258. Mycotaxon Ltd., Ithaca.

Abstract – Changes in distribution of selected rare and decreasing lichen species in the Czech Republic were evaluated. Ten species (*Flavopunctelia flaventior, Parmelina pastillifera, P. quercina, P. tiliacea, Peltigera horizontalis, P. polydactylon, Sclerophora coniophaea, S. farinacea, S. pallida* and *S. peronella*) were mapped on the basis of revision of herbarium material. Comparison with the present distribution showed a sizeable decline in most species. Many species are vanishing and grow in single remaining localities in the territory of the Czech Republic, i.e. in refugia in south-west Bohemia (Böhmerwald, the Šumava Mts). Two species have not been confirmed at present and are possibly extinct in the Czech Republic (*Sclerophora coniophaea* and *S. farinacea*). Environmental changes (air pollution, forest management, change of habitats) are the main factors responsible for the decrease.

Key words – air pollution, biodiversity, ecology, environment

Introduction

The lichen flora of many European countries is changing owing to changes in the environment, including air pollution, changes in forest management and decrease of potential suitable substrates/habitats. Proportion of threatened species is increasing and they are included in red lists published in many countries.

Lichenological research in the present territory of the Czech Republic has a long history. Unfortunately, a publication summarizing the Czech lichen flora was not available until the issue of the Catalogue (Vězda & Liška 1999). However, the data on distribution for many lichen species are rather old, and current data are not available or only in limited amount because of lack of specialists interested in lichens.

Changes in the Czech lichen flora can be demonstrated by those species included in the project to study changes of distribution of selected rare and decreasing li-

[1]*Institute of Botany, Academy of Sciences of the Czech Republic CZ-252 43 Průhonice, Czech Republic*
liska@ibot.cas.cz, zpalice@yahoo.com
[2] *Senegalská 635, CZ-160 00 Praha 6, Czech Republic*
[3]*Department of Botany, Faculty of Biological Sciences, University of South Bohemia, Branišovská 31, CZ-370 05, České Budějovice, Czech Republic • j.vondrak@seznam.cz*
[4]*Department of Botany, Faculty of Science, Charles University, Benátská 2, CZ-128 01 Prague 2, Czech Republic*

chens. So far, results for 26 species have been published (see Liška et al. 1996, 1998a, 1998b). Most of these lichens were previously included in the Red-data book of threatened cryptogams (cf. Liška & Pišút 1995).

Materials and methods

A revision of relevant material in large herbaria (PRC, PRM, BRNM, BRNU, BRA, SAV) was the main source for a reconstruction of previous distributions. Knowledge of the present distribution of these species is based mainly on the authors' field research, which was primarily concentrated on areas with well-preserved habitats and lichen flora. Most field excursions were focused on the Šumava Mts. (Böhmerwald). Other mountain areas (e.g. Novohradské hory, Slavkovský les, Českomoravská vrchovina, Brdy, Krkonoše, Bílé Karpaty, Jeseníky) have been screened less intensively. If herbaria are not mentioned, specimens are deposited in private herbaria of collectors.

A grid system (MTB) was used as a mapping method (the locality includes the number of the MTB square). Previous distribution comprises data from before 1970 (open circles on maps). Closed circles represent data from 1970 onwards. In case of high number of recent localitites, only a map is provided and no localities are listed. Data on the category of threat in selected European countries were extracted from the following sources: Aptroot et al. (2004), Cieśliński et al. (2003), Gärdenfors (2005), Motiejűnaité (1999), Pišút et al. (2001), Rassi et al. (2001), Scheidegger et al. (2002), Sérusiaux (1989), Søchting & Alstrup (2002), Türk & Hafellner (1999), Wirth et al. (1996) and Woods & Coppins (2003). Nomenclature of lichens follows Santesson et al. (2004) and Nimis & Martellos (2003).

Results

Flavopunctelia flaventior

The species is recorded from all continents except Australia and Antarctica. In Europe, it is scattered throughout the temperate region, and is most frequent in warm and dry areas (the Mediterranean); nevertheless, rather few localities are known from some regions (e.g. less than 10 localities have been published from Italy [cf. Nimis 1993]).

The lichen grows from hilly to submontane altitudes, predominantly in sunny places. The most frequent substrate is bark of deciduous trees with high pH (rarely it has been collected on siliceous rocks), the lichen is tolerant of eutrophication.

Hitherto, only two reliable localities were published from the Czech Republic: hill Holedná (near Brno city), collected by Suza in 1918 (cf. Suza 1919) and in the Novohradské hory Mts. (cf. Peksa et al. 2004, see also the locality below) [Fig. 1]. Some

older collections of *F. flaventior* might have been misidentified for the superficially similar *Flavoparmelia caperata* and relevant herbarium material should be revised.

It is difficult to assess the conservation status of *F. flaventior* in the Czech Republic, because more data (concerning ecology as well as knowledge of previous distribution) are necessary. According to Wirth (1995), *F. flaventior* is more toxitolerant than *Flavoparmelia caperata,* and is apparently spreading. On the other hand, only two recent localities exist in Slovakia, both in less polluted areas: the Pieniny Mts. (Pišút & Guttová 1997) and the Malá Fatra Mts. (Guttová 1997).

