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Changes in the epiphytic bryophyte flora in Katowice city (Poland)

Adam STEBEL[a*] *& Barbara FOJCIK*[b]

[a]*Department of Pharmaceutical Botany, School of Pharmacy with Division of Laboratory Medicine, Medical University of Silesia in Katowice, Ostrogórska 30, 41-200 Sosnowiec, Poland*

[b]*Department of Botany and Nature Protection, Silesian University, Jagiellońska 28, 40-032 Katowice, Poland*

Abstract – In the area of Katowice city (S Poland) a significant increase in the number of sites of some epiphytes (mainly from the genera *Orthotrichum* and *Ulota*) were recorded. The comparison of their distribution in 2001 and 2015 shows two groups: (1) species of which the number of localities is obviously higher, e.g. *Orthotrichum diaphanum, O. obtusifolium, O. pumilum* and *O. speciosum* and (2) species new in the bryoflora, *i.e. Leskea polycarpa, Orthotrichum affine, O. patens, O. rogeri, O. stramineum, O. striatum, Radula complanata, Syntrichia latifolia, Ulota bruchii* and *U. crispa*. The analysis of the preference of epiphytes towards inhabited phorophytes reveals that the most commonly and abundantly inhabited species were poplar and willow trees, which show higher pH values of bark.

Central Europe / Liverworts / Mosses / Recolonization of epiphytes / Silesia

INTRODUCTION

Among bryophytes, epiphytes (species growing on bark of living trees and shrubs) are a strongly specialized group. They depend on the composition of precipitation, from which they obtain nutrients (Rao, 1982; Smith, 1982). In urbanized areas precipitation contains significant amounts of pollutants, which is an extreme stress factor for epiphytes. The deleterious effects of air pollution on epiphytes have been described by numerous authors since the second half of the twentieth century (e.g. Gilbert, 1968; LeBlanc & De Sloover, 1970; LeBlanc & Rao 1973, 1974; Rao, 1982; Farmer *et al*., 1992). Sensitivity of epiphytes to pollution and local changes in species distribution and composition are used in monitoring of the natural environment (Rao, 1982; Adams & Preston, 1992; Giordano *et al*., 2004; Chakrabortty & Paratkar, 2006).

A long term observation indicates the variable dynamics of the epiphytic bryoflora changes (as well as of the epiphytic lichens biota). Air contamination, especially SO_2, causes the decrease in vitality and the vanishing of most of the epiphytic species. In the sixties and seventies of the twentieth century, the decline of the epiphytic floras under the impact of air pollution was usually described, and

* Corresponding author: astebel@sum.edu.pl

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the absence of epiphytes was particularly emphasized in city centers (Gilbert, 1968; Smith, 1982; Touw & Rubers, 1989; Hallingbäck, 1992; Sim-Sim *et al*., 2000; Govindapyari *et al*., 2010). Over the recent years, the situation has changed. In the most developed countries the emissions of SO_2 have started to decrease considerably over the last decades. As a result of the improvement of air quality, a local increase in epiphytes diversity (both of lichens and bryophytes) has been observed in many European countries. They spread in areas in which they have not been observed for a long time (e.g. Hawksworth & McManus, 1989; Gilbert, 1992; Gunn *et al*., 1995, Vanderpoorten, 1997; Stapper *et al*., 2000; Bates *et al*., 2001; Franzen, 2001; Vanderpoorten & Engels, 2002; Hultengren *et al*., 2004; Zechmeister *et al*., 2007; Duckett & Pressel, 2009; Fudali, 2011). In urbanized areas, for example, the appearance or the significant increase in the number of localities of obligate epiphytes from the *Orthotrichum* and *Ulota* genera are recorded (Adams & Preston, 1992; Vanderpoorten, 1997; Stapper & Kricke, 2004; Stevenson & Hill, 2008; Duckett & Pressel, 2009; Dymytrova, 2009; Richter *et al*., 2009a, 2009b).

A similar phenomenon has been recently observed in Polish towns as well. In the nineties, the urban bryophyte floras in Poland were usually characterized by the scantiness of epiphytic bryophytes (Fudali, 1994; Żarnowiec, 1996; Fojcik & Stebel, 2001). However, political changes which started in 1989, connected with the economic transformations, caused, among others, a general decline in heavy industry. The restrictions of the emissions led to a gradual fall in the emission of SO_2, NO_x and other atmospheric pollutants. Over the recent years, an increase in the number of stands of light-demanding epiphytic species has been noted in some urban areas (Fudali, 2011, 2012; Fojcik & Stebel, 2014). Recent climate changes have probably contributed to the existence of this phenomenon as well (Bates & Preston, 2011; Pócs, 2011).

Major changes in the distribution and diversity of epiphytic bryophytes were observed in the area of Katowice city (southern Poland). The city covers nearly 165 km^2 and has almost 300 000 inhabitants. Katowice is the capital city of the Upper Silesian Industrial District and one of the biggest industrial hubs in Poland. Until the recent years, there were nine coal mines and four steel or non-steelworks. Some of them do not exist anymore, whereas others have been significantly modernized. In the recent decades, a tangible improvement of the condition of environment is observed. For example, in Katowice the emission of SO_2 decreased from 6363 tones in 1998 to 2 612 in 2014, and emission of NO_x – from 2271 tones in 1998 to 834 in 2014 (Central Statistical Office of Poland, 2016).

