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LICHEN MAPPING IN KOMÁROM, NW HUNGARY

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For air pollution lichen mapping of Komárom (NW Hungary) 50 lichen taxa were collected at 84 sites between October 1997 and April 1999. Except for 3 species (*Caloplaca decipiens*, *Evernia prunastri*, *Physcia tenella*) all are new for the investigated area, as it was lichenologically poorly known before. The occurrence of the most frequent species (*Amandinea punctata*, *Lecanora hagenii*, *Phaeophyscia orbicularis*, *Physcia adscendens*, *P. tenella*, *Xanthoria parietina*) correlates with the dominating dust pollution. Two different zones can be distinguished on the basis of the lichen flora. These are situated in the highly built-up central and in the surrounding areas.

Key words: air pollution, lichen mapping, Komárom, Hungary

INTRODUCTION

A correlation between the presence and absence of lichens and air pollution in and around cities was first suggested by Turner and Borrer (1839). Since that time several books and chapters of books (e.g. Ferry et al. 1973, Gilbert 1970, 1973, Hawksworth and Rose 1976, Galun and Ronen 1988) have been published on this relation. The various fields of this subject studied until recent times, as it is found in several pages of reviewed papers in "Recent literature on lichens and air pollution" (e.g. Henderson 1999, 2000). The importance of these investigations is the best shown by Cislaghi and Nimis (1997), who compared the distribution of lichens to the distribution of mortality by lung cancer. Some hope for rehabilitation of a better environment is suggested by Hawksworth and McManus (1989) who presented the recolonization of lichens in London due to the cleaner air.

In Hungary bioindication studies by lichens were carried out in Debrecen (Felföldy 1942), Szeged (Gallé 1979), Budapest and its surroundings (Farkas 1982, Lőkös 1983, Farkas et al. 1985, Farkas 1990), Debrecen (Toldi 1986), Szombathely and its surroundings (Kiss 1990), Miskolc (Váncsa and

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Váncsa 1990), Szolnok (Malatinszki 1992), Vác (Szabados 1993) and Gyöngyös (Pallos 1996). The air pollution situation in Komárom was only known from chemical analysis. A single lichen specimen (*Caloplaca decipiens*, Balás 1939) was known from the BP Lichen Herbarium only. Solymosi (1978) published 11 epiphytic lichen species (*Calicium pusillum*, *C. subtile*, *Evernia prunastri*, *Graphis scripta*, *Lecanora carpinea*, *Peltigera horizontalis*, *Physcia tenella*, *Physconia pulverulenta*, *Ramalina fastigiata*, *Rinodina exigua*, *R. pyrina*) from the Komárom area during his studies along Danube. Nearby areas in Slovakia were studied by Pišút in 1964, Rusko (1978) and Lackovičová (1997a, 1997b). A common result of the above studies was that due to increasing air pollution several species disappeared from the area.

Therefore we decided to study the lichen flora and distribution in Komárom, to compare the lichenological and chemical data of air pollution, to establish zones of air pollution on the basis of epiphytic lichen dis-

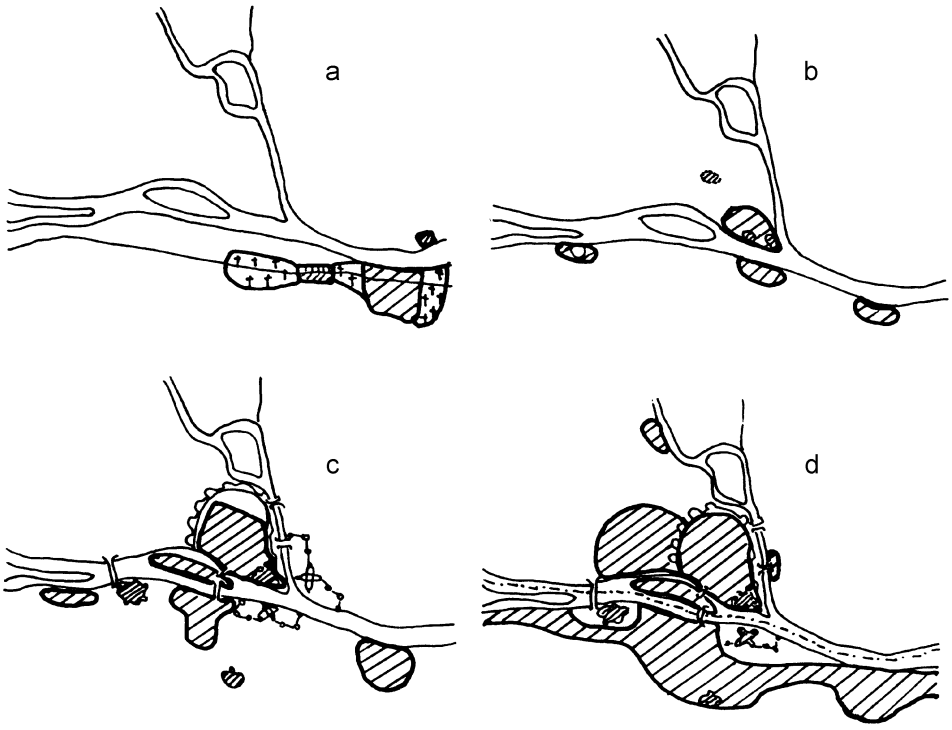

Fig. 1. Development of Komárom (based on figures of Kecskés (1984, pp. 8–9)). a = 1–4. century, b = 10. century–middle 16. century, c = middle 18. century–1896, d = 1977–1984

tribution by the help of hierarchical agglomerative classification. Built-up areas and other factors (e.g. climatic factors) are also intended to be considered (Molnár 1999).

