A STUDY REGARDING THE IMPACT OF FORESTRY MANAGEMENT ON LICHEN FLORA WITHIN FORESTS FROM BUCHAREST SURROUNDINGS (ROMANIA)

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Abstract. The conservation of old-growth stands is of a crucial importance to lichens. Within investigated forests there were inventoried a total of 13 lichen species of which 63% were recorded to Biglaru Forest and 37% were found in Băneasa Forest, respectively. The investigated stands are intensively managed and this fact is in a close correlation to prevailing of synanthropic lichen species. A high abundance of lichen species was observed both in upper canopies of trees and on lignicolous substrata. Within the investigated forests a special importance is attributed to bark characteristic and illumination conditions. In the researched area, there have been recorded three lichen species which indicate a moderate to high environmental quality.

Keywords: lichens, Băneasa, Biglaru, managed stands, forests.

Rezumat. Studiu privind impactul managementului forestier asupra lichenoflorei în pădurile din împrejurimile Municipiului Bucureşti (România). Conservarea pădurilor seculare este de o importanţă crucială pentru speciile de licheni. În pădurile investigate au fost inventariate 13 specii de licheni dintre care 63% au fost înregistrate pentru Pădurea Biglaru şi 37% pentru Pădurea Băneasa. Pădurile investigate sunt intensiv gospodărite fapt corelat cu predominanţa speciilor de licheni sinantropice. S-a observat că speciile de licheni au o abundenţă înaltă atât în coronamentul superior cât şi pe substraturi lignicole. În pădurile investigate o importanţă specială este atribuită atât caracteristicilor ritidomului cât şi condiţiilor de iluminare. În aria cercetată au fost înregistrate trei specii de licheni care indică o calitate moderat-înaltă a mediului.

Cuvinte cheie: licheni, Băneasa, Biglaru, păduri gospodărite, păduri.

INTRODUCTION

The woodland researched area has been intensively clear-cut especially to agriculture practicing (ŞERBĂNESCU, 1959). Thus, the logging of old-growth stands presents a strong importance for agricultural practices (JÜRIADO et al., 2009), as one of the major components of economy (KANTVILAS & JARMAN, 2006). Fragmentation and degradation of old-growth stands affect lichen communities because epiphytic lichens depend on host tree species and its properties, stand age and spatial-temporal continuity, light, aspect, availability of water, inclination of trunks, as key factors of their development. The explanation consists in the fact that epiphytic lichens have a long generation time as well as poor dispersal and colonization ability (JÜRIADO et al., 2009; MORLEY & GIBSON, 2010).

The young-growth stand is an important limiting factor to the growth of epiphytic lichens in managed stands, therefore the fragments of old-growth stands distributed in a matrix of plantations are important in secondary plantation especially to diaspore dispersal (HILMO et al., 2009). Even-aged plantations differ from old-growth stands in both physical factors and structural heterogeneity (HILMO et al., 2009), the light being one of the most important factors for lichen growth (HILMO et al., 2009; SMITH, 1921). Old trees provide suitable microhabitats for colonization of especially rare lichens (MORLEY & GIBSON, 2010), and a heterogeneous habitat to maintain biodiversity in forest ecosystem. For this reason, lichens are indicators of stand continuity and late-succession in forests (ROOT et al., 2007). The remnant trees provide a temporary link between old and young forests and sources in which propagules may disperse to nearby ageing forests (MORLEY & GIBSON, 2010).

This study is aimed to knowledge the impact of managed stands on lichen communities. The main objectives is based on assessment of the managed stands characteristics closely related to lichen flora in Băneasa (Bucharest) and Biglaru (Ilfov County) forests.

MATERIAL AND METHODS

Study area

The investigated forestry areas are situated from the geographical point of view in the Northern and Eastern parts of Bucharest Municipality within the Romanian Plain (Fig. 1).

