

An isolated site of calciphilous lichens in the Kujawy region

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Abstract. The paper presents a list of lichen species occurring in three quarries and on mine dumps located within the dust emission impact zone of the cement plant “Kujawy”. The species occur in the lowlands far from their natural localities on limestone rocks in southern Poland. The study area is therefore a valuable habitat island for epilithic and epigeic species of calciphilous lichens in central Poland. Particularly noteworthy are taxa characteristic of natural limestone rocks found in mountain areas of Poland: *Verrucaria calciseda*, *Verrucaria nigroumbrina* *V. obfuscans* and *V. polysticta*, as well as nine species from the Polish Red List of Lichens: *Bacidia rubella*, *Caloplaca* cf. *cerina*, *Enchylium coccophorum*, *Endocarpon pusillum*, *Heppia adglutinata*, *Lempholema chalazanum*, *Goidanichia ambrosiana*, *Thelidium incavatum* and *Th. papulare*.

Key words: biodiversity, lichenized fungi, endangered species, calciphilous lichens, Kujawy, environmental island, anthropopression, anthropogenic habitats.

1. Introduction

Human impact on the landscape is usually manifested in its fragmentation, followed by simplification of the vegetation structure, which leads to the degradation and loss of habitats and consequently biodiversity decline (cf. Fahrig, 2003; Fischer & Lindenmayer, 2007). In some cases, however, man creates new semi-natural habitats, which do not occur spontaneously in a given area. Their presence extends the range of many groups of organisms. Examples of such habitats include old quarries and waste dumps of lime industry in the Kujawy region. They are particularly valuable in lichenological terms as they represent habitat islands with specific calciphile lichen biota comprising a number of rare lowland species. This is an example of human impact on the distribution and dispersion of lichens that enables colonization of new regions by these organisms (cf. Wirth, 1995).

The research aimed at taxonomic classification of lichens occurring in the study area, description of their biota

and habitat preferences as well as a compiled list of lichen species identified so far in this area.

2. Study area

The research was conducted in the area of the Wapienno Mining Plant (excavation pits in Wapienno and Bielawy together with external dumping grounds), i.e. the limestone quarry Lafarge Holcim Cement S.A., the Division in Bielawy, located on the upland plain in the north-eastern part of the Gniezno Lakeland (Kondracki, 2009), about 20 km west of Inowrocław (Fig. 1). The area of quarries stretches over approximately 6 km between Wapienno and Piechcin, at the south-western side of provincial road no. 251 (route Żnin – Inowrocław). It consists of three, currently connected excavation pits. The largest, working pit located in Wapienno stretches as an irregular strip in the south-easterly direction and connects with the older quarry situated in Bielawy, which turns into the third excavation pit located

in Piechcin. The width of the investigated zone is up to ca. 1 km. High mine waste dumps are located next to the quarries; they consist mostly of clay relocated during limestone exposure. Smaller areas are covered by waste lime dumps. Dumping grounds, similarly to the excavation pits, are exposed to human impact of varying intensity. Some of them are covered by newly excavated material, while others are left to natural succession. The whole study area is heavily contaminated with lime dust released not only by the pits, but mostly by the “Kujawy” cement plant located in the immediate vicinity of the quarries.

Limestone mining has begun within the discussed area in 1860 (Czajkowski, 1969) and has been connected with a tectonic uplift referred to as the Central-Polish Anticlinorium or the Kuyavian-Pomeranian anticline. Large blocks of Jurassic limestone are buried beneath a relatively thin layer of boulder clay (3-10 m) on the SW slope of this major uplift; they are exposed to a depth of 60-100 m. Crevices, karst caves and dolomites can be observed on the walls of the quarries. Dolomites occur in the form of veins and irregular pockets with a diameter ranging from a few to several metres (Passendorfer & Wilczyński, 1961).

Study sites:

1. Quarry in Wapienno (52°49'54"N 17° 58'34"E)
2. Dumps in Wapienno (52°49'50"N 17° 57'38"E)
3. Quarry in Bielawy (52°49'08"N 18°00'32"E)
4. Quarry in Piechcin (52°48'52"N 18° 01'45"E).