General investigation relating to bryophytes, conducted earlier in the area of Katowice (Fojcik & Stebel, 2001), showed a limited number of epiphytic species. Species such as *Orthotrichum diaphanum* Schrad. *ex* Brid., *O. obtusifolium* Brid., *O. pumilum* Sw. *ex* anon. and O. *speciosum* Nees were noted in single locations, whereas species like *Leskea polycarpa* Hedw., *Radula complanata* (L.) Dumort. and *Ulota* spp. were absent. Some of the analyzed species, i.e. *Orhotrichum anomalum* Hedw. and *Pylaisia polyantha* (Hedw.) Schimp., occurred exclusively in the anthropogenic rock-like habitats (old concrete walls, posts, etc.). The discovery of the rare and threatened European epiphytic moss *Orthotrichum rogeri* Brid. in Katowice (Stebel, 2010; Ellis *et al*., 2011) led to the necessity of repeating the research on the flora, and in 2010 such investigations were started. First information about spreading of epiphytes in Katowice was shortly given in 2014 (Fojcik & Stebel, 2014), and showed that since 2001 epiphytes were encountered more frequently and were more diverse, including a number of new species. Nevertheless, there was no previous specific study on habitat preferences since epiphytes were extremely rare in Katowice city. It should be taken in mind that the analysis of habitat preferences allows to determine the probability of colonizing particular species of trees and by the same time it allows to determine the range of colonization of a specific area. Consequently, the goal of this paper is to answer to the following questions: 1) Did the epiphytic bryoflora of Katowice change over the last decade?; 2) Do changes have quantitative or qualitative character, or both?; 3) Which species spread?; 4) Which species of phorophytes are preferred by epiphytes?

MATERIALS AND METHODS

The investigation encompassed the monitoring of 16 epiphytic species and was carried out between autumn of 2010 and spring of 2015. The criteria to select the species were: (1) epiphytes known in 2001, encountered in single sites (*Orthotrichum diaphanum, O. obtusifolium, O. pumilum* and *O. speciosum*) (Fojcik & Stebel, 2001), (2) species presently encountered on bark of trees, which in 2001 were known only from anthropogenic rock-like habitats (*O. anomalum* and *Pylaisia polyantha*), and (3) species occurring on bark of trees at present, which in 2001 were absent from the bryophyte flora of Katowice (*Leskea polycarpa, Orthotrichum affine* Schrad. *ex* Brid., *O. patens* Bruch *ex* Brid., *O. rogeri, O. stramineum* Hornsch. *ex* Brid., *O. striatum* Hedw., *Radula complanata, Syntricha latifolia* (Bruch. *ex* Hartm.) Huebener, *Ulota bruchii* Hornsch. *ex* Brid. and *U. crispa* (Hedw.) Brid.

Field study was conducted similarly to the previous work concerning the bryophyte flora of Katowice (Fojcik & Stebel, 2001). The city area was divided into squares of surface equal to l km^2 each, along the ATMOS grid square system (Ochyra & Szmajda, 1981). Each square was visited and its list of epiphytic bryophyte flora species was prepared. Trees were present in all squares, however their species composition and number varied.

The phorophyte species on which particular bryophyte species were encountered were noted to know the preference of epiphytes towards inhabited phorophytes. Sampling was conducted mainly in early spring and late autumn, when trees were leafless, which made the identification of some phorophyte species impossible. Some of *Malus*, *Populus* and *Salix* taxa were especially difficult to distinguish, therefore in the analyses they were divided into three general groups, the *Malus* spp. group, the *Populus* spp. group and the *Salix* spp. group.

The current distribution of the epiphytic bryophyte species was studied and presented on a map prepared on the basis of the 1 km^2 square system. The frequency of species was noted according to the papers by Fojcik & Stebel (2001, 2014): 1-5 squares – very rare; 6-10 – rare; 11-25 – fairly frequent; 26-50 – frequent; 51-80 – very frequent. The nomenclature of mosses follows Ochyra *et al.* (2003) and that of flowering plants follows Mirek *et al*. (2002).

RESULTS

Changes in the number of sites and frequency

The comparison of the number of sites occupied in 2001 with those occupied at present shows a notable increment in all the analyzed species (Table 1).

