

# A comparative study of the lichens of two cemeteries in Belgrade, Serbia

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**Abstract.** A comparison of two cemeteries in Belgrade, Serbia, has been made in order to show how the different environmental factors affect their lichen diversity. The importance of cemeteries as refugia for lichens and as habitats for lichen recolonisation under ameliorating conditions in urban areas is stressed.

**Key words:** air pollution, Belgrade, biodiversity, cemeteries, lichens, Serbia

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## Introduction

Belgrade (population 1,58 million), the capital of Serbia, is situated at the confluence of the Danube and Sava Rivers at altitudes ranging from 60 to 253 m; it has a moderately continental climate, and over the period 1960–1990 had a mean annual relative air humidity of 71 % and a mean annual temperature of 11.9 °C (Savic 1998).

Very limited data on the city's lichens exist prior to the epiphytic surveys in the first half of the 1990s by Milic & Blazencic (1993) and Savic (1998), the latter summarising the known published work, providing useful information on the climate and SO<sub>2</sub> pollution and a reasonably clear account of the poor state of the urban lichen communities. A similar picture of the epiphytic lichens is to be observed today, with no apparent improvement in biodiversity. There appears to be no previous study of the non-epiphytic lichens of the city. The authors therefore took the opportunity to undertake a comparative study of two major cemeteries near the centre of Belgrade during a short visit there in September 2004.

Cemeteries are particularly important habitats for lichens in both rural landscapes and urban environments, more particularly in the latter where their growth is confined to 'oases' within an otherwise hostile milieu. This is not to say that such areas are free from air pollution, the over-riding factor governing lichen distribution, but within such protected areas lichens have a better chance of survival and are more valuable as pollution monitors when all other disturbing factors are

minimised (John 1989). Unfortunately, the sanctity of these habitats is increasingly disregarded and vandalism of such sanctuaries is on the increase. Fortunately the two Belgrade cemeteries under consideration are reasonably free from the latter, although it should be noted that there are differences (mostly relating to their management) between the Orthodox and Jewish cemeteries which have affected (or will affect) their lichen diversity (see below).

## Site and habitat details

Both cemeteries investigated are situated *ca* 2 km to the west of the city centre. The Orthodox cemetery, Novo groblje (23.44 hectares) is bordered by the Ruzveltova – Mije Kovacevica, Severni Bulevar, and Svetog Nikole roadways. The much smaller Jewish cemetery, Jevrejsko groblje (1.50 hectares) is separated from the Orthodox cemetery by the Ruzveltova – Mije Kovacevica roadway; the two cemeteries therefore experience virtually the same urban environmental (climate and pollution) conditions.

As well as being much larger than the Jewish cemetery, the Orthodox cemetery is much more open, being intersected in places with wide avenues often bordered by trees; furthermore, it appears to be better maintained (some areas currently under reconstruction in terms of memorials and access) and more frequented by visitors to graves and the church. Additionally, its gravestones are mainly constructed of polished granite,

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although extensive cementwork occurs between formal graves where multi-interments are made beneath concrete slabs; interestingly these informal interments are usually marked by wooden crosses at the edges of the slabs, thereby providing an additional and important substratum for lichens.

On the other hand, the Jewish cemetery is more enclosed, other than an area at the entrance where a large marble memorial has been erected, and is bordered by a row of mature *Populus nigra* L. A central avenue is bordered by conifer trees mainly devoid of lichens, but a single *Juglans regia* L. to the north-west of the cemetery supports a richer lichen community, matched only by *Populus nigra* at this site. The Jewish cemetery appears, at least in part, to be less well maintained and frequented, but for its size there is a wide variety of saxicolous substrata for lichen colonization; in addition, the large marble memorial mentioned above, although maintained, has surfaces and niches supporting a relatively high number of lichens.

## Species lists

Key: 1 = Orthodox cemetery, 2 = Jewish cemetery. Herbarium material to support some of these records has been incorporated into the personal herbarium Seaward and in POLL (John 2002).