Conservation status in other countries: EN (Poland, Slovakia), NT (Netherlands, Switzerland), LC (Germany), not red-listed in Austria.

Fig. 1. Distribution of *Flavopunctelia flaventior* in the Czech Republic.

Records after 1970:

6951: Českobudějovická pánev, Netolice, Kratochvíle, old oak alley, near chateau, N 49°03'30", E 14°10'30", bark of *Quercus robur*, 28.7.2002 J. Vondrák

6952: Českobudějovická pánev, České Budějovice, protected area Vrbenské rybníky, bark of *Quercus robur*, 28.4.2002 J. Vondrák

7052: Českobudějovická pánev, České Budějovice, Haklovy Dvory, alley of oaks, N 49°00'00", E 14°24'50", bark of *Quercus robur*, 3.10.2001 J. Vondrák

7154: Třeboňská pánev, Nové Hrady, Byňov, dam of "Byňovský rybník" pond, 470m, N 48°49'30", E 14°48'20", bark of *Quercus*, 11.5.2002 J. Vondrák

7254: Novohradské podhůří, ca 0.5 km S od Horní Stropnice, crossroads to Humenice village, 550 m, *Fraxinus excelsior*, 15.8.1998 R. Dětinský (Peksa et al. 2004)

Parmelina pastillifera

A temperate-montane oceanic (suboceanic) lichen of largely European distribution with outliers in the wetter areas of Asia (Caucasus, Himalaya). Most records come from south-west Europe; northwards, the area of distribution extends to Nordland in coastal Norway (cf. Santesson et al. 2004). In Central Europe, it is a rare species except in the Alps. In the past, *Parmelina pastillifera* was not always distinguished from *P. tiliacea* (Hoffm.) Ach., therefore old records of *P. tiliacea* may include specimens of *P. pastillifera*. It seems to be more frequent in western Europe (it shows a more oceanic tendency in contrast to *P. tiliacea*), where the species often grows also as a saxicolous species including in man-made sites (cf. Purvis & James 1992). In Central Europe, it grows in well-lit forests and on solitary trees in submontane to montane areas with high rainfall. The most frequent substrate is the bark of beech (and other deciduous trees), rarely growing on rocks (Wirth 1995). Unlike *P. tiliacea*, it does not occur on highly eutrophicated bark in Central Europe; however, it is at least tolerant of eutrophicated habitats in western and southern Europe, e.g. it is reported as a member of the nitrophilous *Xanthorion* alliance in Italy (Nimis 1993). The species was also shown to be able to colonize new areas (Kricke & Feige 1999).

In the Czech Republic, 3 localities were reported (Fig. 2). The Bohemian locality in the Šumava Mts. (Palice 1999) and two Moravian localities (Bílé Karpaty Mts., cf. Liška & Pišút 1995, and Moravsko-Slezské Beskydy Mts., cf. Orthová 2000).

Note: We found a specimen (No 850443, PRM) collected by A. Hilitzer and labeled "oak on dike of Rožmberk lake, 2.10.1929, leg. A. Hilitzer". However, the hand-written notes on the envelope refer to a different locality (Lupad?) and date (18.8.1927). Probably, the specimen was erroneously labeled, or an old envelope of another specimen was used for a new collection, but this last version is less likely. Therefore, this sample is not considered here. In the same herbarium (PRM), another specimen (No 850450) was found: also collected by A. Hilitzer in the Bavarian part of the Šumava Mts. (Klein Falkenstein, *Acer pseudoplatanus*, ca 1000 m, 20.8.1924), but this locality is now located in Germany.

A recently published record in the Red data book (Liška & Pišút 1995) from the Bílé Karpaty Mts. could not be confirmed in 1997 (the old walnut tree has probably been felled).

Further finds from the Czech Republic are likely – both in the western part (namely the Šumava Mts.) and the eastern part (Carpathians).

In the neighbouring area of the Carpathian forests it seems to be relatively frequent as was demonstrated by revision of herbaria by Orthová (2000); also our own field experience from the Zakarpatye region supports this assumption.

Conservation status in other countries: RE (Netherlands), CR (Finland, Slovakia), EN (Denmark, Sweden), VU (Germany, Austria), NT (Switzerland), LC (Great Britain), DD (Poland).

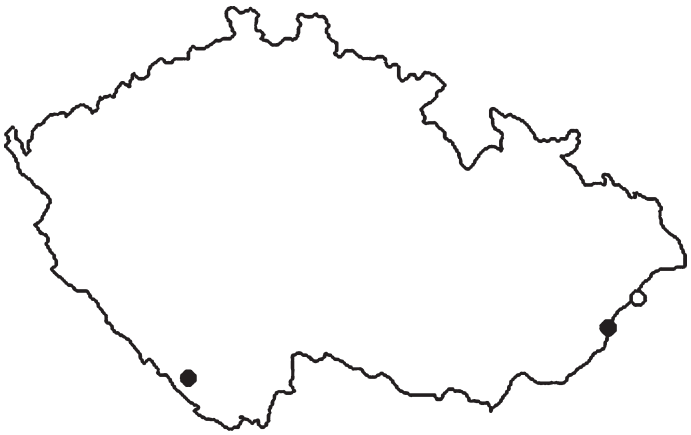

Fig. 2. Distribution of *Parmelina pastillifera* in the Czech Republic.