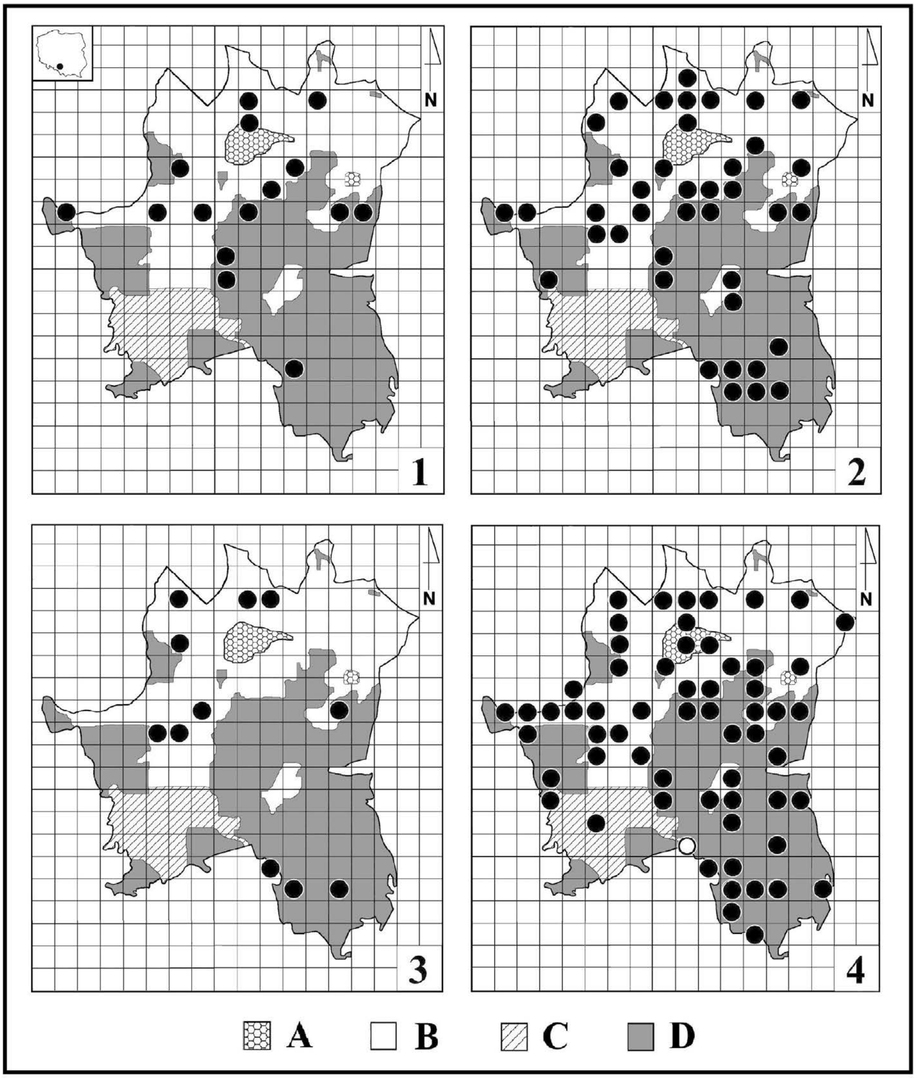
Table 1. Comparison of the number of sites where the analyzed bryophyte species were found growing as epiphytes in Katowice city in the years 2001 and 2015

Epiphytic bryophyte species	*Number of sites*	
	2001	*2015*
Leskea polycarpa Hedw.	0	15
Orthotrichum affine Schrad. *ex* Brid.	0	40
Orthotrichum anomalum Hedw.	0	11
Orthotrichum diaphanum Schrad. *ex* Brid.	1	61
Orthotrichum obtusifolium Brid.	1	23
Orthotrichum patens Bruch *ex* Brid.	0	2
Orthotrichum pumilum Sw. *ex* anon.	1	75
Orthotrichum rogeri Brid.	0	1
Orthotrichum speciosum Nees	2	45
Orthotrichum stramineum Hornsch. *ex* Brid.	0	2
Orthotrichum striatum Hedw.	0	6
Pylaisia polyantha (Hedw.) Schimp.	0	27
Radula complanata (L.) Dumort.	0	9
Syntrichia latifolia (Bruch *ex* Hartm.) Huebener	0	2
Ulota bruchii Hornsch. *ex* Brid.	0	14
Ulota crispa (Hedw.) Brid.	0	9

In 2001, only 4 of the analyzed species growing as epiphytes (*Orthotrichum diaphanum, O. pumilum, O. obtusifolium* and *O. speciosum*) were noted in 2 squares. At present, 2 species known previously only from artificial rock-like habitats (*O. anomalum* and *Pylaisia polyantha*) and 10 new species (*Leskea polycarpa, O. affine, O. patens, O. rogeri, O. stramineum, O. striatum, Radula complanata, Syntricha latifolia, Ulota bruchii* and *U. crispa*) appeared on the bark of trees and shrubs. The number of squares with epiphytes is 91. Thus, over the last 15 years their number increased 45.5 times. The analysis of frequency shows that at present 4 species are very rare (*Orthotrichum patens, O. rogeri, O. stramineum* and *Syntrichia latifolia*), 3 rare (*Orthotrichum striatum, Radula complanata* and *Ulota crispa*), 4 fairly frequent (*Leskea polycarpa, Orthotrichum anomalum, O. obtusifolium* and *Ulota bruchii*), 3 frequent (*Orthotrichum affine, O. speciosum* and *Pylaisia polyantha*), and 2 very frequent (*Orthotrichum diaphanum* and *O. pumilum*). In 2001 almost all noted species were very rare (Table 1). An exception is *Orthotrichum anomalum*, which was previously categorized as ‘rare’, but all of its sites were on anthropogenic rock-like habitats. Information about the distribution of all species (only on bark of living trees and shrubs) is presented in Figs 1-16.