The study area

Komárom is situated on the Little Hungarian Plain (Kisalföld), at the junction of Duna (Danube) and Vág-Duna at 50–100 m above see level (Fig. 2). Its climate is semiarid, moderately warm, moderately dry continental with relatively mild winters. Mean annual temperature is 9.5 °C, mean yearly rainfall is 530–540 mm. Winds of western and northwestern prevailing direction are strongest here on the Little Hungarian Plain within Hungary.

The development of the settlement Komárom was analysed by Bunovácz (1988), Csikány and Horváth (1998) and Kecskés (1973, 1984, 1985) (Fig. 1). The first signs of a human population at this area dates back to 3500–2500 B. C. A fortress was built on the northern bank of the Danube by the conquering Hungarians recognising the advantageous position of the place during the tenth century. In the seventeenth century the increasing trade (and traffic) through the crossing point on the Danube resulted in small settlements also on the southern bank of the Danube: Rév, Szőny, Koppánmonostor. The smaller settlements formed a united city several decades ago.

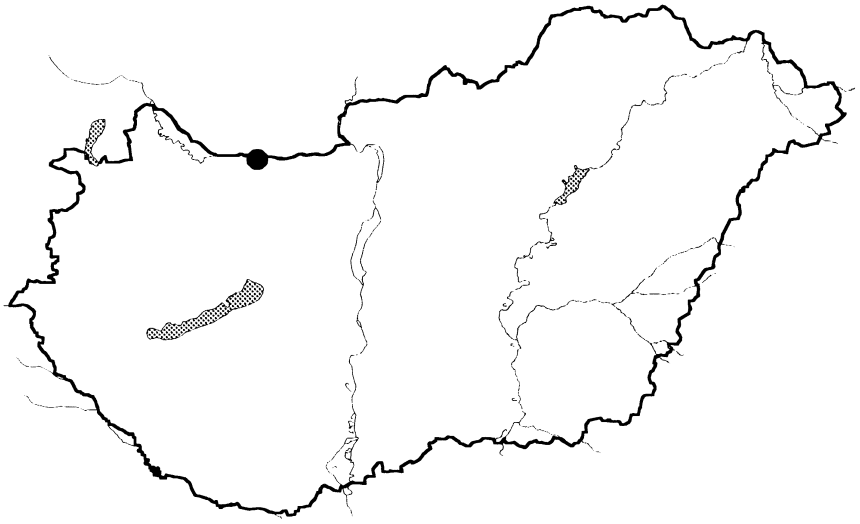

Fig. 2. Location of the study area in Hungary

Komárom is a small city. The area of the highly built-up central part of Komárom is 1491 ha, the surrounding fields (mainly agricultural areas) cover 5526 ha extending 13 km along the Danube. The number of inhabitants in Komárom is ca 20,000.

The air pollution (dust, SO_2, NO_2, etc.) originates from anthropogenic sources, from the relatively heavy traffic (along the former main route between Budapest and Vienna), industrial and agricultural activities, and heating. The situation has been improved in the last decade due to decreasing industrial activity and advantageous changes in heating systems (gas heating project). Air pollution parameters are measured at 5 points of the city (dust at 5 points, sulphur dioxide and nitrogen dioxide at 3 points – Fig. 3). Dust pollution dominates over the year reaching or slightly exceeding the value of public health limits, other pollutants remain under these limits.

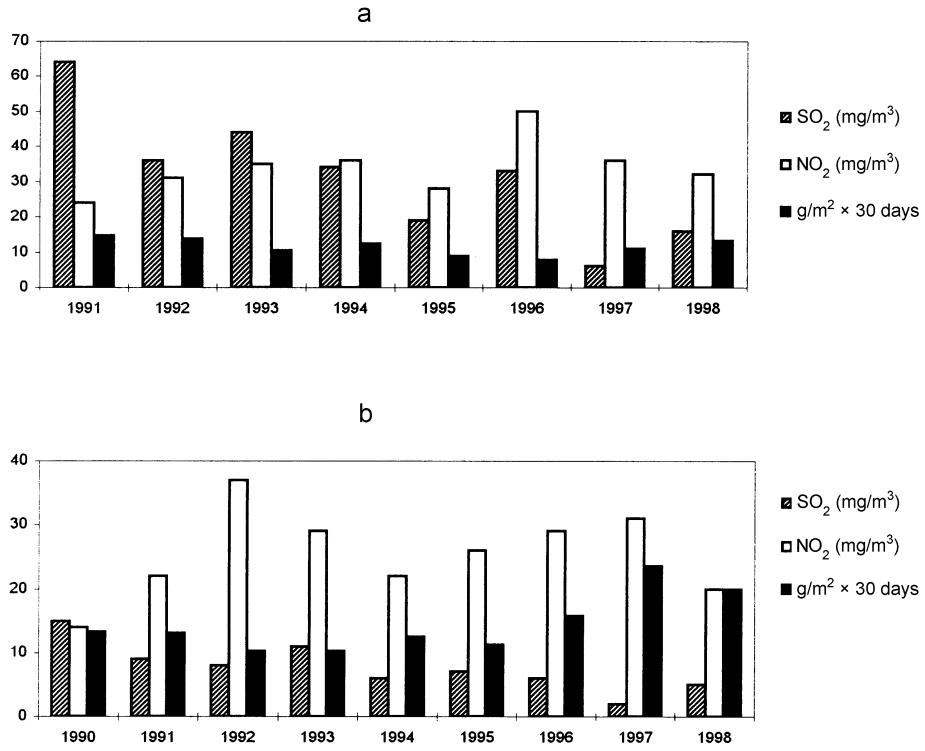

Fig. 3. Main measured parameters over the year in Komárom. a = 6 months with public heating ("winter" half year), b = 6 months without heating ("summer" half year)