According to the symbols used in the ATPOL system of grid squares (Zajac, 1978), the study area is located within square CC56.

3. Materials and methods

Taxonomic material was collected in the course of fieldwork conducted in 1994-1998 as well as in 2004 and 2006. The study material consisted mostly of specimens of epilithic lichens growing on old walls of quarries and epigeic lichens collected on mine dumps and stacking yards. In addition, relatively rare specimens of epiphytic lichens collected from the bark of trees growing along access roads and other places adjacent to the quarries were also identified.

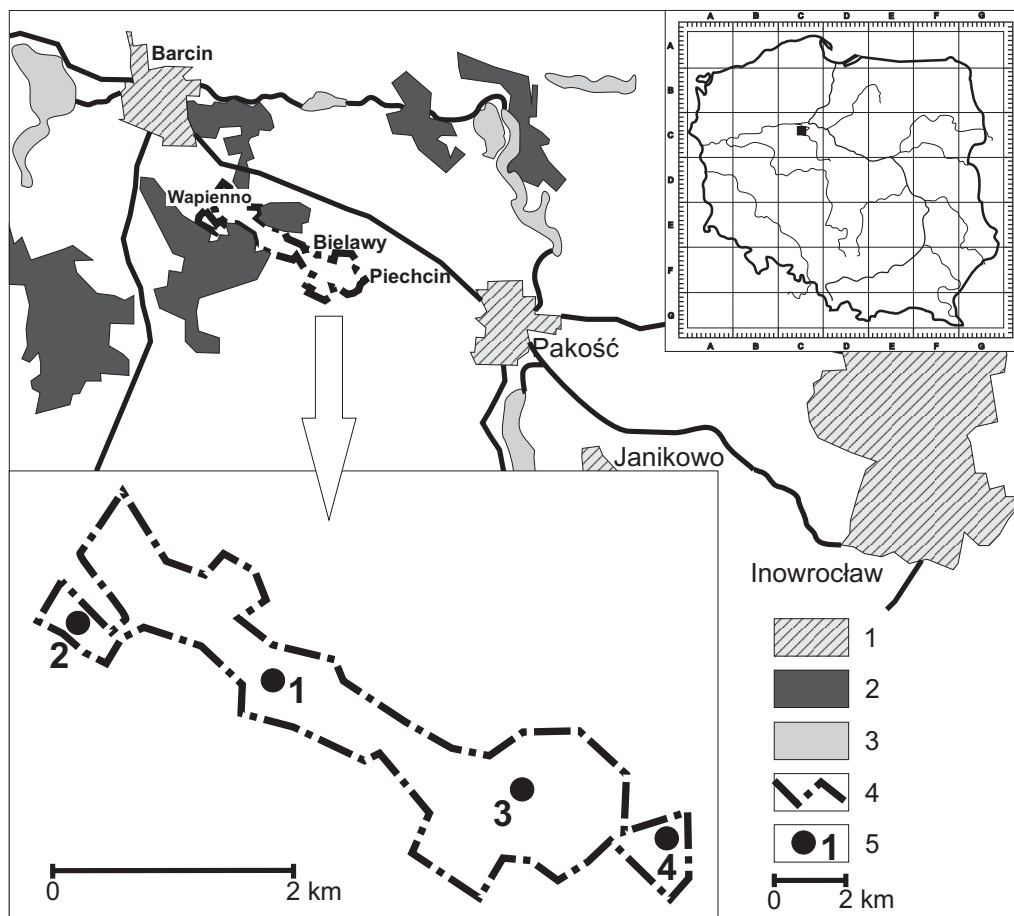


Figure 1. Location of the research area and study sites; 1 – towns and cities, 2 – forests, 3 – lakes, 4 – quarry border, 5 – study sites (1 – Quarry in Wapienno, 2 – Dumps in Wapienno, 3 – Quarry in Bielawy, 4 – Quarry in Piechcin)

Lichens were identified using several identification keys, e.g. Purvis et al. (1994), Wirth (1995), Smith et al. (2009), Nowak & Tobolowski (1975). Identification of species from the genus *Verrucaria* was based mainly on the work by Krzewicka (2012).