Records after 1970:

6874: Bílé Karpaty, Nedašov, *Juglans regia*, 21.5.1992 J. Liška (not refound in 1997)

7149: Šumava, Volary, Černý Kříž, loco "U hotelu", *Fraxinus escelsior*, 740 m, 19.1.1996 Z. Palice (Palice 1999)

Parmelina quercina

A widely distributed species reported from all continents except Antarctica and South America. The centre of its European distribution lies in the southern part of the Mediterranean area, and the northern limit reaches Denmark. It grows from low altitudes to mountain areas with high rainfall. It prefers solitary trees, but it may grow also in open forests and is rarely known from rocks. The main host tree is oak (low elevation); it switches to other tree species at higher altitudes. It is a species of unshaded habitats (e.g. tree crowns) and is often found on fallen twigs on the ground.

P. quercina was probably not a rare lichen in the Czech Republic in the past as evidenced by luxuriant herbarium specimens (Fig. 3). However, there are few published records. Only a part of the potential herbarium material has been revised (PRC, BRA and PRM), but it represents a substantial part and therefore it is possible to reconstruct a picture of the former distribution of this species. Old records

are concentrated in areas frequently visited by earlier generations of lichenologists. The surroundings of Prague have yielded a high number of specimens and one may expect that it was probably a relatively frequent species. However, the recent records are very sparse, and are concentrated within areas with low levels of air pollution (the only exception is from a deep and well-preserved valley near Olomouc city), but only isolated and damaged thalli are found. Therefore, this species could be regarded as critically endangered. The main cause of its decline is sensitivity to high levels of air pollution.

Conservation status in other countries: RE (Denmark), CR (Germany, Netherlands, Poland and Slovakia), VU (Austria, Great Britain), NT (Switzerland).

Fig. 3. Distribution of *Parmelina quercina* in the Czech Republic.

Records after 1970:

5970: Suchá Rudná – above the village, *Acer platanoides*, 23.9.1994 J. Liška
6370: Hlubočky – near road to Nepřivaz village, *Fraxinus excelsior*, 15.7.1992 J. Liška
6951: between villages Horní and Dolní Chrášťany, *Quercus* sp., 12.9.1985 J. Liška
6951: 1 km SW of Chvalovice village, *Quercus* sp., 12.9.1985 J. Liška
6954: Lužnice n.L., near Potěšil pond, *Quercus* sp., 13.9.1993 J. Liška et Z. Palice
7052: 1.5 km SW of Dubné village, *Quercus* sp., 12.9.1985 J. Liška
7053: Slavošovice, *Quercus* sp., 6.5.1986, J. Liška
7155: Hranice near Nové Hrady, *Quercus* sp., 7.5.1986, J. Liška
7162: near Popice village, 1993, B. Gruna

Parmelina tiliacea

A species of Eurasian distribution pattern, reported also from Macaronesia (Canary Islands and Madeira) and Africa. Records from North and South America and Australia (Oksner 1993) probably refer to other, related taxa (cf. Hale 1976). According to the species-pair concept, it is considered to be a secondary species of *P. quercina*. However, the rule predicting a larger distribution area of a secondary species does not hold in the case of *P. tiliacea*: its distribution area is not as large as the area of *P. quercina*.

P. tiliacea is rather common in Europe growing from lowlands to mountains, and distributed mainly in the central and eastern part (in contrast to the more oceanic *P. pastillifera* and more southerly distributed *P. quercina*). It grows on bark of solitary deciduous trees (*Fraxinus*, *Tilia*, *Quercus* etc.) in slightly to moderately eutrophicated habitats (trees on village greens and near roads), rarely on rocks, roofs etc. We have seen fertile thalli in herbaria, but not in the field.

P. tiliacea is not a rare species in the Czech Republic, where it is by far the most frequent species within the genus *Parmelina* (Fig. 4). It occurs rather frequently and it is still possible to find rich populations in areas with low levels of air pollution; this species may be a dominant lichen on some solitary trees by roadsides, in parkland etc. A certain degree of nitrophily in this species, compensating for the effects of acid pollution is one factor which may explain its distribution. A comparison of present distribution with old localities revealed areas where the species has decreased: north-west, north and central Bohemia, i.e. areas experiencing the highest levels of air pollution.

Fig. 4. Distribution of *Parmelina tiliacea* in the Czech Republic.

Conservation status in other countries: EN (Denmark), VU (Netherlands, Poland, Germany), NT (Finland, Slovakia), LC (Austria, Great Britain, Switzerland).

Peltigera horizontalis

A holarctic species with suboceanic preferences, avoiding extreme continental situations (Martínez et al. 2003). The European distribution area is broad, extending from the Mediterranean (here growing mainly in mountains) to the northernmost part of Scandinavia.

It occurs on bases (sometimes also on trunks) of old deciduous trees, on mossy rocks and boulders, and sometimes also on bare soil (mainly on places with low competition from flowering plants, e.g. hollow ways). It grows both on acidic and basic substrates, preferring shady habitats with high humidity. *P. horizontalis* is sometimes regarded as an indicator of forests with a long ecological continuity.