MATERIAL AND METHODS

Lichen samples were collected at 84 sites (Fig. 4) between October 1997 and April 1999:

1. Almásfüzitő-felső lakótelep (ltp. – housing estate)
2. Szőny-Molaj (ltp. - housing estate)
3. Szőny-Molaj, Stadion út (road)
4. Szőny-Molaj, Duna-part (bank of Danube)
5. Szőny, Bokréta utca – Szabadság utca kereszteződés (junction of streets)
6. Szőny, Vasútállomás (railway station)
7. Szőny, Magtár épületének falai (outer wall of the building)
8. Szőny, Selye János Kórház parkja (park)
9. Szőny, Kossuth Lajos utca, artézi kút talapzata (concrete structure)
10. Szőny, Kossuth L. u. – Tatai út kereszteződés (junction of streets)
11. Szőny, Tatai út (Komárom végét jelző táblánál) (at the city border)
12. Szőny, Tatai út – Mocsai út kereszteződés (Huszár-dűlő) (junction of streets)
13. Szőny, Virág utca vége (street)
14. Szőny, Virág utca – Ifjúság utca kereszteződés (junction of streets)
15. Szőny, Vasút utcától északra (north from the street)
16. Szőny, Korpáskúti-dűlő (field)
17. Szőny, Túróhát (field)
18. Komárom, Csősz-hegy (field)
19. Komárom, Térffy Gyula utca, park (park)
20. Komárom, Igmándi-erőd falai (outer walls of the building)
21. Komárom, Rüdiger I.-tó partja (lake side)
22. Komárom, Tópart ltp. parkja (park)
23. Komárom, Igmándi úti vadgesztenye-fasor (avenue)
24. Komárom, Arany János utca (street)
25. Komárom, Babits Mihály utca (street)
26. Komárom, Szamos utca 4. (street)
27. Komárom, Szabadság tér (square)
28. Komárom, Petőfi Sándor Általános Iskola udvara (playground)
29. Komárom, Csillag-erőd falai (outer walls of the building)
30. Komárom, Új Csillag ltp. (housing estate)
31. Komárom, Csillag ltp. (housing estate)
32. Komárom, Mártírok útja (Gyermekvárosnál) (road)
33. Komárom, Bem József utca – Táncsics Mihály utca kereszteződés (junction of streets)
34. Komárom, Bem J. utca – Czuczor Gergely utca kereszteződés (junction of streets)
35. Komárom, Táncsics Mihály utca (street)
36. Komárom, Jókai Mór liget (grove)
37. Komárom, Jókai Mór Gimnázium Sport utcai sarka (street)
38. Komárom, Sport utca (street)
39. Komárom, Czibor Zoltán Sporttelep (sports ground)
40. Komárom, Szélső utca (street)
41. Komárom, Rákóczi Ferenc rakpart (quayside)
42. Komárom, Gyár utca (street)
43. Komárom, Autóbusz-pályaudvar (bus-station)

44. Komárom, Szent István tér (square)
45. Komárom, Kelemen László utca – József Attila utca kereszteződés (junction of streets)
46. Komárom, Klapka György utca – Temető utca kereszteződés (junctions of streets)
47. Komárom, Duna Áruház parkolója (parking place)
48. Komárom, Csokonai V. M. utca, ltp. (housing estate)
49. Komárom, Csokonai V. M. utca, Vita Sütőipari Vállalat betonkerítése (concrete fence)
50. Komárom, Sportpálya (sports ground)
51. Komárom, Temető parkolója (parking place)
52. Komárom, Temető (cemetery)
53. Komárom, Báthori István utca (street)
54. Komárom, Báthori I. utca – Marek József utca kereszteződés (junction of streets)
55. Komárom, Marek József utca (street)
56. Komárom, Báthori I. utca – Igmándi út kereszteződés (junction of streets)
57. Komárom, Beöthy Zsolt utca (street)
58. Komárom, Jókai Mór tér (square)
59. Komárom, Frigyes laktanya (barrack)
60. Komárom, Gujon Richárd utca (street)
61. Komárom, Zrínyi Miklós utca – Bocskai István utca kereszteződés (junction of streets)
62. Komárom, Mátyás király utca (street)
63. Komáromtól 0.5 km-re délre, a 13-as számú főút mellett közvetlenül (half km south of Komárom, near road 13)
64. Komáromtól 1 km-re délre, a 13-as számú főút mellett közvetlenül (1 km south of Komárom, near road 13)
65. Komáromtól 1 km-re délre, a 13-as számú főúttól kb. 300 méterre
66. Komárom, Alsó-hosszú-dűlő (field)
67. Komárom, Monostori-erőd (fortress)
68. Koppánymonostor, Pálffy Miklós utca (street)
69. Koppánymonostor, Duna-part (Monostor panziónál) (bank of Danube)
70. Koppánymonostor, Duna-part (Szent Pál-sziget) (bank of Danube)
71. Koppánymonostor, Horgász köz (lane)
72. Koppánymonostor, Radnóti Miklós utca (street)
73. Herkályi- (Ácsi) erdő (forest)
74. Komárom, MÁV ltp. (housing estate)
75. Komárom, Korona utca (street)
76. Komárom, Szent László utca eleje (street)
77. Komárom, Klapka György út (road)
78. Komárom, Tóth Lőrinc utca (street)
79. Nagy- és Kisherkály közötti nyárerdő (forest)
80. Nagyherkály
81. Bartusekpuszta
82. Csém
83. Komárom, városközpont (Igmándi út / Mártírok útja / Klapka György út kereszteződése) (the centre of the city)
84. Komárom, Erdélyi utca (street)

