

Lichen recolonization in the city of Toruń

Edyta Adamska

Department of Plant Taxonomy and Geography, Institute of Ecology and Environment Protection,
Nicolaus Copernicus University, Gagarina 9, 87-100 Toruń, Poland
e-mail: adamska@umk.pl

Abstract. Together with the decreasing pollution load in the atmosphere, particularly with sulphur oxides, one can observe inhibition of the process of lichens' biota impoverishment in areas with the increased anthropopressure. Since the end of the 1970s, in most of the cities of Western Europe, the process of recolonization by lichens has been observed. Recently, this phenomenon has been described also in Poland. As a consequence of lichenological researches, carried out in the city of Toruń between 2001 and 2010, as well as based on the literature data, one can confirm the first symptoms of the process of recolonization by these organisms within the city area. In this paper, the most spectacular examples are presented in order to illustrate the early process of recolonization by epiphytic lichens in the city of Toruń during the last 60 years.

Key words: air pollution, environmental monitoring, lichens, recolonization, SO₂, Toruń, urban area.

1. Introduction

As emphasized by many authors, lichens are sensitive indicators of changes in habitat conditions, including air pollution (e.g.: Fałtynowicz 1995; Conti & Cecchetti 2001; Nash 2008).

The phenomenon of lichens' response to changes in the atmospheric concentration of SO₂ is described by e.g. Seaward (1997), according to whom an insignificant increase in SO₂ concentration brings about a significant reduction in the species diversity, whereas even high reduction of SO₂ emission does not at all or only insignificantly affects the growth of species diversity. Furthermore, lichens respond to changes in SO₂ concentration with some delay, as quoted by e.g. Seaward and Letrouit-Galinou (1991), clear symptoms of these responses might be visible after 4–5 years.

Cities all over the world have become an object of observations in respect of the process of recolonization by lichens (e.g.: Rosa & Hawksworth 1981; Hawksworth &

McManus 1989; Pertti 2001; Isocrono et al. 2007; Larsen et al. 2007; McClenahan et al. 2007).

Apart from urbanized areas, recolonization by lichens against a background of changing habitat conditions, was also analysed in forest areas, both in Poland (inter alia Kiszka 2002), as well as outside the borders of the country (e.g. Wagner et al. 2006).

Global environmental changes, from acidification to an increase of habitats' trophic, as a consequence of fertilization of substrata with nitric compounds brought about spreading of nitrophytic and neutrophytic lichen species (Kriecke & Feige 2004).

Recolonization by lichens is a response of these organisms to changes in habitat conditions; on the one hand, a decrease in the emission of sulphur and nitrogen oxides can be observed, and on the other hand – the increase of dustiness (e.g.: Seaward & Letrouit-Galinou 1991; Purvis et al. 2003; Bates 2004; Fałtynowicz 2004; Seaward & Coppins 2004; Larsen et al. 2007).

Improvement of the air quality in Poland has begun with certain delay in relation to changes in industrialized Europe. According to Grodzińska and Szarek (1995), as compared to other European countries, Poland is one of the most polluted countries with industrial emissions. At the turn of the 1980s and 1990s, Poland was one of the main producers of SO₂, and at that time, the emission of this gas from the Polish territory amounted to over 4 million tons.

According to the report on environmental conditions, since the beginning of the 1990s, a tendency has been observed in Poland for the decreasing concentrations of toxic substances in the atmospheric air, for instance the emission of SO₂ was reduced by half at that time (cf. Fałtynowicz 2004).

Impoverishment of lichens' biota in Poland was described in the areas, where lichenological researches have been carried out till the end of the 1990s (e.g.: Wilkoń-Michalska et al. 1988; Kiszka 1993; Kiszka 1999; Śliwa 2000).

Whereas, the effects of the tendency for the decreasing emission of pollutants, observed in Poland since the beginning of the 21st century, are already evident in the studies on the biota of lichens after 2000 (Kiszka 2002; Fałtynowicz 2004; Kubiak 2005; Adamska 2008).

