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Original Scientific Paper

The sinstructure of epiphytic lichens within forests from the eastern part of Bucharest Municipality (Romania)

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ABSTRACT: This study is based on assessment of epiphytic lichen sinstructure within forestry ecosystems from the eastern part of Bucharest Municipality. The number of lichen species was found to increase with distance from Bucharest. Within Goştilele and Călăreţilor forests, the most abundant were common lichen species and the less common lichen species were recorded less frequently. A less common lichen species in the area of study, namely *Ramalina pollinaria*, sampled in Pustnicul Forest was recorded more frequently (50% relative abundance) compared with cosmopolitan lichen species, such as *Physcia adscendens*, *Xanthoria parietina* etc., which had lower relative abundances. All lichen species were recorded on trunks with a rough rhytidoma and with diameters more than 0.50 m.

Key words: epiphytic lichen, sinstructure, forests, Bucharest Municipality, Romania

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INTRODUCTION

It is now well known that the number of lichen species increases as a function of the distance from urban and industrial polluted areas (Kapusta *et al.* 2004; Sommerfeldt & John 2001). Neitlich & McCune (1997) have evaluated species richness depending on the forest structure: the species number was higher within middle-aged forests which included trees with weak canopies, moderate within old-growth forests, and low in young forests.

The main anthropogenic activities responsible for substrata eutrophication are agricultural practices and farming. Increases of nitrogen oxides in the atmosphere are followed by a spectacular increase of nitrophilous lichen taxa, such as *Physcia* (Schreb.) Michaux (1803), *Phaeophyscia* (Moberg. (1977), and *Xanthoria* (Fr.) Th. Fr. (1860) (Otnyukova & Sekretenko 2008).

In areas around Bucharest Municipality, large areas of forests have been cleared, especially for agricultural use (Şerbănescu 1959). Conversion of natural old-growth forests to even-aged secondary plantations, represents the main cause of decreasing lichen abundances and species richness and even their disappearance from forests (Dettki *et al.* 2000; Purvis 2000; Hilmo *et al.* 2009). There are a few lichen species which are growing in forests after the trees have become mature and developed a specific substrate and a suitable microclimate in the canopy (Morley & Gibson 2010). Trees at a given age in even-aged plantations do not experience the same environmental conditions as trees of a similar age in old natural stands (Hilmo *et al.* 2009); therefore forestry management has a detrimental effect on lichen species. It has been shown that relict stands of ancient forests provide refugia for particular lichen communities in an otherwise unsuitable, disturbed or developed landscape (Morley & Gibson 2010).

The older oak (*Quercus cerris* L.) from Pustnicul Forest (Ilfov County), represents suitable microhabitats for rare and threatened lichen species, such as *Hypotrachyna sinuosa* (Sm.) Hale (Vicol 2010) found on the Red List of macrolichens from Romania (Sârbu *et al.* 2007).

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This study aimed to assess the epiphytic lichens sinstructure from forests in the eastern part of Bucharest Municipality. Special attention was given to environmental drivers with a major influence on epiphytic lichens.

MATERIAL AND METHODS

The area studied was located in the eastern part of Bucharest within the Romanian Plain (Fig. 1).

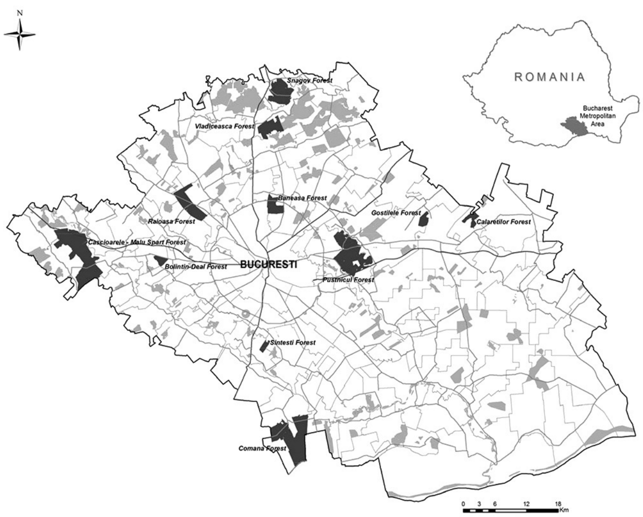

Fig. 1. Forests in the area of study.