Altogether 630 specimens (mainly corticolous and fewer saxicolous) were collected. A few terricolous specimens originate from wall crevices of buildings and fortresses only.

Identified specimens are deposited in the Lichen Herbarium of the Hungarian Natural History Museum (BP). For identification the following literature sources were used: Purvis et al. (1992), Verseghy (1994), Wirth (1995a, b) and Degelius (1954) for *Collema* species.

A list of species was compiled, the distributions of species were mapped. Zones were established on the basis of the number of species, their distribution, comparing to the level of built-up areas and known air pollution data. Lichen data were analysed by multivariate classification methods (for further details see Csontos et al. 2000).

RESULTS

List (and characterisation) of species

The following 50 taxa were found on the 84 collecting sites:

Amandinea punctata (Hoffm.) Coppins et Scheideg., *Aspicilia contorta* (Hoffm.) Krempelh., *A. moenium* (Vainio) G. Thor et Timdal, *Bacidina arnoldiana* agg., *Bacidina* cf. *egenula* (Nyl.) Vězda, *Caloplaca citrina* (Hoffm.) Th. Fr., *C.* cf. *crenulatella* (Nyl.) Oliv., *C. decipiens* (Arnold) Blomb. et Forss., *C. dolomiticola s. l.*, *C. saxicola* (Hoffm.) Nordin, *C. teicholyta* (Ach.) Steiner, *Candelariella aurella* (Hoffm.) Zahlbr., *C. medians* (Nyl.) A. L. Sm., *C. xanthostigma* (Ach.) Lettau, *Cladonia* spp., *Collema crispum* (Hudson) Weber ex Wigg., *Endocarpon pusillum* Hedwig, *Evernia prunastri* (L.) Ach., *Hypogymnia physodes* (L.) Nyl., *Lecania erysibe* agg., *Lecanora albescens* (Hoffm.) Branth et Rostrup, L. cf. *chlarotera* Nyl., *L. campestris* (Schaerer) Hue, *L. conizaeoides* Nyl. ex Crombie, *L. dispersa* (Pers.) Sommerf., *L. hagenii* (Ach.) Ach., *L. muralis* (Schreber) Rabenh., *L. saligna* (Schrader) Zahlbr., *Lecidella elaeochroma* (Ach.) Choisy, *L. stigmatea* (Ach.) Hertel et Leuck., *Lepraria incana* (L.) Ach., *Leptogium plicatile* (Ach.) Leighton, *Parmelia sulcata* Taylor, *Phaeophyscia nigricans* (Flörke) Moberg, *P. orbicularis* (Necker) Moberg, *Physcia adscendens* (Fr.) Oliv., *P. caesia* (Hoffm.) Fürnr., *P. dimidiata* (Arnold) Nyl., *P. stellaris* (L.) Nyl., *P. tenella* (Scop.) DC., *P. wainioi* Räsänen, *Pleurosticta acetabulum* (Necker) Elix et Lumbsch, *Sarcogyne regularis* Körber, *Scoliciosporum chlorococcum* (Graewe ex Stenh.) Vězda, *Staurothele frustulenta* Vainio, *Strangospora pinicola* (Massal.) Körber, *Verrucaria muralis* Ach., *V. nigrescens* Pers., *Xanthoria elegans* (Link) Th. Fr., *X. parietina* (L.) Th. Fr.

Locality numbers and substrates are presented in Table 1.

Forty-seven species (see the above list, except *Caloplaca decipiens*, *Evernia prunastri*, *Physcia tenella*) are new to the investigated area (cf. Introduction). *Bacidina* cf. *egenula* is new also to Hungary, however this record needs further investigation in the field.