There are many published localities of *P. horizontalis* from the Czech Republic (Fig. 5), but these data are not always reliable. This species was sometimes confused with

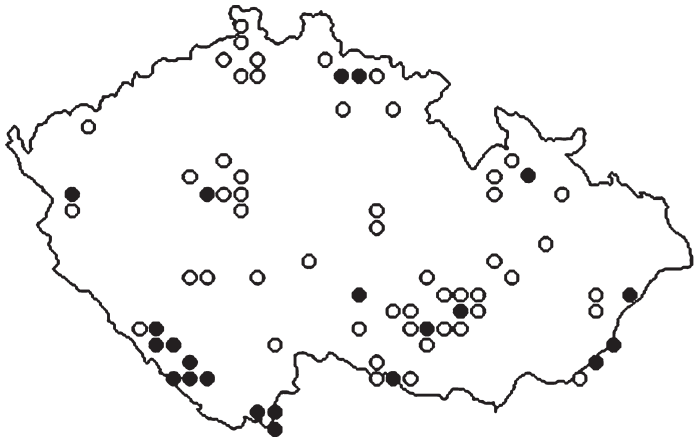

Fig. 5. Distribution of *Peltigera horizontalis* in the Czech Republic.

others, mainly *P. degenii* and *P. polydactylon*. *P. horizontalis* was formerly frequent throughout the whole territory. However, the present distribution pattern suggests a rapid decline in this species. It is now relatively frequent only in mountain areas in the southern part of the territory. The reasons for such a rapid decline are not completely clear and a complex of anthropogenic factors is probably responsible (e.g. acid rain, habitat change). Since *P. horizontalis* has been undoubtedly decreas-

ing and this tendency is expected to continue, the species should be assessed as a threatened species irrespective of the relatively high number of recent localities.

Conservation status in other countries: RE (Netherlands), CR (Lithuania), EN (Poland), VU (Denmark, Germany and outside the Alps in Austria), NT (Switzerland), LC (Great Britain), not red-listed in Slovakia.

Peltigera polydactylon

A subcosmopolitan species, and one of the most widespread species of the genus (Martínez et al. 2003). The European distribution is similar to that of *P. horizontalis*, but *P. polydactylon* shows a slightly continental tendency.

Published records are not reliable, because this species was often confused with *P. horizontalis* and others (*P. degenii* or *P. neckeri*). It grows on rocks and boulders (often covered with mosses), bare soil, fallen rotten tree trunks and sometimes also on the base of deciduous tree trunks. It prefers acidic substrata and has a tendency to colonize rather sunny places.

Previously, this lichen was scattered and locally frequent in the territory of the Czech Republic, but it was slightly rarer than *P. horizontalis*. At present, it is a relatively rare lichen, collected mainly in mountain areas in the southern part of the territory (Fig. 6). The distribution dynamics of *P. polydactylon* are similar to *P. horizontalis,* i.e. showing a continued rapid decrease; therefore it should be included in a category of endangered species.

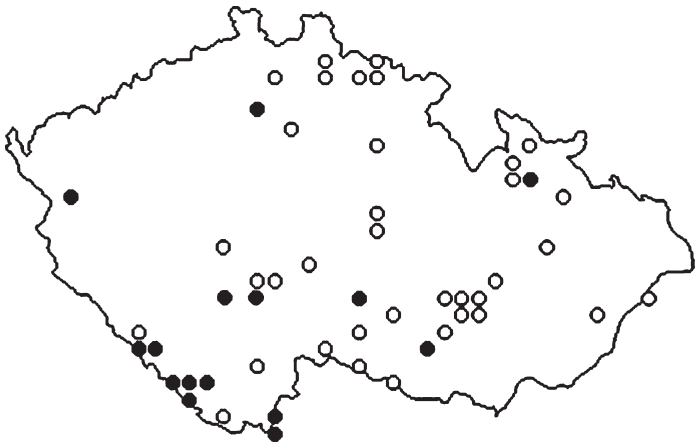

Fig. 6. Distribution of *Peltigera polydactylon* in the Czech Republic.

Conservation status in other countries: VU (Germany), DD (Poland), LC (Great Britain, Switzerland), R (Denmark), not red-listed in Slovakia nor Austria.

Sclerophora coniophaea

A relatively frequent lichen in northern Europe on bark and wood of dead as well as living coniferous and deciduous trees (Poelt & Vězda 1981, Santesson et al. 2004). In Central Europe, this species is much rarer (Poelt & Vězda 1981) and most records (mainly historical) refer to the Carpathian forests, where old firs are a predominant substrate (Nádvorník 1942). Interestingly, *S. coniophaea* has not been recorded in the Alps so far.

Only one locality from the territory of the Czech Republic is documented (Fig. 7): virgin forest on Mt. Žákova hora in the Žďárské vrchy Mts., collected by Kovář in the beginning of the 20th century (not published, but identity of the specimen confirmed by Nádvorník [1942] in his outline of family *Caliciaceae* of Central Europe). At present, this lichen is unknown in the Czech Republic and is probably regionally extinct. However, it is possible that this species could be rediscovered.

Conservation status in other countries: RE (Slovakia), NT (Finland, Sweden).