The list of species provides: the site name, the frequency of occurrence, the type of substrate, habitat and the category of threat. Categories of threat were determined according to the Red List of Threatened Lichens in Poland (Cieśliński et al. 2006): EN – Endangered, VU – Vulnerable, NT – Near Threatened.

The frequency of occurrence of individual taxa was assessed as: very rare, rare, relatively rare, frequent, relatively common and common.

The collected material was deposited at the Herbarium of Nicolaus Copernicus University in Toruń (TRN).

Nomenclature of species followed mostly the Index Fungorum (2016) database and Fałtynowicz & Kossowska (2016). Nomenclature for *Collema* was used according to Otálora et al. (2014), for the genus *Verrucaria* (Krzewicka, 2012), except for *Verrucaria calciseda*.

4. Results and discussion

A total of 53 lichen species were found in the study area, including epilithic, epigeic and epiphytic lichens. Given the size of the study area, the identified biota of lichens is relatively large. For comparison, 57 calciphilous species were reported from northern Poland (Sągin, 1998), 160 taxa of epilithic calciphilous lichens were identified on naturally exposed rocks in the Kraków-Wieluń Upland (Nowak, 1967), 152 species in the Pieniny Mountains (Tobolewski, 1958) and 153 species in the Western Tatras (Olech, 1985).

List of species

- Acarospora moenium* (Vain.) Räsänen [syn. *Aspicilia moenium* (Vain.) G. Tor & Tindal] – Wapienno, Bielawy, frequent on limestone and metal in the upper parts of the quarries, near industrial buildings.
- Athallia holocarpa* (Hoffm.) Arup, Frödén & Søchting [syn. *Caloplaca holocarpa* (Hoffm.) A.E. Wade] – Wapienno, Bielawy, Piechcin, relatively common, on rocks and bark of *Salix* spp.
- Bacidia rubella* (Hoffm.) A. Massal. – Wapienno rare, on the bark of *Salix* spp., near the mine dump, VU.
- Bilimbia sabuletorum* (Schreb.) Arnold [syn. *Myxobilimbia sabuletorum* (Schreb.) Hafellner] – Piechcin, Bielawy, scattered, on mosses and bare soil.
- Blennothallia crispa* (Weber ex F.H. Wigg.) Otálora, P.M. Jørg. & Wedin [syn. *Collema crispum* (Huds.) Weber in F.H. Wigg. var. *crispum*] – Wapienno, Bielawy, Piechcin, common, on the ground, limestone and mosses covered with a thick layer of dust, usually in the barren form adapted to vegetative propagation.
- Buellia griseovirens* (Turner & Borrer ex Sm.) Almb. – Wapienno, rare, on the bark of *Salix* spp., at the mine dump.
- Caeruleum heppii* (Nägeli ex Körb.) K. Knudsen & Arcadia [syn. *Acarospora heppii* (Naeg. in Hepp) Naeg. in Körb.] – Wapienno, rare, on small pebbles collected on the mine dump.
- Calogaya decipiens* (Arnold) Arup, Frödén & Søchting [syn. *Caloplaca decipiens* (Arnold) Blomb. & Forss.] – Wapienno, Bielawy Piechcin – common, on limestone, in sunlit places.
- Caloplaca saxicola* (Hoffm.) Nordin] – Piechcin, frequent on long-exposed limestone.
- Caloplaca* cf. *cerina* (Hedw.) Th. Fr. – Bielawy, rare, VU.
- Candelariella aurella* (Hoffm.) Zahlbr. – Wapienno, Bielawy, Piechcin – common, on sunlit limestone and bark of trees (*Populus* spp., *Salix* spp.).
- Clauzadea monticola* cf. (Ach.) Hafellner & Bellem. – Wapienno.
- Flavoplaca citrina* (Hoffm.) Arup, Frödén & Søchting [syn. *Caloplaca citrina* (Hoff.) Th.Fr.] – Piechcin, rare, recorded on a concrete pillar.
- Enchylium coccophorum* (Tuck.) Otálora, P.M. Jørg. & Wedin [syn. *Collema coccophorum* Tuck.] – Bielawy, Piechcin, relatively common on the ground, on a small elevated surface, on the western side of tracks and access roads of the quarry, EN.
- Enchylium limosum* (Ach.) Otálora, P.M. Jørg. & Wedin [syn. *Collema limosum* (Ach.) Ach.] – Wapienno, Bielawy, Piechcin, relatively common on the ground and weathering rock waste, along the roads and on the mine dumps.
- Enchylium tenax* (Sw.) Gray – Piechcin, relatively common on small dumps surrounding the quarry from the west and south.
- Endocarpon pusillum* Hedw. – Bielawy Piechcin, relatively common on mosses and humus soil, in sunny places, on the edge of quarries, VU.
- Goidanichia ambrosiana* (A. Massal.) Tomas. & Cif. [syn. *Staurothele ambrosiana* (A. Massal.) Zschacke] – Piechcin, very rare on small stones covering the limestone waste heap, VU.
- Heppia adglutinata* (Kremp.) A. Massal. [syn. *Hepia lutosa* (Ach.) Nyl.] – Piechcin, collected once in a small rock crevice, on the western wall of the quarry, EN.
- Lecania erysibe* (Ach.) Mudd – Bielawy, Piechcin, relatively common on limestone, in dry and sunny places.
- Lecidella stigmatea* (Ach.) Hertel & Leuckert – Piechcin, rare on limestone.