The collected species (corticolous indicated in boldface) varies in frequency of their occurrence (characterised by the number of collecting sites), listed in the sequence of decreasing frequency:

Lecanora hagenii	39	*Lecania erysibe* agg.	3
Amandinea punctata	35	**Lecanora conizaeoides**	3
Lecanora dispersa	29	*Physcia caesia*	3
Phaeophyscia orbicularis	25	*Candelariella medians*	2
Candelariella aurella	24	*Cladonia* spp.	2
Physcia adscendens	24	*Endocarpon pusillum*	2
Physcia tenella	23	**Hypogymnia physodes**	2
Xanthoria parietina	16	**Lepraria incana**	2
Lecanora muralis	13	*Leptogium plicatile*	2
Caloplaca cf. *crenulatella*	11	*Physcia dimidiata*	2
Lecanora albescens	11	*Xanthoria elegans*	2
Parmelia sulcata	11	*Aspicilia moenium*	1
Caloplaca citrina	10	*Bacidina* cf. *egenula*	1
Lecanora saligna	10	*Caloplaca dolomiticola* s. l.	1
Sarcogyne regularis	9	*Caloplaca teicholyta*	1
Verrucaria nigrescens	9	*Collema crispum*	1
Phaeophyscia nigricans	8	**Evernia prunastri**	1
Physcia stellaris	6	**Lecanora** cf. **chlarotera**	1
Verrucaria muralis	6	*Lecanora campestris*	1
Candelariella xanthostigma	5	**Lecidella elaeochroma**	1
Scoliciosporum chlorococcum	5	*Lecidella stigmatea*	1
Caloplaca saxicola	4	*Physcia wainioi*	1
Strangospora pinicola	4	**Pleurosticta acetabulum**	1
Aspicilia contorta	3	*Staurothele frustulenta*	1
Caloplaca decipiens	3	*Bacidina arnoldiana* agg.	1

Obligately corticolous species in this study

Lecanora hagenii	39	**Scoliciosporum chlorococcum**	5
Amandinea punctata	35	**Strangospora pinicola**	4
Physcia adscendens	24	**Lecanora conizaeoides**	3
Physcia tenella	23	**Hypogymnia physodes**	2
Xanthoria parietina	16	**Lepraria incana**	2
Parmelia sulcata	11	**Evernia prunastri**	1
Lecanora saligna	10	**Lecanora** cf**. chlarotera**	1
Physcia stellaris	6	**Lecidella elaeochroma**	1
Candelariella xanthostigma	5	**Pleurosticta acetabulum**	1

The most frequent species, known from the literature as nitrofrequent (e.g. *Lecanora hagenii*, *Amandinea punctata*, *Phaeophyscia orbicularis*, *Xanthoria parietina*), are widely distributed in the studied area. The typical toxitolerant species were found only at a few sites, e.g. *Scoliciosporum chlorococcum* (5), *Lecanora conizaeoides* (3).

Statistical analysis

Lichen floristical data and their distribution data in Komárom were analysed by hierarchical agglomerative classification methods. For results and a detailed discussion see Csontos et al. (2000).

Method MINGFC was most helpful for establishing and confirming lichen distribution zones. The localities of highly built-up areas and those of with more vegetation were possible to distinguish similarly to the results of mapping of species.

Lichen map of Komárom

A zone map of lichen distribution in Komárom and its surroundings (Fig. 4) was created on the basis of lichen floristical data, their mathematical analysis, investigating the distribution of built-up area and pollution data. According to our results the investigated area consists of two struggle zones and some patches of normal lichen vegetation. No lichen desert was detected.

The centre of Komárom with continuous built-up area with relatively high pollution (CO, Pb) due to increased traffic is the inner struggle zone (struggle zone I). Epiphytic lichen cover is not higher than 5%, dominating species is *Lecanora hagenii*. Foliose lichens if any (e.g. *Phaeophyscia orbicularis*, *Physcia adscendens*, *P. tenella*, *Xanthoria parietina*), present with small (1–2 cm^2) thalli.

Surrounding areas with lower degree of built-up area and pollution is the outer struggle zone (struggle zone II). Epiphytic lichen cover (ca 30–40%) and size of foliose lichen thalli (5–50 cm^2) are close to normal. Thalli of *Xanthoria parietina*, occurring in both zones, are sterile and about 1 cm in diameter in zone I, and richly fertile with the size of 20–50 cm^2 in zone II.

Normal zone was recognised at only two localities (Ácsi-erdő, Csém). These areas are not very rich in species, however some rare species occurred exclusively at one or both places (e.g. *Hypogymnia physodes*, *Lecanora*

Table 1

The occurrence of the lichen species at the collecting sites (ct: corticolous, r, ru: saxicolous, t, te: terricolous)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
Amandinea punctata	ct	ct	ct	ct						ct	ct	ct	ct		ct	ct		ct	ct		ct	ct								ct
Aspicilia contorta																													ru	
Aspicilia moenium																														
Bacidina arnoldiana agg.																														
Bacidina cf. *egenula*																														
Caloplaca citrina		ru					ru													ru				ru						
Caloplaca cf. *crenulatella*																					ru			ru						
Caloplaca decipiens		ru																												
Caloplaca dolomiticola s. l.																								ru						
Caloplaca saxicola																				ru							ru			
Caloplaca teicholyta							ru																							
Candelariella aurella		ru					ru		ru											ru	ru			ru						
Candelariella medians							ru																	ru						
Candelariella xanthostigma	ct																ct													
Cladonia spp.																				r,t										
Collema crispum																				r,t										
Endocarpon pusillum							ru													ru										
Evernia prunastri																														
Hypogymnia physodes	ct																													
Lecania erysibe agg.							ru													ru							ru			
Lecanora albescens							ru													ru				ru						
Lecanora cf. *chlarotera*																														
Lecanora campestris																				ru										
Lecanora conizaeoides																						ct								
Lecanora dispersa		ru					ru		ru											ru	ru		ru	ru						
Lecanora hagenii	ct	ct			ct	ct				ct		ct	ct	ct	ct	ct						ct								
Lecanora muralis		ru					ru													ru	ct					ru				
Lecanora saligna	ct							ct							ct							ct	ct				ct			
Lecidella elaeochroma																														
Lecidella stigmatea																				ru										
Lepraria incana																ct														
Leptogium plicatile							r,t													r,t										
Parmelia sulcata	ct	ct										ct				ct		ct												
Phaeophyscia nigricans							ru										ct										ru			
Phaeophyscia orbicularis	ct	r,c	ct	ct									ct									ct								ct
Physcia adscendens	ct	ct	ct							ct		ct					ct	ct												ct
Physcia caesia		ru																												
Physcia dimidiata																				ru										