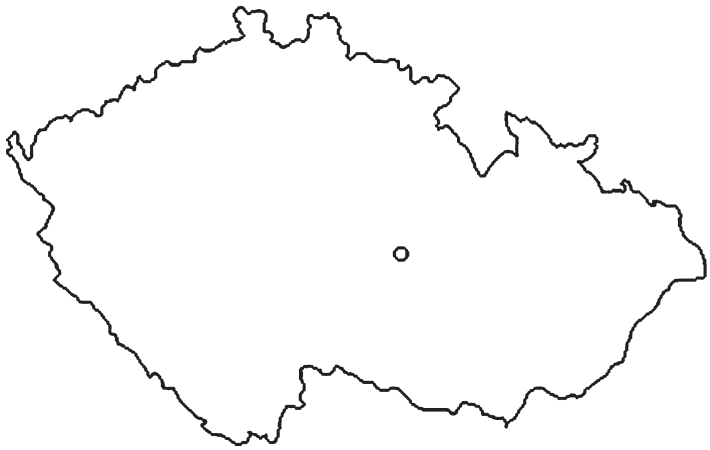

Fig. 7. Distribution of *Sclerophora coniophaea* in the Czech Republic.

Sclerophora farinacea

One of the rarest members of the genus *Sclerophora* in Europe. The distribution covers an area from southern Scandinavia to Central Europe (Poelt & Vězda 1981).

Furthermore, it was recorded also in the Caucasus, Himalaya and North America (Tibell 1999, Aptroot & Feijen 2002). In Central Europe, *Sclerophora farinacea* formerly occurred in oak forests in well-preserved valleys (Nádvorník 1942).

In the territory of the Czech Republic, it was collected only on bark of *Ulmus* spp. and *Acer campestre* in a small area in the valleys of the Oslava and Jihlava rivers (Fig. 8). However, the environment has considerably changed during recent decades (a large part of the valley has been drowned by a reservoir) and this species has not been refound recently. Therefore the species is treated as extinct in the Czech Republic.

Conservation status in other countries: RE (Slovakia, Germany, Great Britain), CR (Finland, Poland), NT (Sweden).

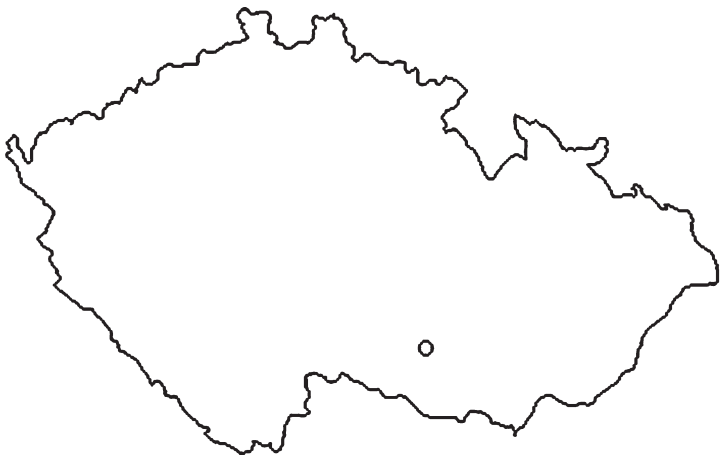

Fig. 8. Distribution of *Sclerophora farinacea* in the Czech Republic.

Sclerophora pallida

The commonest member of the genus, with a wide distribution covering most of Europe but excluding the northernmost and southernmost parts where the natural substrates of this lichen (*Ulmus*, *Fraxinus* or *Quercus*) do not occur. The species is also known from Siberia, North America (Tibell 1999) and Japan (Tibell & Thor 2003). In the Czech Republic, data from various parts of the territory exist, and this species was most frequent in colline to submontane forests (Fig. 9). It is interesting that the only recent record comes from the mountain belt. *S. pallida* occurs on dry bark and wood of old deciduous trees, either solitary trees or trees in well-lit

woods, in contrast to *S. peronella*. However, the ecological niches of both species may overlap, as shown by a mixed collection of both species in PRM.

Conservation status in other countries: RE (Denmark), CR (Germany, Poland, Slovakia), VU (Austria, Finland, Great Britain, Switzerland).

Record after 1970:

6946: Šumava, loco "Medvědí hřbet" near Mt. Rachel, solitary *Acer pseudoplatanus* near borderline, 1200 m, 10.6.1997 Z. Palice

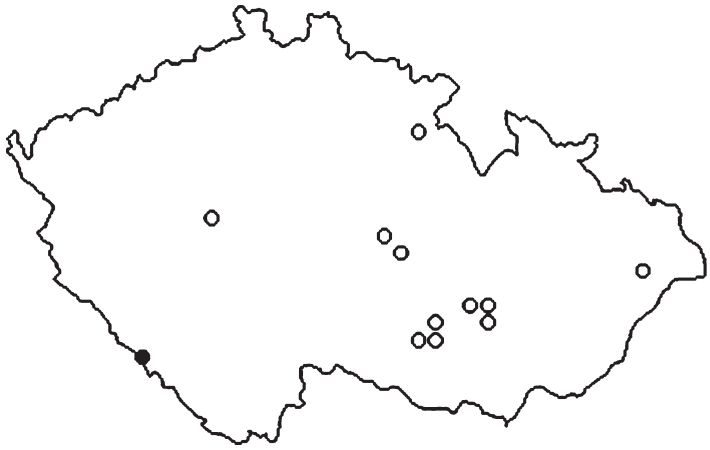

Fig. 9. Distribution of *Sclerophora pallida* in the Czech Republic.