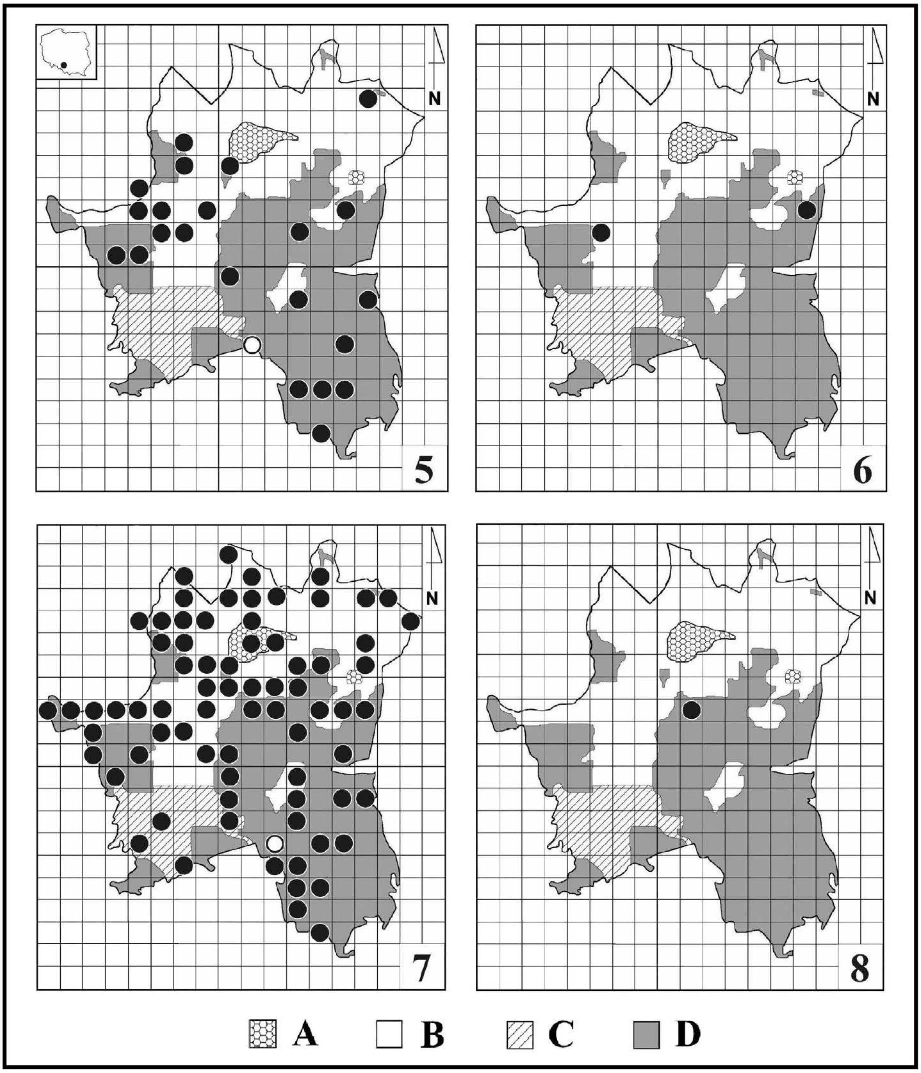
Phorophytes

Among over 80 species and cultivars of trees and shrubs occurring in Katowice (Tokarska-Guzik & Rostański, 1997), 25 with monitored epiphytic species were noted: *Acer negundo* L., *A. platanoides* L., *A. pseudoplatanus* L., *Alnus glutinosa* (L.) Gaertn., *Betula pendula* Roth., *Crataegus monogyna* Jacq., *Fagus sylvatica* L., *Fraxinus excelsior* L., *F. pennsylvanica* Marshall, *Malus* spp. group



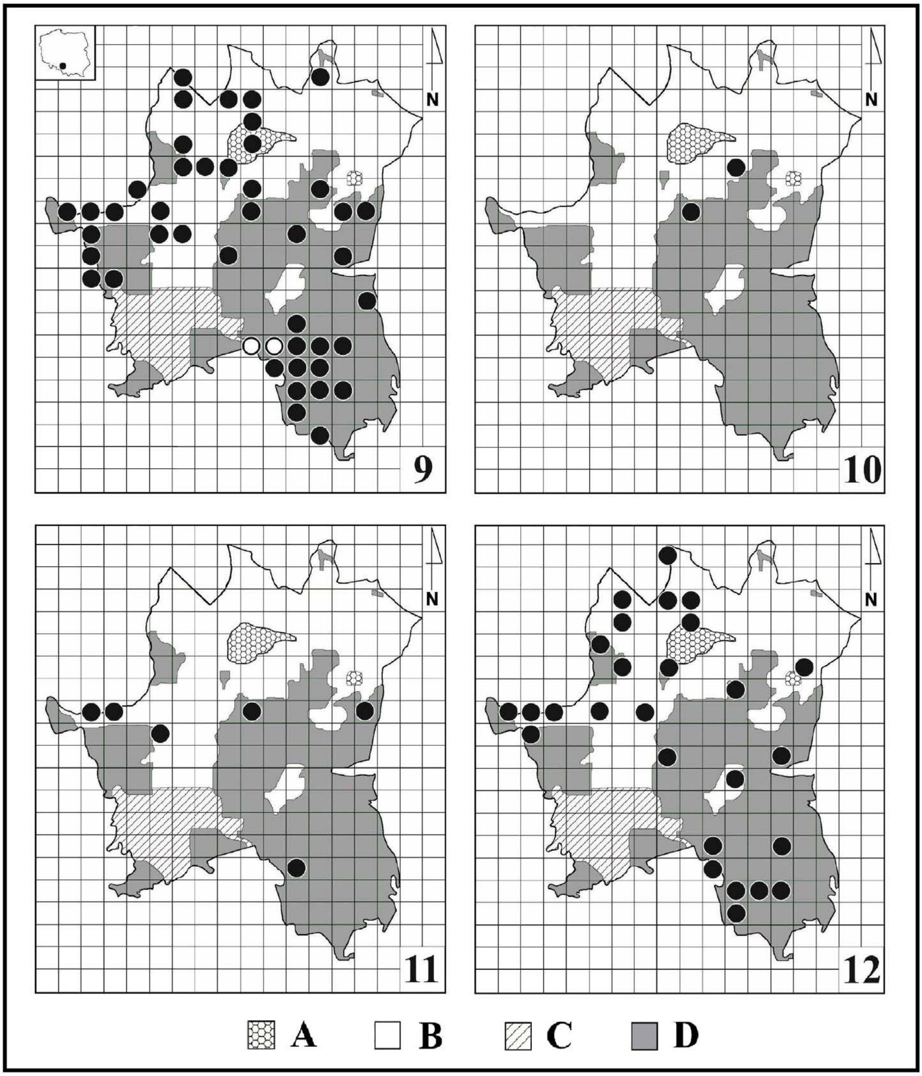
Figs 1-4. Distribution on 1 × 1 km square system in the city of Katowice against the background of the main types of land-use complexes – only stations on bark of living trees and shrubs were considered (A – downtown, B – suburbs, C – agricultural area, D – forest). **1.** *Leskea polycarpa*. **2.** *Orthotrichum affine*. **3.** *O. anomalum*. **4.** *O. diaphanum* (white dots: localities in 2001 according to Fojcik & Stebel (2001), at present confirmed; black dots: new localities). In the upper left corner the location of Katowice city in Poland is given.