As a whole, the area of study is characterized by a temperate-continental climate. The annual mean air temperature (calculated for 1961-2000) ranges between 9.8°C at Tâncăbești and 11.2°C in both Giurgiu and Bucharest-Filaret. The average air humidity ranges between 75%-85%. Annual mean precipitation decreases from north (613.1 mm) to south (550 mm) of Bucharest. The prevailing winds are those from the north-east (22.4% at Băneasa and 23.2% at Afumaţi) and south-west (14.8% at Băneasa and 8.1% at Afumaţi). Multiannual means of the De Martonne aridity index decrease from north to south and from west to east, as a consequence of the declining altitude and increasing degree of continentality, showing a tendency to aridity (Pătroescu 1988; Iojă 2008).

Within the studied area, the vegetation is represented by sylvo-steppe. The sylvo-steppe zone, is characterized by the presence of *Quercus pubescens* Willd., followed by *Quercus cerris* L., *Quercus frainetto* Ten., and *Quercus pedunculiflora* K. Koch. The oak species are often found in association with *Acer campestre* L., *Carpinus betulus* L., and *Carpinus orientalis* Mill. A relatively high frequency of mediteranean species such as *Ruscus aculeatus* L. and *Fraxinus ornus* L. is a sylvo-steppe particularity. The herbaceous species are represented by an abundance of *Arum orientale* M. Bieb., *Brachypodium sylvaticum* (Huds.) Beauv., *Carex tomentosa* L., *Festuca valesiaca* Schleich. ex Gaudin, *Lithospermum purpurocaeruleum* L. (*Buglossoides purpurocaerulea* (L.) I. M. Johnst.), and *Polygonatum latifolium* (Jacq.) Desf. (Bălteanu *et al.* 2006; Iojă 2008).

For this study, the following forests were investigated: Pustnicul Forest (Ilfov County), Goștilele Forest (Călărași County), and Călăreţilor Forest (Călărași County) (Fig. 1).

Epiphytic lichen species were investigated according to Bartók (1985), with some modifications. In each of the studied forests, up to nine sampling units of 10 m x 10 m were randomly selected. A total of 27 sampling units were investigated within the study area. Within each sampling unit of 10 m x 10 m, from each of the three forests a tree located near the centre of the unit was selected. Within all sampling units, 27 trees were sampled. On each tree from each sampling unit a frame of 20 cm x 20 cm was set on the selected trees, at a heigh of 1 m above the soil.

Surveying samples. References used to determine the collected lichen species were Moruzi & Toma (1971) and Ciurchea (2004).

Lichen species were identified based on the colour reaction of the thallus, morphology, aspects of thalline elements, microscopic analysis of preparations using chemical reagents, such as potassium hydroxide (KOH), calcium chloride ($CaCl_2$), and iodine-potassium iodide.

The nomenclature used for lichens is according to Ciurchea (2004) and that used for host trees is according to Ciocârlan (2009).

Data analyses. The relative abundance of each lichen species was calculated using the following formula (Botnariuc & Vădineanu 1982):

$$A = \frac{n}{N} \times 100$$, where:

A is relative abundance;

n is the total number of individuals of a particular species present in a certain number of sampling units;

N is the total number of individuals from all investigated sampling units.

The truck diameter of each sampled tree was measured within each forest.

The number of epiphytic lichen species was analysed in relation to the distance from Bucharest Municipality, and .

It was taken into account the correlation between the trees bark and the growth form of the epiphytic lichen species.

The map was realized using ArcGis 9.3 software.

RESULTS

A total of 16 lichen species were recorded in the three investigated forests (Table 1), of which a high percentage (43.47%) was recorded in Călăreţilor Forest, followed by Goştilele Forest (30.43%), and Pustnicul Forest (26.08%). The number of lichen species was found to increase as a function of the distance from Bucharest Municipality (Fig. 2). Regarding the abundance of sampled lichen species, a high percentage (50.25%) was attributed to *Ramalina pollinaria*, a less common species in the studied area (pers. com.), which has been found within Pustnicul Forest. In this forest, the cosmopolitan lichen species had lower percentage abundances. Unlike Pustnicul Forest, within Goştilele and Călăreţilor forests, the most abundant lichen species were the cosmopolitan ones, such as *Physcia adscendens* (Fr.) Oliv. (68.10%), *Amandinea punctata* (Hoffm.) Coppins & Scheidegger (23.59%) in Goştilele, and *Physcia adscendens* (49.84%) and *Physconia detersa* (Nyl.) Poelt. (31.83%) in Călăreţilor. The following lichen species were less frequent within the study area: *Physconia enteroxantha* (Nyl.) Poelt., *Parmelina tiliacea* (Hoffm.) Hale, *Melanelia olivacea* (L.) Essl., and *Pleurosticta acetabulum* (Necker) Elix & Lumbsch, with the lowest percentage abundances (Table 2).