Sclerophora peronella

The species is known from Europe (Poelt & Vězda 1981, Tibell 1999) and North America (Esslinger 1997); its European distribution covers an area from southern Scandinavia to southern Italy (Puntillo 1994). The species is rather rare in Europe (Poelt & Vězda 1981). However, it is relatively common in mountains of southern Italy according to Puntillo (1994).

Surprisingly, a relatively high number of recent localities from the territory of the Czech Republic was discovered (Fig. 10). Recent localities are situated in well preserved mountain forests (Šumava Mts.) or in an inversion valley (Orlické hory Mts.), only exceptionally growing on roadside trees (Šumava Mts.). Previously, it was also collected in mountains on the Czech-Moravian border and in NE Moravia (Moravskoslezské Beskydy Mts.).

S. peronella is a lichen of natural deciduous and mixed forests. A stable microclimate of virgin forests and the availability of old trees are the main factors for occurrence

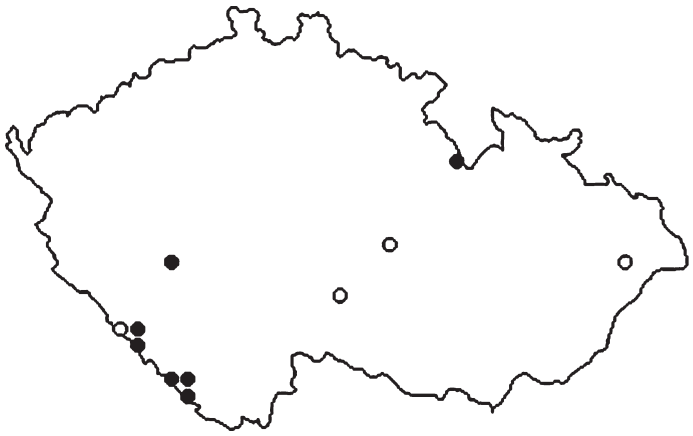

Fig. 10. Distribution of *Sclerophora peronella* in the Czech Republic.

of this species. In Italian Calabria, beech and fir are typical substrates for this lichen. In the Czech Republic, it has been recently collected mainly on *Fagus sylvatica*, also on *Acer pseudoplatanus* and rarely other deciduous trees and on *Abies alba*, often on dry disintegrating shaded wood of living trunks (often hollow) without bark, or on old bark. It was not accompanied by any other lichen species. The presence of *Sclerophora peronella* (as well as other species of order *Caliciales*) can be used as a good indicator of ecological continuity of forest habitat (Tibell 1992).

Conservation status in other countries: CR (Germany, Poland, Slovakia), EN (Austria, Denmark), VU (Finland), NT (Great Britain, Sweden).

Records after 1970:

5865: Orlické hory, reservatio Zemská brána, Pašerácká lávka, ad ripam fluminis Divoká Orlice, ad lignum nudum (*Alnus glutinosa*), 550 m, 11.4.1997 J. Halda et Š. Haldová (Halda 1999, herb. Halda, Palice)

6448: Brdy, Rožmitál p. Třemšínem, Třemšín, ca 200 m S of watchtower, *Acer pseudoplatanus*, 820 m, 13.8.1998 Š. Bayerová

6846: Šumava, Prášily: Mt. Ždanidla - SW slope, in hollow trunk of *Fagus*, 1100 m, 23.5.1996 Z. Palice

6946: Šumava, near borderline between Javoří slať and Rokytecká slať peatbogs, 1150 m, 21.6.1995 R. Dětinský

6946: Šumava, Modrava: Mt. Smrkový vrch close to Weitfällerská slať peatbog, shaded wood of living *Acer pseudoplatanus*, 1100 m, 11.8.1994 Z. Palice; Ibid., 21.6.1995 R. Dětinský

7148: Šumava, Volary: hollow *Acer pseudoplatanus* at roadside between České Žleby and Hliniště, 850 m, 1992 Z. Palice

7148: Šumava, České Žleby: Mt. Radvanovický hřbet, on wood of *Ulmus glabra*, 900 m, 11.10.1996 Z. Palice

7148: Šumava, Nové Údolí: on wood of old solitary *Acer platanoides* at roadside, 830 m, 11.10.1998 Z. Palice; Ibid., bark of an old road-side *Ulmus*, 815 m, 7.9.2001 leg. A. Guttová, Z. Palice et P. Uhlík (herb. Palice)

7149: Šumava, Volary: Jelení vrch (8km S of Volary), on decorticated trunk of beech (*Fagus sylvatica*), 900 m, 25.9.1994 Z. Palice

7149: Šumava, Volary: Mt. Stožec, nature reserve "Medvědice", on *Fagus*, 900 m, 5.7.1994 Z. Palice