(including *Malus domestica* Borkh. and *M. sylvestris* Mill.), *Populus* spp. group (including *Populus x berolinensis* (K. Koch) Dippel, *P. x canadensis* Moench, *Populus* "NE 42" (= *P.* "Hybrida" 275), *P. nigra* L. "Italica" and *P. tremula* L.), *Quercus robur* L., *Robinia pseudoacacia* L., *Salix* spp. group (including *Salix alba* L., *S. caprea* L., *S. fragilis* L., and *S. x sepulcralis* Simonk), *Sambucus nigra* L., *Sorbus aucuparia* L. *emend* Hedl., and *Tilia cordata* Mill.



Figs 5-8. Distribution on 1 × 1 km square system in the city of Katowice against the background of the main types of land-use complexes. **5.** *Orthotrichum obtusifolium*. **6.** *O. patens*. **7.** *O. pumilum*. **8.** *O. rogeri* (rest of legend and symbols as in Figs 1-4).

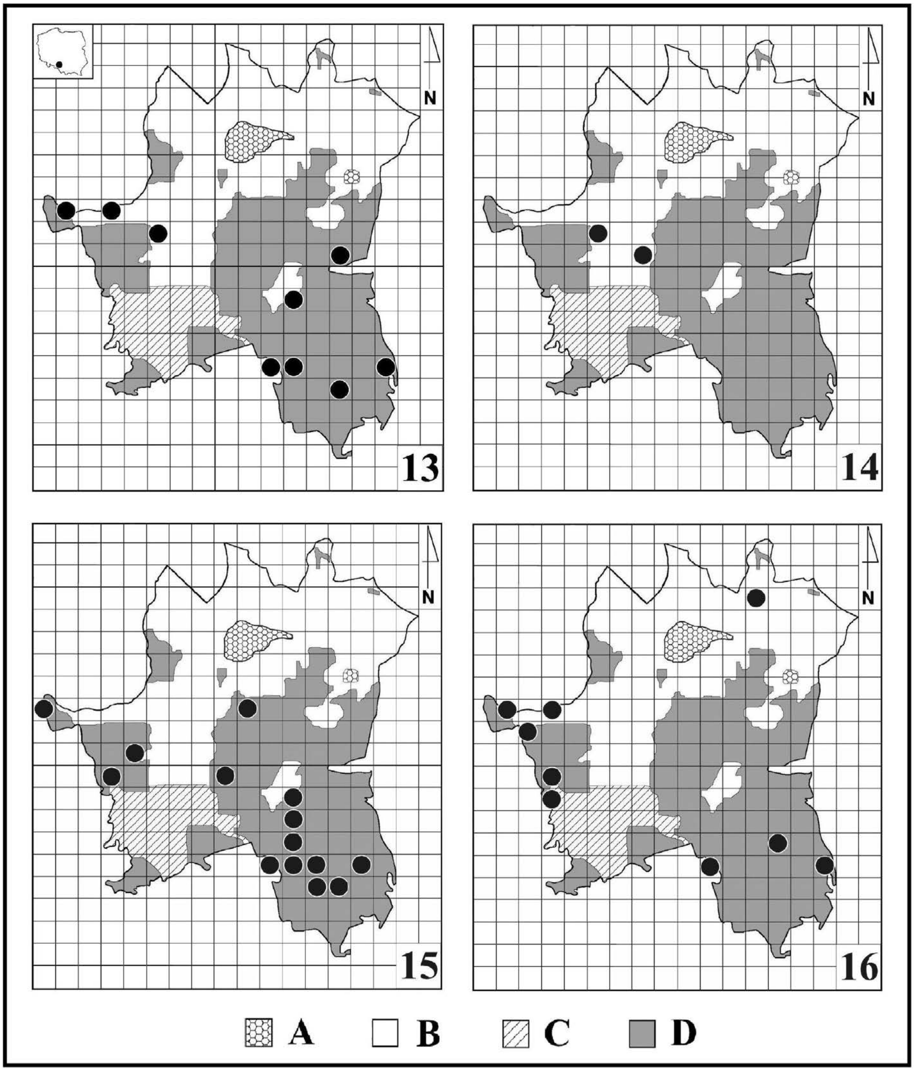
Altogether, 415 entries concerning the occurrence of epiphytes on a particular species of phorophyte were gathered, that were found on a total number of 673 phorophytes. Epiphytes most frequently occurred on bark of the representatives of *Populus* spp. (46.5%) and *Salix* spp. (35.5%). The other phorophytes hosted a much lower percentage of epiphytes: *Fraxinus pennsylvanica* (3.9%), *F. excelsior* (3.4%), *Quercus robur* (2.2%), *Acer negundo* (1.9%), *Robinia pseudoacacia* (1.2%), *Acer platanoides* and *Sambucus nigra* (1.0% each), and the rest of them with a lower percentage (between 0.5% and 0.2%) (Fig. 17).