2. The study area

The city of Toruń is situated between 52° 58' and 53° 04' of north latitude, and between 18° 32' and 18° 43' of east longitude. Within the current administrative limits, the city covers the area of over 115 km². According to physical and geographical regionalization of Poland, Toruń is situated in the mesoregion of the Toruń Valley, the macroregion of the Toruń-Eberswalde ice-marginal Valley, included within the subprovince of the South Baltic Lakeland (cf. Andrzejewski & Kot 2006).

3. Materials and methods

Lichenological studies were conducted in 2001–2010. The study area is located within the administrative limits of the city of Toruń. Collection of lichens was done from all possible substrata of their occurrence, with particular consideration for epiphytic lichens. The collection was performed in accordance with the system of squares of 1x1 km ATPOL, modified for lichenological objectives (Cieśliński & Fałtynowicz 1993). Historical data on the species composition and the occurrence of lichens in the city of Toruń from the 1950s and 1980s (Wilkoń-Michalska et al. 1988), as well as modern data, were compiled on cartograms in order to reveal changes in time and space. The identification keys by Purvis et al. (1992) and other monographs

were used to identify the collected lichens. The names of lichens are given after Diederich et al. (2010).

4. Results and discussion

In Toruń, during the last 60 years, since the first lichenological information, at first a considerable impoverishment of lichens' biota was recorded (Wilkoń-Michalska et al. 1988), whereas at present, a reversal process has been observed. Conclusions included in the literature, related to the impoverishment of lichens' biota in Toruń, were connected with the progressive dynamic development of the city during this period. Deteriorating environmental conditions had been affecting the quality of life in Toruń as long as the late 1990s.

Since 2001, habitat conditions of the city have been significantly improving. The level of SO₂ concentrations in Toruń considerably decreased over the years, at all measuring points (Wojtczak et al. 2007).

During the on-going lichenological researches in Toruń, based on the documented cartographic literature data, the assumption was made about the possibility of lichens' return to their previously occupied sites.

At present, nitrophilous, coniofilous and heliophilous species are spreading in Toruń due to changes in the type and concentrations of pollutants. This concerns mainly epiphytic lichens, such as: *Phaeophyscia orbicularis*, *Physcia tenella*, *Xanthoria candelaria*, *X. parietina* and *X. polycarpa*. The contribution of these species at particular research sites (squares) is presented in Figure 1. At present, these taxa occur in particularly large numbers in the centre of the city.

The return of *Xanthoria polycarpa* is a particularly evident example (Fig. 2A). According to Wilkoń-Michalska et al. (1988), in the 1950s, the species was recorded at more than a half of the localities in the centre of Toruń, whereas after 30 years, thalli of this lichen were recorded at only 3 sites distant from the city centre. At present, *X. polycarpa* has returned to the previously occupied sites, so the number of sites increased (more than 60% of the sites) and it spreads over the entire area of the city.

Xanthoria parietina is another species that spreads currently in the area of Toruń. This taxon was recorded at 99 sites (more than 73% of the sites), while in 1980s, *X. parietina* was recorded at only 33 sites, far from the industrial centre of the city (Fig. 2B).

For comparison, Kepel (1999) observed that during 40 years, biota of lichens in Poznań underwent a considerable impoverishment. For example in the 1950s, *Xanthoria parietina* (Fig. 3) occurred in Poznań, similarly like in Toruń, in the city centre at most of the sites, while 40 years later, the range of this species shifted towards the city limits. The author drew similar conclusions also regarding the oc-

currence of *Xanthoria polycarpa* in the city of Poznań. At that time, no symptoms of recolonization by these species were recorded.

However, in the city of Kielce, similarly like in Toruń, spreading of some species was observed during the current lichenological researches, e.g.: *Phaeophyscia orbicularis* and *Xanthoria parietina* (Łubek 2010).

Physcia tenella constitutes an example of yet another nitrophilous lichen returning to former occurrence localities in Toruń. At present, it covers 107 localities, whereas in the 1980s, this species was recorded at only 16 sites far from the city centre. Whereas 60 years ago, *Physcia tenella* occurred, like at present, also in the centre of Toruń (Fig. 2C).