7249: Šumava, Nová Pec: Mt. Hraničník - N slope, mixed mountain forest, decorticated part of old *Fagus*, 1150 m, 17.6.1995 Z. Palice

Conclusion

1. The previous distribution of 10 lichen species (*Flavopunctelia flaventior, Parmelina pastillifera, P. quercina, P. tiliacea, Peltigera horizontalis, P. polydactylon, Sclerophora coniophaea, S. farinacea, S. pallida* and *S. peronella*) in the Czech Republic has been mapped on the basis of revision of herbarium material. A comparison with the present distribution (based mainly on the authors' field research) has been performed, and in most of the mapped lichen taxa, rapid changes during the 20th century have been demonstrated. Most species have decreased in frequency, some of them have become extinct. Some lichens survive at single localities, mainly (or only) in southern Bohemia. *Flavopunctelia flaventior* was either overlooked in the past or may have shown an increase in abundance.
2. Two lichens (*Sclerophora coniophaea* and *S. farinacea*) have not been found recently and therefore are regarded as possibly extinct.
3. The occurrence of *Parmelina pastillifera* and *Sclerophora pallida* is now limited to a single remaining locality each.
4. *Parmelina quercina* and *Sclerophora peronella* have been recently recorded at fewer than 15 localities.
5. Some lichens are not particularly rare, but have declined in abundance: *Parmelina tiliacea* has been lost in 20%, and *Peltigera horizontalis* and *P. polydactylon* has been lost in 70% of mapping squares where they were formerly present.
6. The present distribution of previously common lichens and the cause of their decrease follows a general pattern, showing a dependence on site history and level of air pollution. The first evidence of a decline can be demonstrated in heavily polluted areas, and the extent of change coincides with the level of air pollution. The present distribution pattern of some relatively frequent species

is similar to the distribution of some sensitive species some decades or a century ago.

7. Sensitivity of some lichens is increased because they are near the limits of their natural distribution.

Acknowledgements

We thank to Dr E. Brabec for his technical assistance with a database and mapping software. All curators and keepers of herbaria are gratefully acknowledged for their help. We also thank A. Orange who kindly corrected the English. The study was financially supported by the Grant Agency of the Czech Republic (No 206/03/1214), the Academy of Sciences of the Czech Republic (AV0Z60050516) and the Agency for Nature Conservation and Landscape Protection of the Czech Republic. ZP would like to acknowledge the support by the Ministry of Education, Youth and Sports, Czech Republic, project no. 21620828.

References

Aptroot A. & Feijen F. J.
2002 Annotated checklist of the lichens and lichenicolous fungi of Bhutan. Fungal Diversity 11: 21-48.

Aptroot A., van Herk C. M., Sparrius L. B. & Spier J. L.
2004 Checklist van de Nederlandse korstmossen en korstmosparasieten. Buxbaumiella 69: 17-55.

Cieśliński S., Czyżewska K. & Fabiszewski J.
2003 Czerwona lista porostów wymarlych i zagrozonych w Polsce. Red list of threatened lichenized fungi in Poland. Monogr. Bot. 91: 13-49.

Esslinger T. L.
1997 A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. North Dakota State University: http://www.ndsu.nodak.edu/instruct/esslinge/chcklst/chcklst7.htm (First Posted 1 December 1997, Most Recent Update 14 June 2005), Fargo, North Dakota.

Gärdenfors U. (ed.)
2005 Rödlistade arter i Sverige 2005 – The 2005 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala.

Guttová A.
1997 Zaujímavé nálezisko epifytických lišajníkov vo Vrátnej doline, Malá Fatra, Slovensko. Bryonora 20: 17-18.

Halda J.
1999 Příspěvek k poznání lichenoflóry Orlických hor. 2. Udolí horních toků řek Bělé, Zdobnice a Divoké Orlice. Acta Mus. Richnoviensis, Sect. Natur. 6(1): 1-32.

HALE M. E. JUN.
1976 A monograph of the lichen genus *Parmelina* Hale (*Parmelinaceae*). Smithson. Contrib. Bot. 33: 1-60.

KRICKE R. & FEIGE B.
1999 Neufund der Blattflechte *Parmelia pastillifera* (Harm.) Schub. & Klem. in Ratingen (Nordrhein-Westfalen). Flor. Rundbriefe 33: 98-101.

LIŠKA J. & PIŠÚT I.
1995 Lišajníky. In: Kotlaba F. (ed.), Červená kniha ohrozených a vzácnych druhov rastlín a živočíchov SR a ČR 4. p. 120-156, Príroda, Bratislava.

LIŠKA J., DĚTINSKÝ R. & PALICE Z.
1996 Importance of the Šumava Mts. for the biodiversity of lichens in the Czech Republic. Silva Gabreta 1: 71-81.
1998a A project on distribution changes of lichens in the Czech Republic. Sauteria 9: 351-360.
1998b Změny v rozšíření vzácných a ohrožených lišejníků v České republice I. Příroda 12: 131-144.

MARTÍNEZ I., BURGAZ A. R., VITIKAINEN O. & ESCUDERO A.
2003 Distribution patterns in the genus *Peltigera* Willd. Lichenologist 35: 301-323.

MOTIEJŪNAITÉ J.
1999 Checklist of lichens and allied fungi of Lithuania. Botanica Lithuanica 5: 251-269.