### *Lichens on gravestones and memorials*

- Acarospora cervina* A. Massal. – 2, rare, a single thallus ca 10 cm diam. on a calcareous table tomb.
- Amandinea punctata* (Hoffm.) Coppins & Scheid. – 1, rare, on a single siliceous grave surround influenced by iron railing.
- Aspicilia contorta* (Hoffm.) Kremp. – 2, locally frequent, on calcareous table tombs.
- Aspicilia contorta* subsp. *hoffmanniana* S. Ekman & Fröberg – 2, rare, but abundant on a single calcareous table tomb.
- Caloplaca citrina* (Hoffm.) Th. Fr. – 1, uncommon, on a variety of calcareous substrata, particularly cement work; – 2, rare, found only on a marble memorial and a few calcareous gravestones.
- Caloplaca crenularia* (With.) J.R. Laundon – 2, rare, two thalli (7 cm & 9 cm diam.) on a single siliceous table tomb.
- Caloplaca decipiens* (Arnold) Blomb. & Forssell – 2, locally abundant, on a marble memorial and occasional on calcareous gravestones.
- Caloplaca dolomiticola* (Hue) Zahlbr. – 2, rare, on a marble memorial.
- Caloplaca holocarpa* (Ach.) A.E. Wade – 1, locally frequent, on calcareous substrata; 2, common, on a marble memorial and table tombs.
- Caloplaca lithophila* H. Magn. – 2, occasional, on calcareous substrata.
- Caloplaca teicholyta* (Ach.) J. Steiner – 1, rare, on cementwork; – 2, locally frequent, on a marble memorial and table tombs.

- Candelariella aurella* (Hoffm.) Zahlbr. – 1, frequent, on a variety of calcareous substrata; – 2, locally frequent, on a marble memorial and table tombs.
- Candelariella vitellina* (Hoffm.) Müll. Arg. – 1, infrequent, on siliceous substrata, including those influenced by iron; – 2, locally frequent, on siliceous substrata, particularly table tombs.
- Lecania inundata* (Hepp ex Körb.) M. Mayrhofer – 2, rare, on a marble memorial.
- Lecanora albescens* (Hoffm.) Branth & Rostr. – 1, rare, on a few calcareous gravestones; – 2, rare, on a few calcareous gravestones and a marble memorial.
- Lecanora crenulata* Hook. – 1, infrequent, on cementwork and a few gravestones; 2, infrequent, on calcareous substrata.
- Lecanora dispersa* (Pers.) Sommerf. – 1, common, on a variety of calcareous substrata, particularly cementwork; – 2, common, on a variety of calcareous substrata.
- Lecanora muralis* (Schreb.) Rabenh. – 1, locally frequent, on cementwork, some thalli over 10 cm in diam.; – 2, very common on calcareous substrata, some table tombs being almost entirely covered by thalli at various stages of development and in some cases supporting a very high proportion of juvenile thalli less than 1 cm in diam.
- Lecanora polytropa* (Hoffm.) Rabenh. – 1, rare, on a single siliceous grave surround influenced by iron railing.
- Lecidea fuscoatra* (L.) Ach. – 1, rare, on a single siliceous grave surround influenced by iron railing; – 2, rare, as var. *grisella*, on a single table tomb.
- Lecidella stigmathea* (Ach.) Hertel & Leuckert – 1, rare, on cementwork; – 2, rare, on the mortar of a few graves.
- Rinodina gennarii* Bagl. – 1, rare, on cementwork.
- Verrucaria caerulea* DC. – 2, rare, on a marble memorial.
- Verrucaria muralis* Ach. – 1, frequent, on calcareous substrata; – 2, locally frequent, on marble monument and occasional, on other calcareous substrata.
- Verrucaria nigescens* Pers. – 1, common, on a variety of calcareous substrata; – 2, common, on calcareous substrata.

### *Lichens on lignum*

- Amandinea punctata* – 1, rare, on a wooden seat.
- Candelariella vitellina* – 1, occasional, on a variety of woodwork.
- Lecanora conizaeoides* Cromb. – 1, uncommon, on a few wooden crosses and a single wooden seat.
- Lecanora dispersa* – 1, uncommon, on a single wooden seat.
- Lecanora muralis* – 1, rare, a few small thalli on a wooden seat.
- Lecanora saligna* (Schrad.) Zahlbr. – 1, rare, on a wooden seat.
- Phaeophyscia orbicularis* (Neck.) Moberg – 1, rare, a few thalli up to 5 mm diam. on wooden crosses.
- Physcia biziana* (A.Massal.) Zahlbr. – 1, rare, a single thallus (6 × 10 mm) on wooden cross.

- Physcia tenella* (Scop.) DC. – 1, uncommon, a few tiny thalli on wooden crosses.  
*Placynthiella icmalea* (Ach.) Coppins & P. James – 1, locally frequent, on wooden crosses and a single wooden seat.  
*Trapeliopsis flexuosa* (Fr.) Coppins & P. James – 1, rare, on a single wooden cross.  
*Trapeliopsis granulosa* (Hoffm.) Lumbsch – 1, infrequent, on wooden crosses.