The studied area is characterized by a temperate-continental climate. The air annual mean temperature (calculated for the period 1961-2000), records value range between 9.8°C at Tâncăbeşti and 11.2°C both at Giurgiu and Bucharest-Filaret. The multiannual values of air humidity range between 75% and 80%. Annual mean precipitation values decrease from North (613.1 mm) to South (550 mm) of Bucharest. The prevailing winds are those from North-East (22.4% at Băneasa and 23.2% at Afumaţi) and South-West (14.8% at Băneasa and 8.1% at Afumaţi) (IOJĂ, 2008).

The vegetation of the investigated areas is represented by the forest-steppe and nemoral forests. The forest-steppe zone is characterized especially by the presence of *Qercus pubescens* WILLD., *Quercus pedunculiflora* K. KOCH, and nemoral zone is represented by *Quercus cerris* L., *Quercus frainetto* TEN., *Quercus robur* L., *Carpinus orientalis* Mill., *Tilia* sp., etc. (BĂLTEANU et al., 2006).

Figure 1. The map of investigated forests (Source: this is an own construct map by http://www.nationsonline.org/oneworld/map/google_map_romania.htm; Google Earth Software).
Figura 1. Harta pădurilor investigate (Sursa: aceasta harta este prelucrată după http://www.nationsonline.org/oneworld/map/google_map_romania.htm; Google Earth Software).

Field method

Field activity was performed during April-August 2010. Within both investigated sites, a total of 12 sampling units were randomly selected. For each site, six sampling units of 4 m x 4 m were performed. In all sampling units from the studied area, a total of 20 trees were sampled. Epiphytic lichens have been inventoried beginning from the basis of the trunks of the sampled trees to the height of 1.5 m. The lignicolous lichen species were taken into account. In Băneasa and Biglaru forests there were identified 7 and 12 lichen species, respectively.

Surveying samples

The lichen species were determined according to CIURCHEA (2004) and MORUZI & TOMA (1971). Lichen species were identified based on morphology, anatomy, aspects of thalline elements, colour reactions of thallus, and microscopic investigation. Some chemical reagents, such as KOH (potassium hydroxide), $CaCl_2$ (calcium chloride), and IIK (iodine in potassium iodide) were prepared and applied as spot tests for the identification of the lichen samples (MORUZI & TOMA, 1971). The nomenclature used for lichens is according to data found on www.mycobank.org. The nomenclature of tree species is according to CIOCÂRLAN (2009).

RESULTS AND DISCUSSIONS

Within the research area, a great majority of old-growth natural forests was replaced by young-growth secondary stands. Thus, the conversion of old natural forest to even aged plantations was detected, this being one of the major causes of decrease in forest lichen abundance and species richness (HILMO et al., 2009). It was observed that, Băneasa and Biglaru forests have been intensely managed.

A total of 13 lichen species were inventoried within the investigated sites (Table 1), of which 63% were found within Biglaru Forest and 37% of the all were recorded from Băneasa Forest (Fig. 2). In Biglaru Forest (Ilfov County), situated at 21 km from the polluted area of Bucharest (IOJĂ, 2008), the richness of lichen species is higher than that recorded for Băneasa Forest (Bucharest), in spite of an intense forestry management. As in the studied area, in other studies, the species richness is increasing as a function of the distance from polluted areas due to an improvement of air quality (BARTÓK, 1980; PAOLI et al., 2006; LIŠKA & HERBEN, 2008).

There is a major difference regarding the trees composition within both investigated site. The Băneasa Forest is characterized in a great deal by the presence of *Tilia* genus compared to Biglaru Forest where *Quercus* genus is dominant.

According to field observations, within the two intensely managed stands, the lichen species either are generally absent as in Băneasa Forest (because of density of trees and their multi-layered canopies) or are represented

by a lower number in Biglaru Forest. In Băneasa and Biglaru forests, the lichen species were found on a lowest number of host trees trunks (three and two trees, respectively) (Table 1). Within glades in the investigated even-aged stands there prevailed in a great deal, common lichen species and an extremely low number of rare lichen species compared to the old-stands in these forests (Figs. 3; 4). An inappropriate forestry management, for instant: a massive replacement of old-growth stands with young-growth stands has a negative effect on lichen species richness (PURVIS, 2000; HILMO et al., 2009). In managed stands, the tree species are densely distributed and therefore the light availability is limited with negative effects on the growth of lichens species and their vitality (HILMO et al., 2009). Thus, the light is an important key factor to the establishment of lichen species on tree trunks.