NÁDVORNÍK J.
1942 Systematische Übersicht der mitteleuropäischen Arten der Flechtenfamilie *Caliciaceae*. Stud. Bot. Čechica 5: 6-46.

NIMIS P. L.
1993 The Lichens of Italy. Torino, Museo Regionale di Scienze Naturali.

NIMIS P. L. & MARTELLOS S.
2003 A second checklist of the lichens of Italy with a thesaurus of synonyms. Museo regionale di scienze naturali, Aosta.

OKSNER A. M.
1993 Flora lyšajnykiv Ukrajiny. Kyjiv, Naukova Dumka.

ORTHOVÁ V.
2000 Nové nálezy *Parmelia pastillifera* (Harm.) Schub. et Klem. a *P. submontana* Nádv. ex Hale a ich rozšírenie na Slovensku. Bryonora 25: 13-17.

PALICE Z.
1999 New and noteworthy records of lichens in the Czech Republic. Preslia 71: 289-336.

PEKSA O., SVOBODA D., PALICE Z., DĚTINSKÝ R. & ZAHRADNÍKOVÁ M.
2004 Lišejníky. In: Papáček M. (ed.), Biota Novohradských hor: modelové taxony, společenstva a biotopy. p. 100-104, 293-297. Jihočeská Univerzita České Budějovice.

PIŠÚT I. & GUTTOVÁ A.
1997 A few rare or overlooked lichenized ascomycetes from Slovakia. Biologia, Bratislava, 52: 495-498.

PIŠÚT I., GUTTOVÁ A., LACKOVIČOVÁ A. & LISICKÁ E.
2001 Červený zoznam lišajníkov Slovenska (december 2001). In: Baláž D., Marhold K. & Urban P. (eds.), Červený zoznam rastlín a živočíchov Slovenska, Ochr. Prír. 20 (Suppl.): 23-30.

POELT J. & VĚZDA A.
1981 Bestimmungschlüssel europäischer Flechten. II. Bibl. Lichenol. 16: 1-390.

PUNTILLO D.
1994 The lichen order *Caliciales* in Calabria (S. Italy). Flora Mediterranea 4: 111-161.

PURVIS O. W., COPPINS B. J., HAWKSWORTH D. L., JAMES P. W. & MOORE D. M. (EDS.),
1992 The lichen flora of Great Britain and Ireland. London, Natural History Museum.

RASSI P., ALANEN A., KANERVA T. & MANNERKOSKI I. (EDS.)
2001 The 2000 Red List of Finnish species. Helsinki, Ministry of the Environment & Finnish Environment Institute.

SANTESSON R., MOBERG R., NORDIN A., TØNSBERG T. & VITIKAINEN O.
2004 Lichen-forming and lichenicolous fungi of Fennoscandia. Uppsala, Museum of Evolution, Uppsala University.

SCHEIDEGGER C. & CLERC P.
2002 Rote Liste der gefährdeten Arten der Schweiz: baum- und erdbewohnende Flechten. Bern, Birmensdorf & Genève, BUWAL-Reihe Vollzug Umwelt.

SÉRUSIAUX E.
1989 Liste rouge des macrolichens dans la Communaute Europeenne. Liege, Centre de Recherches sur les Lichens, Département de Botanique.

SØCHTING U. & ALSTRUP V.
2002 Danish Lichen Checklist. Copenhagen, Botanical Institute, University of Copenhagen.

SUZA J.
1919 Třetí příspěvek k lichenologii Moravy. Čas. Mor. Mus. 17: 201-222.

TIBELL L.
1992 Crustose lichens as indicators of forest continuity in boreal coniferous forests. Nord. J. Bot. 12: 427-450.
1999 Calicioid lichens and fungi. In: Ahti T. et al. (eds.), Nordic Lichen Flora. Volume 1. p. 20-93. Nordic Lichen Society, Uddevalla.

TIBELL L. & THOR G.
2003 Calicioid lichens and fungi of Japan. Journ. Hattori Bot. Labor. 94: 205-259.

TÜRK R. & HAFELLNER J.
1999 Rote Liste gefährdeter Flechten (Lichenes) Österreichs. 2. Fassung. In: Niklfeld H. (ed.), Rote Listen gefährdeter Pflanzen Österreichs. 2. Auflage. Grüne Reihe des Bundesministeriums für Umwelt, Jugend und Familie, Band 10. p. 187-228. Graz: Austria Medien Service.

VĚZDA A. & LIŠKA J.
1999 Katalog lišejníků České republiky. Botanický ústav AV ČR, Průhonice.

WIRTH V.
1995 Die Flechten Baden-Württembergs. I, II. Stuttgart, Eugen Ulmer Verlag.

WIRTH V., SCHÖLLER H., SCHOLZ P., ERNST G., FEUERER T., GNUCHTEL A., HAUCK M., JACOBSEN P., JOHN V. & LITTERSKI B.
1996 Rote Liste der Flechten (Lichenes) der Bundesrepublik Deutschland. Schriftenreihe für Vegetationskunde 28: 307-368.

WOODS R. G. & COPPINS B. J.
2003 A Conservation Evaluation of British Lichens. London, British Lichen Society.