22. *Lempholemma chalazanum* (Ach.) B. de Lesd. – Piechcin, relatively rare, on old mine dumps and calcareous soil in the near and further vicinity of the quarry, e.g. at the fence of the stadium, NT.
23. *Leptogium byssinum* (Hoffm.) Zwackh ex Nyl. – Wapienno, on a high waste dump and on the roadsides, in some places abundant and scattered over a large area, at others difficult to find.
24. *Mycobilimbia tetramera* (De Not.) Vitik., Ahti, Kuusinen, Lommi & T. Ulvinen ex Hafellner & Türk [syn. *M. fusca* (A. Massal.) Hafellner] – Wapienno, rare, amidst mosses in the lower part of the quarry.
25. *Myriolecis albescens* (Hoffm.) Śliwa, Zhao Xin & Lumbsch [syn. *Lecanora albescens* (Hoffm.) Flörke] – Wapienno, Bielawy, Piechcin, common on limestone along edges of quarries.
26. *Myriolecis dispersa* (Pers.) Śliwa, Zhao Xin & Lumbsch [syn. *Lecanora dispersa* (Pers.) Sommerf.] – Wapienno, Bielawy, Piechcin same as *M. albescens*.
27. *Myriolecis hagenii* (Ach.) Śliwa, Zhao Xin & Lumbsch [syn. *Lecanora hagenii* (Ach.) Ach.] – Wapienno, Bielawy, Piechcin, common on trees and shrubs of the study area, especially on the bark of *Salix* spp.
28. *Parmelia sulcata* Taylor – Wapienno, Bielawy, Piechcin, common on trees and shrubs of the study area, especially on the bark of *Salix* spp. and *Pinus sylvestris*.
29. *Peltigera rufescens* (Weiss) Humb. – Bielawy Zachodnie, rare, amidst mosses, on the land elevation.
30. *Phaeophyscia nigricans* (Flörke) Moberg – Wapienno, rare on the bark of *Salix* spp.
31. *Phaeophyscia orbicularis* (Neck.) Moberg – Wapienno, Bielawy, Piechcin, frequent, on limestone and bark of trees.
32. *Physcia adscendens* (Fr.) H. Olivier – Piechcin, relatively rare, on limestone with a thick layer of dust.
33. *Physcia tenella* (Scop.) DC., in Lamarck & de Candolle – same as *Ph. adscendens*.
34. *Protoblastenia rupestris* (Scop.) J. Steiner – Wapienno, relatively common but over a small area on a steep, unexploited wall of the quarry overgrown with *Pinus sylvestris*.
35. *Sarcogyne regularis* Körb. – Bielawy, rare, on the eastern wall of the quarry receiving large amounts of sunlight.
36. *Thelidium incavatum* Nyl. ex Mudd – Wapienno, Piechcin, rare, on a wall slightly shaded by trees, in the lower part of the quarry, in the place which has not been exploited for more than 20 years. Specimens from Wapienno identified as *Th. incavatum* have spores smaller than the average size presented in the descriptions of this species and a large percentage of degenerated spores. The size of spores is similar to *Th. corconticum* Servit (1954), of unclear taxonomic rank, described from the Czech Karkonosze Mountains (Ceynowa-Giełdon & Adamska, 2014), NT.