Table 1. List of the inventoried lichen species within the investigated forests.
Tabel 1. Lista speciilor de licheni inventariate în pădurile investigate.

Species	Growth form	Investigated sites			
		Băneasa Forest		Biglaru Forest	
		Substrata	Tree height gradient	Substrata	Tree height gradient
Evernia prunastri (L.) ACH. 1810	Fruticose	lignicolous	Upper branches	-	-
Flavoparmelia caperata (L.) HALE 1986	Foliose	-	-	*Quercus robur* L.	Trunk
Hypogymnia farinacea ZOPF. 1907	Foliose	-	-	lignicolous	Upper branches
Hypogymnia tubulosa (SCHAER.) HAV. 1918	Foliose	-	-	lignicolous	Upper branches
Lecanora subintricata (NYL.) TH. FR. 1871	Crustose	-	-	lignicolous	Upper branches
Lepraria finkii (B. DE LESD. ex HUE) R. HARIS 1985	Soredioso-Leprose	*Tilia tomentosa* MOENCH (*T. argentea* DC.)	Trunk	*Quercus robur* L.	Trunk
Parmelia sulcata TAYLOR 1836	Foliose	lignicolous	Upper branches	Lignicolous	Upper branches
Phaeophyscia orbicularis (NĚCK.) MOBERG 1977	Foliose	lignicolous	Upper branches	Lignicolous	Upper branches
Physcia adscendens (FR.) H. OLIVIER 1882	Foliose	*Fraxinus excelsior* L. *Prunus cerasifera* EHRH. var pissardi (CARRIÈRE) C. K. SCHNEID	Trunk	Lignicolous	Upper branches
Physcia aipolia (EHRH. ex HUMB) FÜRNR. 1839	Foliose	lignicolous	Upper branches	Lignicolous	Upper branches
Physcia stellaris (L.) NYL. 1856	Foliose	-	-	Lignicolous	Upper branches
Physconia grisea (LAM.) POELT 1965	Foliose	-	-	Lignicolous	Upper branches
Xanthoria parietina (L.) BELTR. 1858	Foliose	lignicolous	Upper branches	Lignicolous	Upper branches

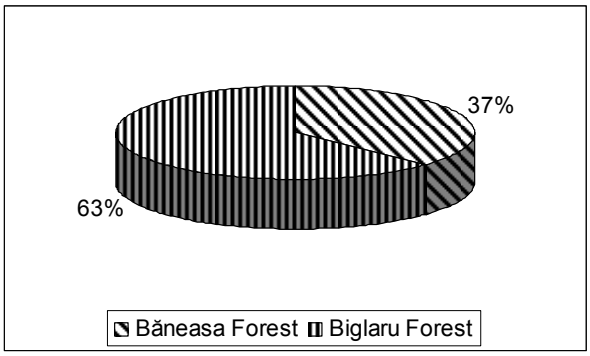

Figure 2. Percentage distribution of lichen species in relation to investigated forests.
Figura 2. Distribuţia procentuală a speciilor de licheni în raport cu pădurile investigate.

In a similar study performed within Knocksink Wood Nature Reserve (Ireland) a relatively low diversity of epiphytic lichens was caused by anthropogenic activities, especially forestry management and a limited availability of light (BRODEKOVÁ et al., 2006).

As a rule within investigated managed stands, lichen species are found in upper canopies rather than at the trunk level. The presence and high abundance of lignicolous lichen species in Băneasa and Biglaru forests (67% and 83%, respectively) confirm the statement on a high abundance of lichen species in upper canopies (Table 1, Figs. 5; 6). On the other hand, a high cover of foliose lichens on lignicolous substrata (Table 1) reflects unfavourable microhabitats on trunk level of old trees with strongly closed canopies (HILMO et al., 2009).