Table 1 (cont.)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
Physcia stellaris		ct															ct													
Physcia tenella	ct	ct	ct	ct								ct					ct	ct										ct		ct
Physcia wainioi							ru																							
Pleurosticta acetabulum																														
Sarcogyne regularis																				ru	ru			ru						ru
Scoliciosporum chlorococcum		ct																			ct		ct							
Staurothele frustulenta																														
Strangospora pinicola																		ct												
Verrucaria muralis																				ru										ru
Verrucaria nigrescens									ru											ru	ru			ru						
Xanthoria elegans																														
Xanthoria parietina	ct	ct		ct								ct				ct														

	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
Amandinea punctata		ct				ct		ct	ct											ct				ct		ct			ct	
Aspicilia contorta														ru																
Aspicilia moenium																														
Bacidina arnoldiana agg.																														
Bacidina cf. *egenula*																									ru					
Caloplaca citrina						ru						ru									ru				ru				ru	
Caloplaca cf. *crenulatella*						ru		ru			ru				ru		ru					ru							ru	
Caloplaca decipiens																									ru					
Caloplaca dolomiticola s. l.																														
Caloplaca saxicola																						ru								
Caloplaca teicholyta																														
Candelariella aurella					ru	ru		ru	ru		ru	ru	ru		ru		ru	ru	ru		ru	ru					ru		ru	ru
Candelariella medians																														
Candelariella xanthostigma																				ct										
Cladonia spp.																					r,t									
Collema crispum																														
Endocarpon pusillum																														
Evernia prunastri																														
Hypogymnia physodes																														
Lecania erysibe agg.																														
Lecanora albescens					ru	ru						ru										ru							ru	ru
Lecanora cf. *chlarotera*																														
Lecanora campestris																														
Lecanora conizaeoides						ct																								
Lecanora dispersa					ru	ru		ru	ru		ru	ru			ru	ru	ru	ru	ru		ru	ru	ru		ru		ru		ru	
Lecanora hagenii	ct	ct	ct	ct		ct	ct	ct	ct	ct	ct	ct		ct						ct				ct		ct		ct	ct	

Table 1 (cont.)

	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
Lecanora muralis					ru	ct								ru					ru										ct	
Lecanora saligna							ct		ct																					
Lecidella elaeochroma																														
Lecidella stigmatea																														
Lepraria incana																														
Leptogium plicatile																														
Parmelia sulcata									ct																				ct	
Phaeophyscia nigricans																													ru	
Phaeophyscia orbicularis					ru				ct	ct				ru					ru				ru	ct		ct			
Physcia adscendens		ct					ct												ct											
Physcia caesia					ru																									
Physcia dimidiata																														
Physcia stellaris																														
Physcia tenella		ct							ct																				ct	
Physcia wainioi																														
Pleurosticta acetabulum																														
Sarcogyne regularis								ru									ru	ru											ru	
Scoliciosporum chlorococcum						ct																								
Staurothele frustulenta																	ru													
Strangospora pinicola						ct			ct																					
Verrucaria muralis																	ru	ru											ru	
Verrucaria nigrescens					ru			ru					ru									ru			ru				ru	
Xanthoria elegans																														
Xanthoria parietina						ct								ct						ct										

	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.	81.	82.	83.	84.	85.	86.	87.	88.	89.	90.
Amandinea punctata			ct	ct	ct	ct				ct		ct	ct	ct					ct	ct	ct	ct								
Aspicilia contorta							ru																							
Aspicilia moenium								ru																						
Bacidina arnoldiana agg.										ru																				
Bacidina cf. *egenula*																														
Caloplaca citrina	ru						ru																							
Caloplaca cf. *crenulatella*																		ru						ru						
Caloplaca decipiens							ru																							
Caloplaca dolomiticola s. l.																														
Caloplaca saxicola							ru																							
Caloplaca teicholyta																														
Candelariella aurella								ru															ru	ru						
Candelariella medians																														
Candelariella xanthostigma							ct													ct										

Table 1 (cont.)