Figs 9-12. Distribution on 1 × 1 km square system in the city of Katowice against the background of the main types of land-use complexes. **9.** *Orthotrichum speciosum*. **10.** *O. stramineum*. **11.** *O. striatum*. **12.** *Pylaisia polyantha* (rest of legend and symbols as in Figs 1-4).

Habitat spectrum of the analyzed species

Not only do selected species analyzed in this paper grow as epiphytes within their whole distributional range, but they also occur in different habitats, i.e. epilithic. In Katowice, species which until the present day have been exclusively found on bark of trees and shrubs are: *Orthotrichum obtusifolium, O. patens, O. rogeri, O. stramineum, O. striatum, Syntricha latifolia* and *U. crispa*. A few of the studied species occur mainly as epiphytes, but were quite rarely observed on



Figs 13-16. Distribution on 1 × 1 km square system in the city of Katowice against the background of the main types of land-use complexes. **13.** *Radula complanata*. **14.** *Syntrichia latifolia*. **15.** *Ulota bruchii*. **16.** *Ulota crispa* (rest of legend and symbols as in Figs 1-4).

logs. These are: *Leskea polycarpa, Orthotrichum affine, O. speciosum, Radula complanata* and *Ulota bruchii*. The third group is formed by bryophytes noted on bark of trees and shrubs, but also on logs and anthropogenic rock-like substrata (walls, posts, etc.). They are: *Orthotrichum anomalum, O. diaphanum, O. pumilum* and *Pylaisia polyantha*. The case of *O. anomalum* is especially interesting since this is a primary saxicolous species (Fojcik & Stebel, 2001). Yet, in Katowice city it currently has more epiphytic sites than the epilithic ones.

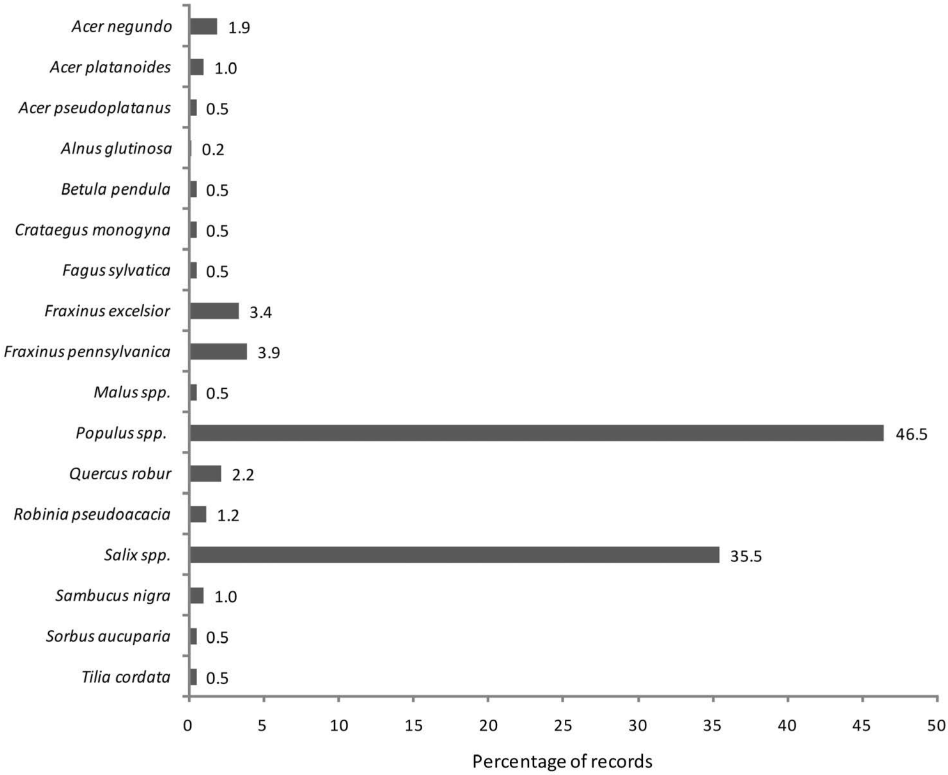


Fig. 17. Percentage of occurrence of epiphytic bryophytes on phorophytes in Katowice city.

Propagation

Almost all of the investigated species were found with sporophytes. Thus, spores are suspected to be their main way of propagation. The exceptions are *Orthotrichum obtusifolium*, *Radula complanata* and *Syntrichia latifolia*, where only gemmae were observed. One species, *Orthotrichum pumilum*, commonly produces sporophytes and, very rarely, gemmae.

Distribution of the analyzed species in the investigated area

The area of Katowice city is heterogeneous. Places characterized by compact development are sometimes separated by broad belts of forest, and the state of preservation of the forests is variable. They are mainly well-managed. Nonetheless, small natural patches exist as well. Old trees in parks also provide good conditions for the development of epiphytes. Due to the aforementioned circumstances, it is impossible to distinguish clear distribution patterns for the investigated species. Undoubtedly, the compact development and industrialized places still remain “epiphytic desserts” where only the most common species (*Orthotrichum diaphanum* and *O. pumilum*) can very rarely grow. On the contrary, the best places for the