Within old-growth stands, it was observed that trees are not uniformly distributed, hence allowing a better illumination of lower third of the trunks. Thus, it is favoured the abundance and richness of lichen species. On the contrary, trees in the managed stands are uniformly planted, therefore have a high density in the sampling sites. In this case, it is prevented the establishment and development of lichen species, especially within Băneasa Forest.

The tree composition and bark characteristics are of a special importance to lichen flora. The old trees in old-growth fragments of *Quercus* L. genus represent a favourable microhabitat for the establishment of lichen species, particularly rare and threatened species, as it was observed within Biglaru Forest. The foliose lichen species, such as

Flavoparmelia caperata (L.) HALE, did not grow on young trees because of their smooth rhytidome. The old trees have a roughly rhytidome with a great capacity to hold moisture. By a strongly contrast, young trees from managed stands do not support a high abundance of lichen flora because of smooth rhytidome with a low capacity to hold moisture (DONICA, 2007). In young open plantations, it was observed a lower cover of lichens on trunks than the old stands both in Băneasa and Biglaru forests. Studies performed on lichen flora in the Yarra Ranges and Errinundra rainforests (Australia) have shown that the composition of lichen communities was changing depending on the successional stages and that these changes were generally more distinct on *Nothofagus cunninghamii* with a roughly rhytidome than on *Atherosperma moschatum* with a smooth rhytidome. The study has pointed out the importance of old trees which support a high number of lichen species, including rare species. These differences in species richness and composition may be attributed to the differences in the levels of bark fissuring, compared to the smooth bark of young trees (MORLEY & GIBSON, 2010).

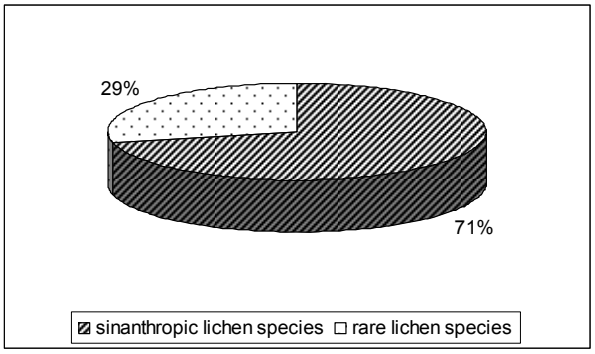

Figure 3. The spectrum of synanthropic lichen species in relation to rare lichen species from Băneasa Forest.
Figura 3. Spectrul speciilor de licheni sinantropice în raport cu cele rare în Pădurea Băneasa.

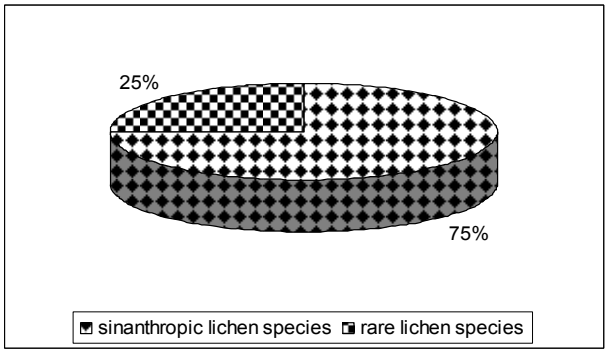

Figure 4. The spectrum of synanthropic lichen species in relation to rare lichen species from Biglaru Forest.
Figura 4. Spectrul speciilor de licheni sinantropice în raport cu cele rare în Pădurea Biglaru.