37. *Thelidium papulare* (Fr.) Arnold – Wapienno, Piechcin, rare, on an old, unexploited wall of the quarry, accompanied by *Th. incavatum* (Ceynowa-Giełdon & Adamska, 2014), NT.
38. *Thelidium rimosulum* Ceyn.-Giełd. – Bielawy, Piechcin, rare, on long-exposed limestone in the western part of the study area. Piechcin (isotyp) (Ceynowa-Giełdon, 2007; cf. Ceynowa-Giełdon & Adamska, 2014).
39. *Thelidium zwackhii* (Hepp) A. Massal. – Wapienno, Piechcin, rare, on a dump and in the lower part of the excavation pit with water (Ceynowa-Giełdon & Adamska, 2014).
40. *Verrucaria aethiobola* Wahlenb. [syn. *Verrucaria cataleptoides* (Nyl.) Nyl.] – Piechcin, on a dump, (22.09.1994, 23.9.1994). Wapienno – at the quarries (13.07.1993); (det. Beata Krzewicka). Reported from Carpathians and North Poland (Krzewicka, 2012).
41. *Verrucaria bryoctona* (Th. Fr.) Orange – Piechcin, very rare, on the ground, near the road at the south-eastern side of the limestone excavation pit. According to Krzewicka (2012), the species grows on basic soil.
42. *Verrucaria calciseda* DC. [syn. *Bagliettoa calciseda* (DC.) Gueidan & Cl. Roux] – Piechcin, rare, on long-exposed limestone, in the warm place with a direct sunlight (17.10.2006).
43. *Verrucaria dolosa* Hepp – western part of Bielawy.
44. *Verrucaria maculiformis* Kremp. – Bielawy, Piechcin, between the quarries, together with *V. nigrescens* i *V. muralis*.
45. *Verrucaria muralis* Ach. – Wapienno, Bielawy, Piechcin, common on sunny rocks and small stones.
46. *Verrucaria nigroumbrina* (A. Massal.) Servit – Wapienno, in the excavation pit of the quarry, Bielawy, Piechcin, on long-exposed limestone (13.07.1993); (det. Beata Krzewicka). According to Krzewicka (2012), this taxon is known in Poland from a few locations in the Carpathians.
47. *Verrucaria nigrescens* Pers. – Wapienno, Bielawy, Piechcin, common in places with direct sunlight, on long-exposed limestone, sometimes in the barren form with soredia.
48. *Verrucaria obfuscans* Nyl. – western part of Bielawy, Piechcin, rare on long-exposed limestone, in sunny and warm places.
49. *Verrucaria* cf. *policensis* Servit – Bielawy, collected on a waste heap (4.09.1993); (det. Beata Krzewicka).
50. *Verrucaria polysticta* Borrer [syn. *V. subfuscella* Nyl.] – Wapienno, on an old, unexploited wall of the quarry (4.04.2004). According to Krzewicka (2012), the species occurs in areas with large natural limestone outcrops e.g. the Kraków-Częstochowa Upland.