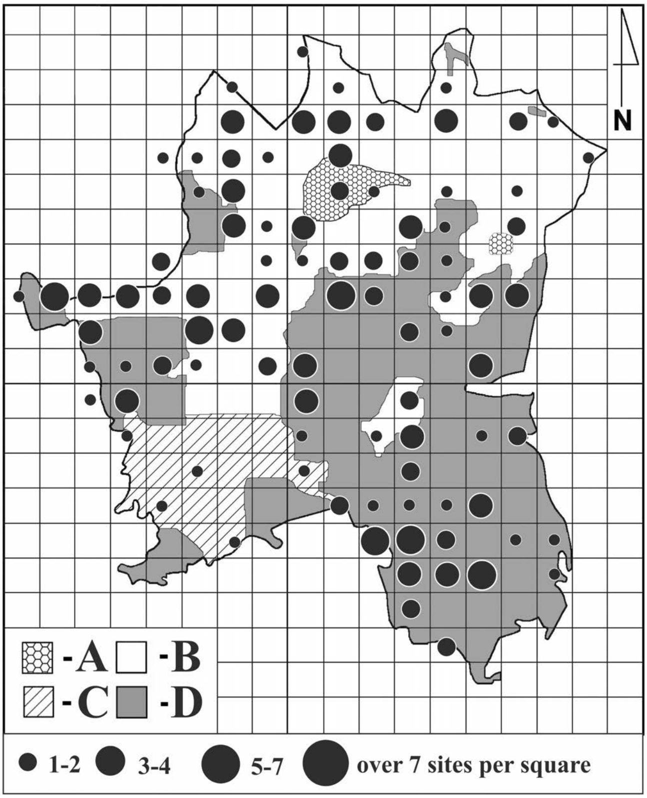


Fig. 18. Number of investigated epiphytic species per 1 × 1 km square in Katowice city against the background of the main types of land-use complexes (A – downtown, B – suburbs, C – agricultural area, D – forest).

occurrence of the investigated species are the margins of forest complexes, extensively used areas in the suburbs with avenues of trees and forest parks. In such areas the diversity of epiphytes is relatively high, with over 7 species per 1 × 1 km square (Fig. 18).

DISCUSSION

The local distribution of epiphytes is the result of mutual relationships between various habitat factors. In urban areas, the major factors which are responsible for epiphyte distribution are air pollution, microclimate (especially the humidity available) and the presence and variety of phorophytes (Seaward, 1979; Zechmeister & Hohenwallner, 2006; Dymytrova, 2009). The decrease in the level of air pollution seems to be the main factor affecting the recolonization of the area of Katowice city by epiphytes. During a relatively short time, the number of records of species previously considered to be very rare in this area increased significantly. Moreover, ten new species have been recorded in this area. Among the newcomers, *Orthotrichum rogeri* is especially worth of notice. It is listed in the European "Red-list of bryophytes" (Schumacker & Martiny, 1995) and considered extinct in the

"Red-list of mosses in Poland" (Żarnowiec *et al.*, 2004). Such epiphytic recolonization in response to declining levels of SO_2 as an air pollutant has been well documented in a range of European countries, as mentioned before. It is suspected that recolonization is also influenced by changing climate factors. However, separate research is needed in order to confirm this hypothesis.

The colonization processes observed in Katowice occurred relatively quickly. A similarly fast recolonization is described e.g. by Richter *et al.* (2009a) in Halle, where in the 1980s-1990s epiphytic bryophytes were completely absent. The epiphytes belong to the most mobile mosses (Adams & Preston, 1992) and they exhibit various ways of reproduction, which enables relatively fast recolonization of habitats (Longton, 1997). Although air pollution inhibits the amphigony of mosses, it is compensated by vegetative propagation which facilitates the growth of some species in most areas (Rao, 1982; Giordano *et al.*, 2004). In Katowice, epiphytes usually produce sporophytes at present (13 out of 16 investigated species) or form vegetative propagules (4 species). Undoubtedly, thanks to this they spread so effectively.

The most commonly and abundantly inhabited phorophyte species were poplar trees and willow trees, namely those of higher pH of bark. Similar preferences in urban areas were observed by Adams & Preston (1992) in London, Dymytrova (2009) in Kiev, Richter *et al.* (2009b) in Halle, Fudali (2011, 2012) in Wrocław, and regarding lichens by Larsen *et al.* (2007) in London and Lisowska (2011) in Skawina. Pioneer softwood trees, such as *Populus* spp. and *Salix* spp., often exhibit a rich epiphytic flora (Vanderpoorten *et al.*, 2004). Most authors agree that pH is of fundamental importance in controlling the re-establishment in formerly polluted areas. Higher pH of bark may buffer the influence of unfavourable habitat factors, which enhances the probability of colonization success of epiphytes (Gilbert, 1968, 1992). For instance, germination may depend on such habitat condition like the pH of bark (Wiklund & Rydin, 2004). Besides, willow bark is rich in nutrients and has high water holding capacity (Gilbert, 1970), which can influence effectiveness of colonization processes.

It is needed to notice that in urban areas the stand composition is a result of economical actions – both in woodlands and other areas. This limits the access to one type of phorophytes, at the same time enhancing the access to others. The current abundance of poplar and willow trees in Katowice increases the probability of encountering non-forest epiphytes. The conservation of the epiphytes in urban areas implies that a minimal amount of pioneer trees such as willows and poplars should be maintained (Vanderpoorten *et al.*, 2004). It would be important to have this in consideration regarding the management in Katowice, where for instance in the old town large representatives of these species are cut down (especially on waysides and in parks) and replaced by young ones of other species.