### Lichens on trees

- Lecanora conizaeoides* – 1, rare, on *Tilia* sp.  
*Lecanora hagenii* (Ach.) Ach. – 2, locally frequent, on the bases of *Populus nigra*.  
*Parmelia sulcata* Taylor – 1, rare, a single 6 mm diam. thallus on *Tilia* sp.  
*Phaeophyscia orbicularis* – 2, locally frequent, on *Juglans regia* and *Populus nigra*.  
*Physcia adscendens* (Fr.) H. Olivier – 2, locally frequent, on *Juglans regia* and *Populus nigra*.  
*Physcia tenella* – 2, locally frequent, on *Juglans regia* and *Populus nigra*.  
*Xanthoria candelaria* (L.) Th. Fr. – 2, rare, a single 6 mm diam. thallus on *Populus nigra*.  
*Xanthoria parietina* (L.) Th. Fr. – 2, locally frequent, on *Populus nigra*, but only a single 15 mm diam. thallus on *Juglans regia*.

### Discussion

Cemeteries and graveyards in urban areas provide refugia for lichens that are often absent from the surrounding area since they are usually respected (Laundon 1970), being free, for example, from vandalism, and thereby able to maintain ecological continuity. Equally, the wide variety of substrata to be found in cemeteries and graveyards, especially those not subjected to cleaning, can support a diverse lichen flora in less polluted environments. Hence, there is often good reason for such habitats being conserved on lichenological as well as historical grounds; furthermore, they frequently provide suitable sites for environmental monitoring, particularly of quantitative and qualitative changes in air pollution.

Despite the favourability of this type of habitat, there is still a rather impoverished lichen flora present in both Belgrade cemeteries due to the over-riding factor of air pollution (Richardson 1992; Seaward 1993). However, there is some evidence from our studies of the epiphytic flora that air quality in Belgrade has improved since the survey of Savic (1998); this being the case, baseline information of this kind will prove invaluable in determining not only the rate and extent of amelioration (Seaward 1997), but also qualitative changes, particularly those resulting from hypertrophication (Seaward & Coppins 2004; Verein Deutscher Ingenieure 2004), as currently observed to some extent on *Populus* and *Juglans* trees in the cemeteries under investigation.

It is also clear that the two cemeteries studied support significantly different lichen floras (Tab. 1), not only in terms of the different saxicolous substrata, but also of the availability of different tree species and lignum. Polished granite gravestones are unsuitable for lichen colonisation; the preponderance of this substratum in the Orthodox cemetery is undoubtedly one of the major reasons for such a sparse and uninteresting lichen community, but human disturbance accounts for the lower diversity and poor cover values of lichens on most substrata. In the Jewish cemetery, on the other hand, the limestone and marble gravestones and memorials, coupled with less human disturbance, are the major reasons for the richer and more evident lichen diversity; however, the greater presence of woodwork (lignum) in the Orthodox cemetery does raise the level of lichenological interest there.

Although the chemical nature of the stone is of over-riding importance (Brightman & Seaward 1977; Weber & Büdel 2001), lichens in cemeteries and churchyards are subjected to an interplay of factors that dictate their distribution and abundance on substrata (Prieto *et al.* 1999); different species of saxicolous lichens, for example, react positively or negatively to the influence of metal ions and bird excreta (James *et al.* 1977), and show a preference for either horizontal or vertical surfaces (Weber 2001). However, the current sparseness of the lichen floras in both Belgrade cemeteries does not permit ecological interpretation of lichen species and communities, although some level of frequency is provided in the above species list.

Lichenological studies of cemeteries and churchyards can be extremely rewarding (Chester 1997), but it should be noted that such habitats are increasingly under threat due to

**Table 1.** Lichen diversity on four different substrata in two Belgrade cemeteries

Substratum	Orthodox cemetery	Jewish cemetery	Both cemeteries
Saxicolous (calcareous)	12	19	20
Saxicolous (siliceous)	4	3	5
Lignicolous	12	0	12
Corticolous	2	6	8
Total	30	28	45

mindless vandalism and environmental mismanagement, such as landscape reconstruction, where for example gravestones are reused as paving, etc., or by over-enthusiastic cleaning of stonework, often to the detriment of both the lichens and the substratum.

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