	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.	81.	82.	83.	84.	85.	86.	87.	88.	89.	90.
Cladonia spp.																														
Collema crispum																														
Endocarpon pusillum																														
Evernia prunastri																						ct								
Hypogymnia physodes													ct																	
Lecania erysibe agg.																														
Lecanora albescens							ru																ru							
Lecanora cf. chlarotera																						ct								
Lecanora campestris																														
Lecanora conizaeoides																ct														
Lecanora dispersa	ru	ru					ru	ru										ru						ru						
Lecanora hagenii			ct	ct	ct		ct	ct						ct	ct		ct	ct		ct	ct									
Lecanora muralis							ru		ru											ct										
Lecanora saligna													ct									ct								
Lecidella elaeochroma																						ct								
Lecidella stigmatea																														
Lepraria incana													ct																	
Leptogium plicatile																														
Parmelia sulcata					ct								ct						ct			ct								
Phaeophyscia nigricans				ct				ru			ct									ct										
Phaeophyscia orbicularis				ct	ct	ct		ru		ct				ct				ru		ct	ct	ct								
Physcia adscendens				ct	ct		ct	ct		ct	ct		ct					ct	ct	ct	ct	ct								
Physcia caesia																														
Physcia dimidiata																				ru										
Physcia stellaris										ct									ct			ct								
Physcia tenella				ct	ct	ct	ct	ct			ct		ct						ct	ct	ct	ct								
Physcia wainioi																														
Pleurosticta acetabulum																						ct								
Sarcogyne regularis							ru																ru							
Scoliciosporum chlorococcum										ct			ct																	
Staurothele frustulenta																														
Strangospora pinicola													ct					ct												
Verrucaria muralis							ru																ru							
Verrucaria nigrescens																							ru	ru						
Xanthoria elegans							ru	ru																						
Xanthoria parietina				ct	ct	ct		ct		ct									ct		ct	ct								

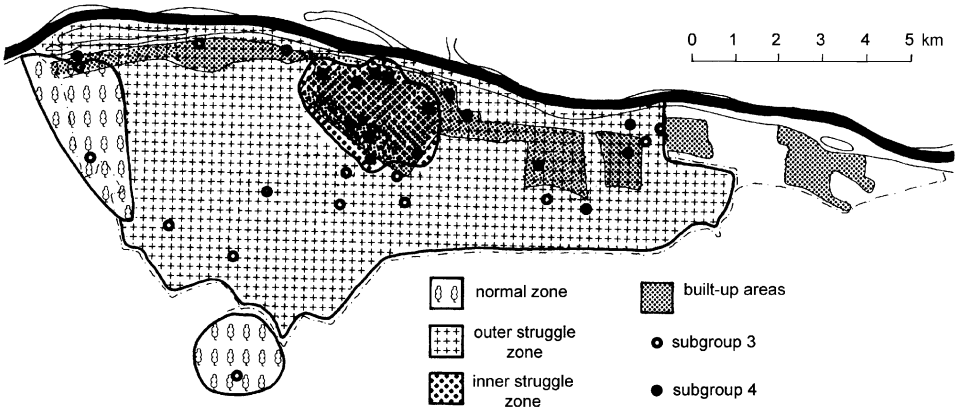

Fig. 4. The lichen map of Komárom with the reallocated epiphytic subgroups obtained by the global optimization method (Csontos et al. 2000)

cf. *chlarotera*, *Lecidella elaeochroma*, *Lepraria incana*, *Pleurosticta acetabulum*). *Evernia prunastri*, the only fruticose species, was found at Csém.

Improvement in environmental conditions due to the activity of the local authorities of public health is possible to be detected by reinvestigation of the lichen flora in the future (compared to the recent lichen map). Changes in lichen cover, extinction or recolonisation of various species can be expected. Colonisation of species is also possible from the normal zone or struggle zone II to the struggle zone I.

*

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REFERENCES

Bunovácz, D. (szerk.) (1998): *Komárom és térsége*. – CEBA Kiadó, pp. 32–40.

Cislaghi, C. and Nimis, P. L. (1997): Lichens, air pollution and lung cancer. – *Nature* 387: 463–464.