For instance, based on the data on the occurrence of lichens during 200 years in the city of Turin, the influence of changes in the habitat conditions in this city has become visible. The following decrease in the atmospheric concentration of SO₂ was recorded in Turin – for example, from 2000 µg/m³ in 1973 to 53 µg/m³ in 1996. At present, nitrophilous species are spreading there like in Toruń (Isocrono et al. 2007).

In the Ruhr Valley, one of the most industrialized areas of Europe, inter alia *Physcia tenella* and *Phaeophyscia orbicularis* currently dominate, likewise in Toruń. Gradual withdrawal of acidophilous species from this area is also

noteworthy, such as toxitolerant *Lecanora conizaeoides* (Kriekke & Feige 2004).

So far, no withdrawal of *L. conizaeoides* has been observed in Toruń. This taxon occurs at most of the research sites in the town, although still in the 1950s it was one of the rare species.

Apart from nitrophilous species, also sensitive acidophilous species are returning to Toruń, such as *Parmelia sulcata* (Fig. 2D).

Among others, recolonization by *Parmelia sulcata* was observed also in Paris, where after 100 years, single thalli of this species were recorded (Seaward & Letrouit-Galinou 1991). At present, a similar situation takes place in many towns of Poland, e.g. in the town of Wrocław (Dimos 2002).

One can also talk about the initiated recolonization by *Evernia prunastri* in Toruń. At present, the number of sites in the town, where this species occurs, has considerably increased, but still it has not been recorded in the centre of Toruń, where it occurred in large numbers in the 1950s.

In the city of Olsztyn, Kubiak (2005) recorded contemporarily *Evernia prunastri* at as many as 147 sites, and Fałtynowicz (2004) believes that the return of this species is one of the most spectacular examples of the recolonization by lichens in Poland.