There was no great difference regarding the inventoried lichen species in relation to trunk diameter. Within Călăreţilor Forest, a relation between trunk diameter of the oldest oaks and the less frequent lichen species was found. Thus, on host trees with a size range of 2-2.50 m, two of the less common epiphytic lichen species

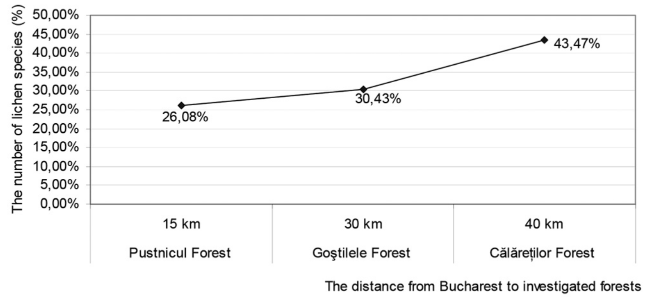

Figure 2. Relation between the number of lichen species and distance from Bucharest Municipality.

(*Melanelia olivacea* and *Pleurosticta acetabulum*) were recorded. Within Pustnicul Forest, only one uncommon lichen species (*Ramalina pollinaria*) was recorded on trunks with a considerable size. The less frequent lichen species, for instance *Physconia enteroxantha* (Nyl.) Poelt. and *Ramalina pollinaria*, were inventoried in Pustnicul Forest on tree trunks with diameters of 0.5-1 m and 1-2 m. *Parmelina tiliacea* and *Pleurosticta acetabulum* were found, the first in Goştilele Forest and the latter in Călăreţilor Forest on trunks with diameters of 0.5-1 m and 1-2 m, respectively. The common lichen species (*Amandinea punctata*, *Physcia adscendens*, *Xanthoria parietina* (L.) Th. Fr., *Physconia detersa*, etc.) showed no strong dependence on trunk diameter (Table 3).

Within Pustnicul and Călăreţilor Forests the majority of lichen species were identified on species belonging to the *Quercus* genus. The epiphytic lichen species from Goştilele Forest were inventoried on *Robinia pseudacacia*

Table 1. List of inventoried lichen species within the studied area.

Trunk diameter							
Pustnicul Forest			**Goştilele Forest**		**Călăreţilor Forest**		
0.5-1 m	1-2 m	2-3.29 m	0.5-1 m	1-2 m	0.5-1 m	1-2 m	2-2.50 m
Physconia enteroxantha	*Ramalina pollinaria*	*Physconia detersa*	*Amandinea punctata*	*Amandinea punctata*	*Parmelia sulcata*	*Pleurosticta acetabulum*	*Melanelia olivacea*
Physcia adscendens	*Lepraria* ssp.	*Ramalina pollinaria*	*Physcia adscendens*	*Physcia adscendens*	*Pseudevernia furfuracea*	*Physconia detersa*	*Phsconia detersa*
Xanthoria parietina	-	*Physcia adscendens*	*Parmelina tiliacea*	*Physconia detersa*	*Lecanora* ssp.	*Xanthoria parietina*	*Pleurosticta acetabulum*
-	-	-	*Ochrolechia frigida*	*Ochrolechia frigida*	*Phaeophyscia orbicularis*	*Physcia adscendens*	*Physcia adscendens*
-	-	-	*Xanthoria parietina*	*Physconia grisea*	*Physcia adscendens*	*Physconia grisea*	*Parmelia sulcata*
-	-	-	-	-	-	*Phaeophyscia orbicularis*	*Xanthoria parietina*
-	-	-	-	-	-	*Lecanora* ssp.	-

Legend: - mean that there is no available data; + indicates the presence of the lichen species.

Table 2. The percentage distribution of relative abundance of lichen species within each forest.