Csikány, T. and Horváth, Cs. (1998): *Komárom erődváros.* – Komárom Város Önkormányzata, pp. 89–142.
Csontos, P., Lőkös, L. and Molnár, K. (2000): Numerical analysis of lichen zones in Komárom, NW Hungary. – *Studia bot. hung.* 30–31: 127–136.
Degelius, G. (1954): The Lichen Genus Collema in Europe. Morphology, Taxonomy, Ecology. – *Symb. Bot. Upsal.* 13(2), Uppsala, 499 pp.
Farkas, E. (1982): *Légszennyeződési vizsgálatok Budapest területén zuzmó-bioindikátorokkal.* – M. Sc. Thesis, ELTE TTK Növényrendszertani és Ökológiai Tanszék, Budapest, 91 pp.
Farkas, E. (1990): *Lichenológiai vizsgálatok Budapesten és a Pilis Bioszféra Rezervátumban – elterjedés, bioindikáció.* (Investigation of the lichen flora in Budapest and in the Pilis Biosphere Reservation – distribution and bioindication.) – Ph.D. Thesis, MTA ÖBKI, Vácrátót, 121 pp.
Farkas, E., Lőkös, L. and Verseghy, K. (1985): Lichens as indicators of air pollution in the Budapest Agglomeration. I. Air pollution map based on floristic data and heavy metal concentration measurements. – *Acta Bot. Acad. Sci. Hung.* 31(1–4): 45–68.
Felföldy, L. (1942): A városi levegő hatása az epiphyton-zuzmóvegetációra Debrecenben. – *Acta Geobot. Hung.* 4: 332–349.
Ferry, B. W., Baddeley, M. S. and Hawksworth, D. L. (eds) (1973): *Air pollution and lichens.* – The Athlone Press, University of London, London, 389 pp.
Gallé, L. (1979): Wirkung der Luftverunreinigung auf die Verarmung der Flechtenvegetation der Stadt Szeged und ihrer Umgebung. – *Acta Biologica* (Szeged), 25(1–2): 3–15.
Galun, M. and Ronen, R. (1988): *Interaction of lichens and pollutants.* – In: Galun, M. (ed.): CRC Handbook of Lichenology, CRC Press, Inc., Boca Raton, Florida, Vol. 3, pp. 55–72.
Gilbert, O. L. (1970): A biological scale for the estimation of sulphur dioxide pollution. – *New Phytologist* 69: 629–634.
Gilbert, O. L. (1973): *Lichens and air pollution.* – In: Ahmadjian, V. and Hale, M. E. (eds): The lichens. – Academic Press, New York, pp. 443–472.
Hawksworth, D. L. and McManus, P. M. (1989): Lichen recolonization in London under conditions of rapidly falling sulphur dioxide levels, and the concept of zone skipping. – *Bot. J. Linn. Soc.* 100: 99–109.
Hawksworth, D. L. and Rose, F. (1970): Qualitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. – *Nature* 227: 145–148.
Hawksworth, D. L. and Rose, F. (1976): *Lichens as pollution monitors.* – Edward Arnold, London, 60 pp.
Henderson, A. (1999): Literature on air pollution and lichens XLVIII. – *Lichenologist* 31: 111–119.
Henderson, A. (2000): Literature on air pollution and lichens XLIX. – *Lichenologist* 32: 89–102.
Kecskés, L. (1973): *Komárom története.* – Városi Tanács VB., Komárom, pp. 1–47.
Kecskés, L. (1984): *Komárom az erődök városa.* – Klapka György Alapítvány, Komárom, 289 pp.
Kecskés, L. (1985): *Komárom.* – Komárom megyei Idegenforgalmi Hivatal, pp. 7–22.
Kiss, T. (1990): *Élet-stratégiák alkalmazása a környezetminőség meghatározásában. Bioindikátorok a zuzmók és társulásaik.* – "Bázis" Magyar Tudományos és Oktatási Egyesület, Budapest, "Játék a biztonságért" sorozat, 135 pp.
Lackovičová, A. (1997a): Aktuálny výskyt lišajníkov v Národnej prírodnej rezervácii Šúr. (Recent occurrence of lichens in the National nature reserve Šúr). – *Bull. Slov. Bot. Spolocn.*, Bratislava 19: 71–77.
Lackovičová, A. (1997b): Lišajníky Pustých Úl'an (Podunajská Nížina). (Lichens of Pusté Úl'any [Podunajská Nížina Lowland]). – *Ochrana prírody*, Banská Bystrica 15: 29–34.

Lőkös, L. (1983): *Transzplantált zuzmóminták atomabszorpciós nehézfémanalízise Budapest területén*. (Atomic absorption analysis of heavy metal contents of lichens transplanted at Budapest). – ELTE TTK Növényrendszertani és Ökológiai Tanszék, Szakdolgozat (Kézirat), M. Sc. Thesis, Budapest, 59 pp.

Malatinszki, G. (1992): Szolnok zuzmótérképe. – *Élet és Tudomány* 49: 1543.

Molnár, K. (1999): *A zuzmók szerepe Komárom és környéke környezetminőségének vizsgálatában*. – ELTE TTK Növényrendszertani és Ökológiai Tanszék, Szakdolgozat (Kézirat), M. Sc. Thesis, Budapest, 73 pp.

Pallos, G. (1996): *Gyöngyös levegőszennyezettségének vizsgálata a zuzmóflóra alapján*. – GATE Mezőgazdasági Főiskolai Kar, Szakdolgozat, Budapest, 57 pp.

Purvis, O. W., Coppins, B. J., Hawksworth, D. L., James, P. W. and Moore, D. M. (1992): *The Lichen Flora of Great Britain and Ireland*. – Natural History Museum Publications, London, 710 pp.

Rusko, M. (1978): *Epifytické lišajniky Burdy a znec istenie ovzdušia*. – Katedra Systematicky Fakulty Univerzity Komenského (kézirat), Bratislava, pp. 1–213.

Solymosi, P. (1978): A Duna hullámtéri erdőinek epiphyton zuzmóvegetációja. – *Bot. Közlem*. 65: 7–13.

Szabados, K. (1993): *Biomonitoring of air quality by lichen mapping in Vác*. – Kézirat, Budapest, 42 pp.

Toldi, O. (1986): *Debrecen és környéke összehasonlító zuzmóflorisztikai felmérése, a zuzmóvegetáció szünfenobiológiai és ökológiai vizsgálata*. – TDK dolgozat, Debrecen, 57 pp.

Turner, D. and Borrer, W. (1839): *Specimen of a Lichenographia Britannica*. – Yarmouth, 240 pp.

Váncsa, A. and Váncsa, A. (1990): Miskolc zuzmótérképe. – *Élet és Tudomány* 45(47): 1487.

Verseghy, K. (1994): *Magyarország zuzmóflórájának kézikönyve*. (The lichen flora of Hungary). – Magyar Természettudományi Múzeum, Budapest, 415 pp.

Wirth, V. (1995a): *Die Flechten Baden-Württembergs*. – Eugen Ulmer GmbH and Co., Stuttgart, 992 pp.

Wirth, V. (1995b): *Flechtenflora*. – Eugen Ulmer GmbH and Co., Stuttgart, 661 pp.