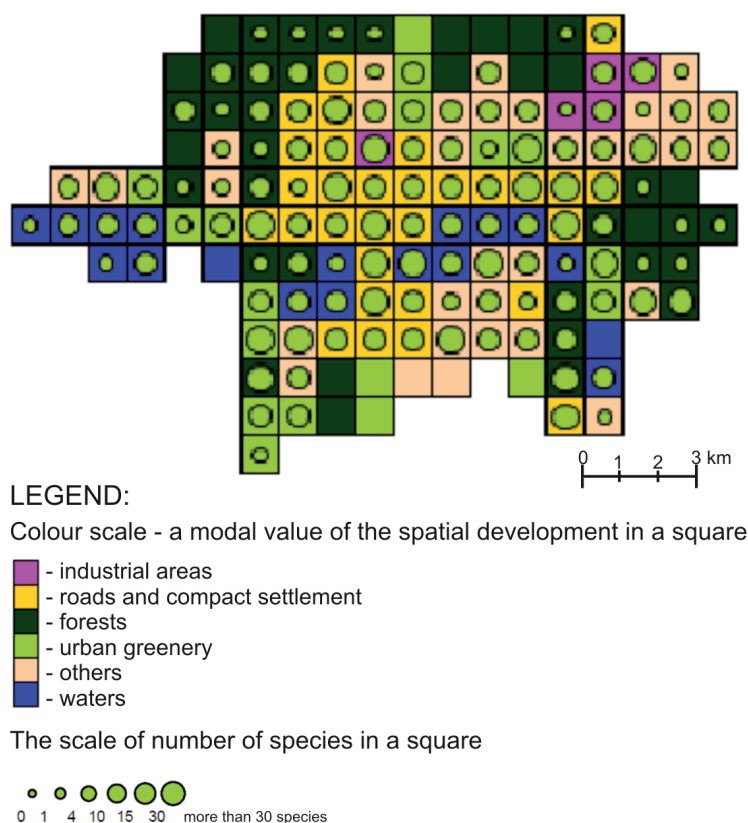
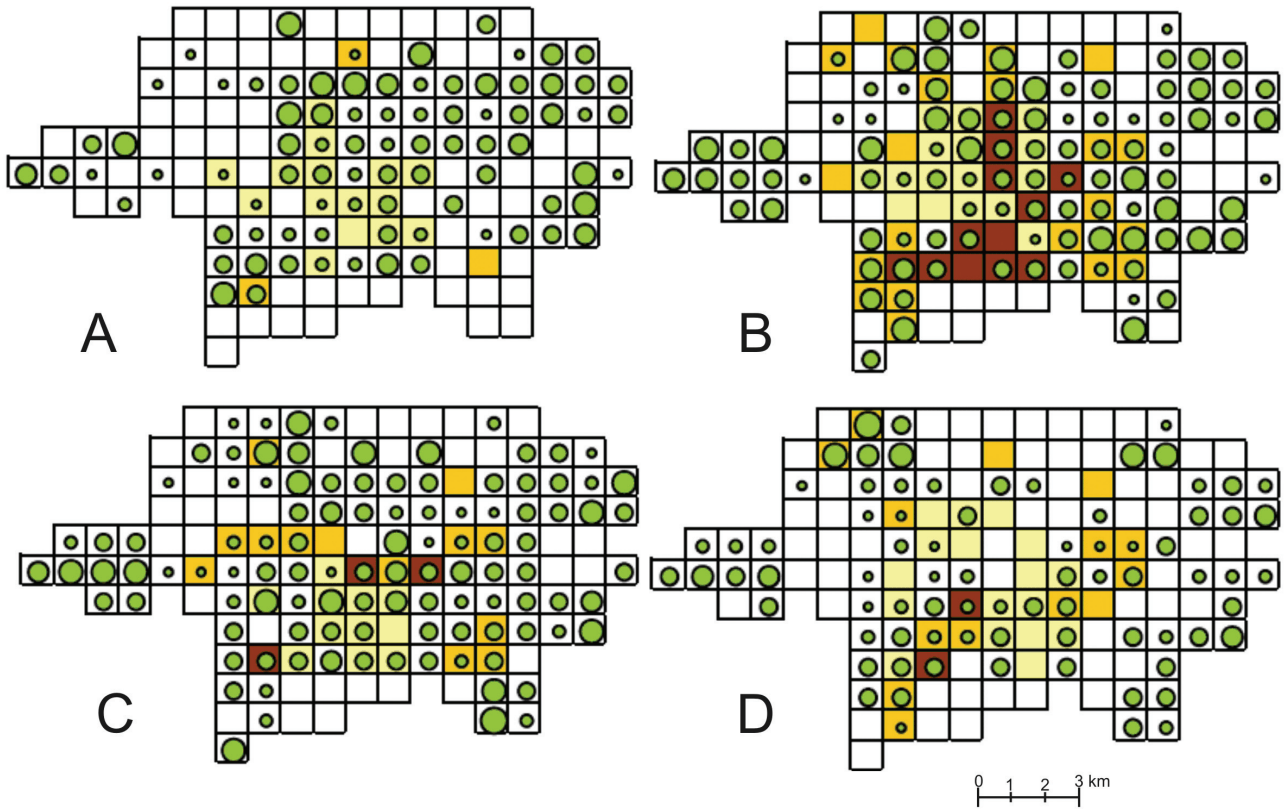


Figure 1. The contribution of nitrophilous species at particular research sites in the city of Toruń in 2001–2010



LEGEND:

The colour scale for particular occurrences during the analysed research periods:

- the 1950s
- the 1980s
- both the 1950s and 1980s

The scale of degrees of cover on all available substrata, expressed in percentage during 2001-2010:

- 0
- 1
- 4
- 10
- 15
- 30
- more than 30 %

Figure 2. The occurrence of lichens (A – *Xanthoria polycarpa* (Hoffm.) Rieber; B – *Xanthoria parietina* (L.) Th. Fr.; C – *Physcia tenella* (Scop.) DC ; D – *Parmelia sulcata* Taylor) in the area of Toruń in the 1950s and 1980s, as well as in 2001–2010 at particular research sites