Species	Host trees		
	Pustnicul	**Goştilele**	**Călăreţilor**
Amandinea punctata (Hoffm.) Coppins & Scheidegger	-	*Robinia pseudacacia* L.	+
Lecanora ssp. Ach.	-	-	*Quercus robur* L.
Lepraria ssp. Ach.	*Quercus robur* L.	-	-
Melanelia olivacea (L.) Essl.	-	-	*Quercus robur* L.
Ochrolechia frigida Mass.	-	*Robinia pseudacacia* L.	-
Parmelia sulcata Taylor	-	-	*Quercus robur* L., *Quercus cerris* L.
Parmelina tiliacea (Hoffm.) Hale	-	*Robinia pseudacacia* L.	-
Phaeophyscia orbicularis (Nĕck.) Moberg.	-	-	*Quercus robur* L.
Physcia adscendens (Fr.) Oliv.	*Fraxinus* ssp. L., *Quercus* ssp. L.	*Robinia pseudacacia* L.	*Quercus robur* L.
Physconia detersa (Nyl.) Poelt.	*Quercus* ssp. L.	*Robinia pseudacacia* L.	*Quercus robur* L.
Physconia enteroxantha (Nyl.) Poelt.	*Fraxinus* ssp. L.	-	-
Physconia grisea (Lahm.) Poelt.	-	*Robinia pseudacacia* L.	*Quercus robur* L.
Pleurosticta acetabulum (Necker) Elix & Lumbsch.	-	-	*Quercus robur* L.
Pseudevernia furfuracea (L.) Zopf.	-	-	*Quercus cerris* L.
Ramalina pollinaria (L.) Ach.	*Quercus robur* L., *Quercus* ssp. L.	-	-
Xanthoria parietina (L.) Th. Fr.	*Fraxinus* ssp. L.	*Robinia pseudacacia* L.	*Quercus robur* L.

Legend: - mean that there is no available data

Table 3. Epiphytic lichen species which were growing on the sampled trees in relation to the trunk diameter.

Species	Family	Investigated forest		
		Pustnicul	**Goştilele**	**Călăreţilor**
Amandinea punctata (Hoffm.) Coppins & Scheidegger	Physciaceae	-	+	-
Lecanora ssp. Ach.	Lecanoraceae	-	-	+
Lepraria ssp. Ach.	-	+	-	-
Melanelia olivacea (L.) Essl.	Parmeliaceae	-	-	+
Ochrolechia frigida Mass.	Pertusariaceae	-	+	-
Parmelia sulcata Taylor	Parmeliaceae	-	-	+
Parmelina tiliacea (Hoffm.) Hale	Parmeliaceae	-	+	-
Phaeophyscia orbicularis (Nĕck.) Moberg.	Physciaceae	-	-	+
Physcia adscendens (Fr.) Oliv.	Physciaceae	+	+	+
Physconia detersa (Nyl.) Poelt.	Physciaceae	+	+	+
Physconia enteroxantha (Nyl.) Poelt.	Physciaceae	+	-	-
Physconia grisea (Lahm.) Poelt.	Physciaceae	-	+	+
Pleurosticta acetabulum (Necker) Elix & Lumbsch.	Parmeliaceae	-	-	+
Pseudevernia furfuracea (L.) Zopf.	Parmeliaceae	-	-	+
Ramalina pollinaria (L.) Ach.	Ramalinaceae	+	-	-
Xanthoria parietina (L.) Th. Fr.	Teloschistaceae	+	+	+

Legend: - mean that there is no available data

Table 4. Host trees of the inventoried lichen species.

Species	Relative abundance (%)		
	Pustnicul Forest	**Goştilele Forest**	**Călăreţilor Forest**
Amandinea punctata (Hoffm.) Coppins & Scheidegger	-	23.50%	-
Lecanora ssp. Ach.	-	-	1.20%
Lepraria ssp. Ach.	15.57%	-	-
Melanelia olivacea (L.) Essl.	-	-	2.40%
Ochrolechia frigida Mass.	-	4.79%	-
Parmelia sulcata Taylor	-	-	2.40%
Parmelina tiliacea (Hoffm.) Hale	-	0.47%	-
Phaeophyscia orbicularis (Nëck.) Moberg.	-	-	4.50%
Physcia adscendens (Fr.) Oliv.	21.60%	68.10%	49.84%
Physconia detersa (Nyl.) Poelt.	10.55%	2.60%	31.83%
Physconia enteroxantha (Nyl.) Poelt.	1%	-	-
Physconia grisea (Lahm.) Poelt.	-	0.23%	1.50%
Pleurosticta acetabulum (Necker) Elix & Lumbsch.	-	-	2.10%
Pseudevernia furfuracea (L.) Zopf.	-	-	0.60%
Ramalina pollinaria (L.) Ach.	50.25%	-	-
Xanthoria parietina (L.) Th. Fr.	1%	0.23%	3.60%

Legend: - mean that there is no available data

trunks (Table 4). All sampled trees had a rough rhytidoma with a large capacity to hold moisture for long periods, so trees with a rough rhytidoma presented favourable microhabitats for lichens to grow.