51. *Verrucaria tectorum* (A.Massal.) Korb – Wapienno, at the bottom of the quarry, at a long-exposed wall, together with *V. muralis*. (det. Beata Krzewicka).
52. *Verrucaria viridicans* Servit – Piechcin, collected in the limestone excavation pit (8.08.1995); (det. Beata Krzewicka). The taxon is known in Poland only from the Kraków-Wieluń Upland (Krzewicka, 2012).
53. *Xanthoria parietina* (L.) Th. Fr – Wapienno, Bielawy, Piechcin, common on trees and shrubs of the study area, especially on the bark of *Salix* spp.

It is also very interesting to compare the capacity of lichens from the discussed group for colonizing the anthropogenic habitats. As described by Sągin (1998), the dispersion mode of taxa might be an important aspect in this process of colonization. Most species of lichens colonizing anthropogenic rock substrates produce numerous apothecia, while species characteristic of natural habitats produce mostly barren thalli with isidia.

On the naturally exposed limestone rocks in the southern part of Poland, lichens are represented by a larger number of species compared to artificial substrates with similar properties. As reported by Pietrzykowska and Kossowska (2010), in the Polish part of the Karkonosze Mountains where there are no natural limestone rocks, calciphilous lichens occur on anthropogenic limestone substrates which result from the construction of mountain hostels. A total of 28 calciphilous lichen species were found there. As described by Szczepańska (2008), a total of 170 species were identified on the rock substrates in the Śnieżnik Massif and in the Bialskie Mountains. Twenty two species were identified on natural outcrops of limestone rocks in Kleśnica (e.g. *Acarospora cervina*, *Dermatocarpon miniatum*, *Scytinium gelatinosum* [syn. *Leptogium gelatinosum*]), and only 8 species on rocks in a marble quarry. Like in Wapienno, Szczepańska (2008) found *Clauzadea monticola* and *Protoblastenia rupestris* on the rocks of the quarry in Kleśnica. The species also occurred on the surface of concrete poles and ruins of buildings. On the other hand, *Collema tenax* and *Sarcogyne regularis* were found by Szczepańska only on the natural substrate in the quarry and on the rock outcrops.

Twenty five epilithic lichen species were found in the Świętokrzyski National Park and in the buffer zone on natural limestone substrates (rocks of Zapusty). Twenty nine taxa were described from artificial bedrock. *Circinaria contorta* [syn. *Aspicilia contorta*], among others, as well as the above-mentioned taxa: *Dermatocarpon miniatum* and *Protoblastenia rupestris* (Łubek, 2007) occurred only on natural rocks.

According to Fałtynowicz (1992), calciphilous lichens (mainly *Myriolecis dispersa*, *Candelariella aurella*, *Myriolecis albescens*, *Phaeophyscia orbicularis*) occur in Western Pomerania on anthropogenic substrates connected with

urban areas and containing calcium carbonate. These pioneer species with a wide ecological amplitude were also found on natural and artificial substrates in the Polish Sudetes (Kossowska, 2008).

Due to the varying intensity of human impact, no lichens or only their initial barren thalli occur over a large area of the strip limestone mine in Kujawy. However, not only the direct mining activity is unfavourable for many lichens. Much more harmful to lichens is pollution generated by dust emission from the large cement plant located in the immediate vicinity of the mine. For this reason, several components of the lichen biota occur in the described area often in a very impoverished form, with a large percentage of degenerated spores.

A different time elapsed since the exposure of limestone substrates makes it possible to follow the succession process of lichens. Crustose species from the genera *Verrucaria* and *Thelidium* are the first to colonize the limestone. They are represented by very rare species: *Thelidium rimosulum* – previously described from Piechcin (Ceynowa-Gieldon, 2007) as well as *Th. incavatum* and *Th. papulare* (cf. Ceynowa-Gieldon & Adamska, 2014) observed for the first time in the Kujawy region far from their natural sites located in the uplands and mountains in the southern part of Poland (Fałtynowicz, 2003). The genus *Verrucaria* is represented by a larger number of species, including *Verrucaria muralis* and *V. nigrescens* – common in Poland, encountered on artificial habitats, often in urban areas (e.g. Adamska, 2014). Less common are *Verrucaria aethiobola* and *V. tectorum*. – known also from the lowland and mountain areas, as well as *V. nigroumbrina*, *V. obfuscans*, *V. polysticta*, *V. cf. policensis* and *V. viricans* – for the first time collected in Kujawy, far from their natural locations on limestones in the southern part of Poland (Fałtynowicz, 2003; Krzewicka, 2012). In addition, species new to Kujawy include also *Verrucaria calciseda*. For comparison, Christensen & Alstrup (2013) reported only one species from the genus *Verrucaria* – *V. muralis* on e.g. limestone rock outcrops in the mountains of northern Greece.