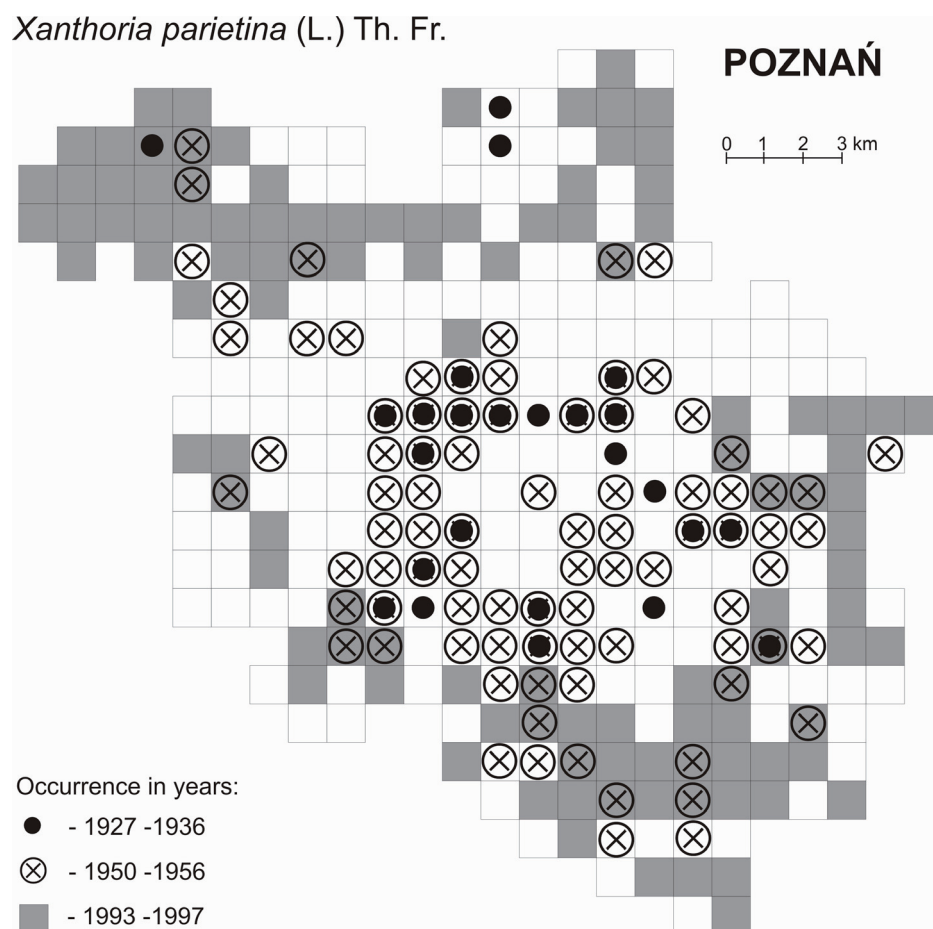


Figure 3. The occurrence of *Xanthoria parietina* (L.) Th. Fr. in the city of Poznań in 1927–1935, 1950–1956 and 1993–1997 (according to Kepel 1999)

5. Conclusions

The process of recolonization by lichens was described in numerous examples in many countries all over the world, recently including also Poland.

The phenomenon of lichens returning to their former sites, against a background of changes in the type and concentrations of pollutants, has been also observed in Toruń.

The most spectacular example is a drop in the concentration of SO₂ in the atmospheric air, which results from the implementation of sustainable development principles in the city management.

At present in Toruń the process of impoverishment of lichens' biota has been inhibited. Currently, due to eutrophication and alkalization of habitats, nitrophilous, coniophil-

ous and heliophilous lichen species become widespread in the town, e.g.: *Xanthoria parietina*, *X. polycarpa*.

To summarize, one can state that based on the analysis of the literature data and on-going lichenological researches concerning the species composition and the distribution of lichens in Toruń, the first symptoms of recolonization by these organisms were observed in the town.

The obtained data constitute the basis for monitoring the process of returning by individual lichen species to their former sites of occurrence.

Acknowledgements

I would like to express my gratitude to the anonymous Reviewer for recommendations and comments on the manuscript of this paper.

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