In Katowice, it has been detected that part of the typical epiphytes change habitat from tree bark to concrete walls. Similar movements have been observed also in other towns (e.g. Gilbert, 1968; Fudali, 2006, 2011, 2012; Sabovljević & Grdović, 2009). This phenomenon has been interpreted as a bryophyte response to acid rain and a subsequent transfer to less acidic habitats. The high pH of substrates such as concrete and cement provides a buffering effect on the toxicity of the urban environment (e.g. Barkman, 1958; Seaward, 1979; Rao, 1982). Probably this is one of the reasons that explains that in urban areas the most frequent species from the genus *Orthotrichum* is *O. diaphanum*, occurring both on concrete walls and bark of trees. This species commonly occurs in many towns and shows an "urbanicolous" character (Fudali, 1994, 2011; Lo Giudice *et al.*, 1997; Vanderpoorten, 1997; Delgadillo & Cárdenas, 2000; Davies *et al.*, 2007, Kirmaci & Ağcagĭl, 2009).

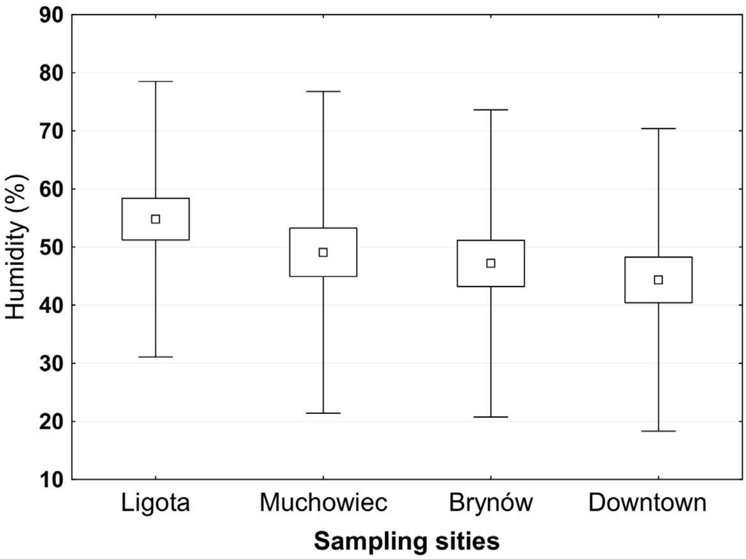


Fig. 19. Values of humidity in selected plots – with epiphytic bryophytes (Ligota, Muchowiec) and without epiphytic bryophytes (Brynów, Downtown) (Fojcik *et al.*, 2015).

In towns, epiphytes occur mainly in parks (Fudali, 1994, 2006, 2011, 2012; Lo Giudice *et al.*, 1997; Grdović & Stevanović, 2006; Dymytrova, 2009; Sabovljević & Grdović, 2009) or in river valleys (Vanderpoorten, 1997; Sabovljević & Grdović, 2009), that is, in the places with elevated humidity levels. Air humidity is perceived as one of the crucial factors which govern colonization processes and limit the occurrence of epiphytes (Bergkvist *et al.*, 1989). Although epiphytes are generally resistant to drought (Oliver, 2009), germination is a crucial stage that requires water (Proctor & Tuba, 2002). Low humidity prolongs the time of germination and limits its effectiveness, while high moisture can facilitate spore germination at suboptimal pH (Wiklund & Rydin, 2004). In Katowice, the largest abundance of epiphytes in their first colonization stages was observed in the neighbourhood of forests and large park areas, commonly situated next to large water reservoirs (Fojcik & Stebel, 2014). Differences in humidity levels in Katowice areas with (Ligota, Muchowiec) and without (Brynów, Downtown) epiphytes reached up to 10% (Fig. 19), which is in agreement with other research results concerning urban and suburban areas (Kratzer, 1937; Rydzak, 1958). Epiphytes preferences towards locations characterized by larger air humidity confirm the significance of this factor for the colonization stage. Although they occurred relatively rarely in occlusive forest complexes, the number of their habitats increases. It may be a result of, among others, the limited access to appropriate phorophytes – the local forests are dominated by mixed coniferous forests and the presence of, for instance, willows and poplars is limited.

If the pace of epiphyte spreading remains the same, the most common species (for example *Orthotrichum pumilum* and *O. speciosum*) will probably be encountered in the majority of the researched squares. One should expect new species as well.

It is worth noting that until the present day, many epiphytic bryophytes known from other urban areas (Lo Giudice *et al.*, 1997; Vanderpoorten, 1997;

Bezgodov, 2000; Pokorny *et al.*, 2006; Duckett & Pressel, 2009; Richter *et al.*, 2009a; Sabovljević & Grdović 2009; Stebel & Bielec, 2004), such as *Anomodon attenuatus* (Hedw.) Huebener, *A. longifolius* (Schleich. *ex* Brid.) Hartm., *A. viticulosus* (Hedw.) Hook. & Taylor, *Homalia trichomanoides* (Hedw.) Schimp., *Leucodon sciuroides* (Hedw.) Schwägr., *Neckera pennata* Hedw., *Orthotrichum lyellii* Hook. & Taylor, *O. tenellum* Bruch *ex* Brid., *Pterigynandrum filiforme* Hedw. and *Zygodon viridissimus* (Dicks.) Brid., have not been observed in Katowice. Partially, differences may result from the local climate and habitat conditions, such as higher levels of humidity, growth of old trees, and the occurrence of limestone rocks (on which some epiphytic species are able to grow).

Epiphytes recolonization in the area of Katowice city occurs relatively quickly. The further trend of these changes (rate, range, inflow of new species) is interesting. For that reason it is important to continue the methodical monitoring of local bryoflora.

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