Among more or less common species from the genus *Verrucaria*, the following species common in Poland: *Candelariella aurella*, *Myriolecis dispersa*, *Myriolecis albescens*, *Calogaya decipiens*, *Calogaya pusilla* and species from the genus *Phaeophyscia* and *Sarcogyne regularis* occur in large numbers on sunlit, long-exposed rocks at the quarries of the study area. Barren thalli of *Acarospora moenium* were observed on the most polluted rocks and metal scraps near industrial buildings.

Species growing on the ground, on dusty mosses and plant debris, on mine waste dumps and rock debris are a separate group of lichens characteristic of areas adjacent to the limestone mines in Kujawy. They are represented mainly by taxa from the family *Collemataceae*, including the most common *Blennothallia crispa* – formerly regarded

as a variety typical of the taxon *Collema crispum*, and less common *C. crispum* var. *metzleri*. Another common lichen in the study area was *Enchylium limosum* – a widespread species in the Kujawy region (Ceynowa-Giełdon, 2001; Ceynowa-Giełdon et al., 2004). Less frequently encountered representatives of the family *Collemataceae* include: *Enchylium coccophorum*, *E. tenax*, *Leptogium byssinum* and *Lempholemma chalazanum*. In warm places exposed to the direct sunlight, thalli of *Endocarpon pusillum* were relatively common in addition to species from the genus *Blennothallia* and *Enchylium*. Also *Heppia adglutinata* was found in the area – a very rare species in Poland.

Epiphytic species, i.e. the most sensitive to air pollution are least represented in the local biota of lichens. Common calciphilous species, e.g. *Athallia holocarpa*, *Candelariella aurella* and *Phaeophyscia orbicularis* – encountered in Poland both on natural rocks and artificial limestone habitats, as well as on the bark of trees and shrubs with more or less alkaline reaction – were found in the study area mainly on the bark of trees and shrubs growing near the mine. As a result of heavy lime dust in the direct vicinity of the mine, they do not show a clear attachment to individual phorophytes. Some of them occur even on the bark of *Pinus* characterised by acid reaction (cf. Cieśliński & Jaworska, 1986; Cieśliński i Czyżewska, 1992; Loppi & Pirintos, 2000). The impact of eutrophication of the bark of trees by the lime dust on the occurrence of epiphytic lichens was also described by e.g. Gilbert (1976) and Kortesharju & Kortesharju (1989).

The relative abundance of threatened (to a varying extent) lichens proves the high natural value of the study area. Nine species from the Red List of Threatened Lichens in Poland (Cieśliński et al., 2006) were found in this area, including *Enchylium coccophorum* and *Heppia adglutinata*, classified as endangered species (EN), *Bacidia rubella*, *Endocarpon pusillum* and *Goidanichia ambrosiana* classified as vulnerable species (VU) and *Lempholemma chalazanum*, *Thelidium papulare* and *Th. incavatum* classified as near threatened (NT). Furthermore, *Thelidium rimosulum*, known so far only from the described area as new to science, could be added to the Red List of Lichens in Poland.

On the regional scale and the scale of northern Poland, *Verrucaria calciseda*, *Lecania erysibe*, *Protoblastenia rupestris* and *Verucaria obfuscans* (rare in lowlands) as well as other species widespread in mountains and uplands of the southern part of the country should be included in the list of rare and endangered species.

5. Conclusions

The area of the discussed strip limestone mine represents an important habitat island for calciphilous lichen species in the Polish lowlands, located far from the limestone

uplands and mountains. So far, 53 lichen taxa have been found there, which proves the taxonomic richness of the calciphile lichen biota, given the small area located in the lowlands of central Poland. The biota includes rare species from the Polish Red List of Threatened Lichens, growing far from their main distribution range. Due to the unique nature of this biota, further lichenological studies in the described area are needed.

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