DISCUSSION

Increasing lichen number as a function of the distance from Bucharest (Fig. 2) was probably due to an improvement of environmental quality. In a study regarding the spatial distribution of lichen richness within Niepołomice Forest, located in proximity to a steelworks and Krakowia town (Poland), lichen numbers were found to increase on a spatial gradient with distance from anthropogenic sources (Kapusta *et al.* 2004). In a similar study performed within Zlatna industrial area (Bartók 1980), a similar increase of lichen number was found with distance from pollutant sources. Vicol (2010) had similar findings in forests from the Bucharest metropolitan area for distance from Bucharest . Here, the number of epiphytic lichen species identified in the southern sector of Pustnicul forest (Vicol 2010) and those inventoried in the north-eastern sector of this forest (in the present study) showed that the number of corticolous lichens decreased from the southern to north-eastern sectors of this forest.

Within the study area, the most abundant species were nitrophilous lichens. The highest abundances of nitrophilous lichens, such as *Amandinea punctata*, *Physcia adscendens*, and *Physconia detersa* (Table 2), were recorded in Goştilele and Călăreţilor forests. Unlike the Goştilele and Călăreţilor forests, within Pustnicul Forest a highest abundance was attributed to *Ramalina pollinaria*. The dominance of *Ramalina pollinaria* accompanied by *Lepraria* ssp. is closely related to the prevalence of host trees with an acid bark, such as *Quercus* ssp. According to field observations, Goştilele and Călăreţilor forests are strongly influenced by agricultural practices, leading to the highest abundances of nitrophilous lichens. The Pustnicul Forest is weakly influenced by rural activities and also by forestry management. In such a situation, the environmental conditions are favourable for *Ramalina pollinaria*, a less common lichen species within the study area, to develop. A study using the abundance of nitrophilous and acidophilous epiphytic lichens as indicators for mapping of ammonia pollution caused by land use and farming was carried out in different ecosystems in the Netherlands. The high abundance of nitrophilous lichen species correlated with the disappearance of acidophilous lichens indicated areas strongly polluted with ammonia (Van Herk 1999). Another study concerning atmospheric pollution with nitrogen oxides, heavy metals, etc., performed in Colle di Val d'Elsa Municipality (Italy) showed a correlation between pollution by nitrogen oxides and the prevalence of common lichen species which grow on substrata enriched with nutrients, such as *Candellaria concolor* (Dicks.) Stnr., *Lecidella elaeochroma* (Ach.) M. Choisy, *Physcia adscendens*, etc. (Loppi & Frati 2006). In regions where agriculture is intensely practised, lichen species of the

Physciaceae Family showed high diversities. These lichen species were associated with a substrata strongly enriched with organic compounds, low atmospheric humidities and an accentuated aridity (Saipunkaev *et al*. 2005; Wolseley *et al*. 2006; Loppi & Frati 2006).

Morley & Gibson (2010) emphasized on the one hand a relationship between successional phase and lichen species compositions and on the other hand the importance of old-growth stands as refugia for particular lichen communities. Extra large trees supported significantly more species, especially uncommon lichen species, than other size classes due to their bark fissuring; therefore the old trees must be protected.

Within the three forests investigated here, the less frequent lichen species were identified, especially on old oaks (Table 4). The rough bark of old trees represents a favorable microhabitat for lichens due to its high capacity to hold moisture (Kapusta *et al*. 2004).

CONCLUSION

Increased distance from any anthropogenic sources has a great impact on the enhancement of lichen diversity. The characteristics of old trees represent favorable microhabitats, especially for less common lichen species; therefore the fragments of old-growth forests must be protected. Rural activities are the main sources responsible for the prevalence of nitrophylous lichen species on trees with an acid rhytidoma. As a consequence of the substrata enrichment, the lichen composition typical of acid substrata is replaced with nitrophilous lichens.

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Botanica SERBICA

REZIME

Sinstruktura epifitskih lišajeva istočnih delova područja Bukurešta (Rumunija)

Vicol Ioana

U ovom radu dat je prikaz sinstruktura epifitskih lišajeva u šumama istočnih delova područja Bukurešta (Rumunija). Uočeno je da se broj vrsta lišajeva povećava sa udaljavanjem od urbane zone.
U šumama Goştilele i Călăreţilor, najčešće su široko rasprostranjene vrste, dok su redje vrste retko beležene. Jedan od redjih lišajeva unutar izučavanog područja je *Ramalina pollinaria*, zabeležena u šumi Pustnicul, gde je blia češća od nekih čestih lišajeva kao što su *Physcia adscendens* i *Xanthoria parietina.*

Ključne reči: epifitski lišajevi, sinstruktura, šume, Bukurešt, Rumunija