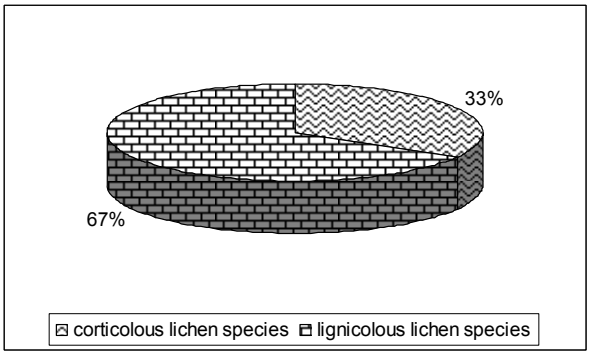

Figure 5. Percentage distribution of inventoried lichen species from Băneasa Forest as a function of substrata.
Figura 5. Distribuția procentuală a speciilor de licheni inventariate din Pădurea Băneasa în funcție de substrat.

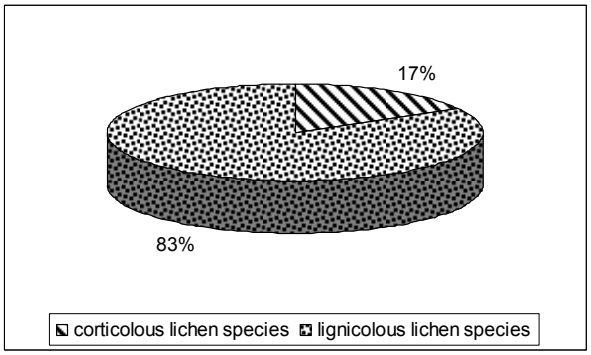

Figure 6. Percentage distribution of inventoried lichen species from Biglaru Forest as a function of substrata.
Figura 6. Distribuția procentuală a speciilor de licheni inventariate din Pădurea Biglaru în funcție de substrat.

Within the managed stands, it was observed a strong difference regarding the degree of illumination in comparison with old growth stands. Trees from young plantations from Băneasa and Biglaru forests are too frequent and multi-layered, therefore the lower third of trunks do not receive a better illumination. In both Băneasa and Biglaru forests, the spatial distribution of trees from old-stands is not uniformly. In a such conditions, the lower third of trunks is more better illuminated favouring the establishment and development of epiphytic lichen species, especially rare species, such as: *Flavoparmelia caperata* sampled in Biglaru Forest.

The important proximal environmental factors operating on epiphytic lichens within young and old stands are moisture regime (average humidity, frequency of wetting and drying) and availability of diffuse but fairly bright light closely related to the complexity of the canopy architecture and substrata type (SILLETT et al., 2000).

In both forests, fruticose and foliose thalli were represented by lichen species which indicate a rather low to moderate resistance to atmospheric pollution, for instant: *Evernia prunastri* and *Physcia aipolia* (Băneasa Forest) and *Flavoparmelia caperata* and *Physcia aipolia* (Biglaru Forest) (ELLENBERG et al., 1992).

Patterns of succession in lichen communities have been observed in many parts of the world with certain lichen species being a characteristic of younger and of older forests (MORLEY & GIBSON, 2010). It was observed that certain investigated lichen species are specific for young and old habitats. In Biglaru Forest, *Flavoparmelia caperata* known as an old-forest species and growing on old tree trunks can be considered as a rare and threatened lichen species. In other study, it was pointed out, the importance of large, isolated old trees to inoculate surrounding younger trees in multiaged stands

such that communities of some old-growth associated lichen species are highest near old trees. Communities of some old-growth associated lichens are affected by forest management, such as clear-cuts. Thus, the clear-cuts of old trees affect lichens diaspore dispersal and also their development; therefore it is important to maintain old-growth forests for the resilience of old-growth associated lichens in a managed forest landscape (SILLETT et al., 2000).

CONCLUSIONS

The managed stands represent one of the major problems which affect lichen diversity. It was found that old-growth stands characteristics are closely related to a high species richness and abundance. In the two managed stands, there were recorded on the one hand a greater number of lichen species on trunks which are better illuminated and a greatest number of lichen species on lignicolous substrata. A great abundance of lichen species was observed in the upper third of the canopies and on the lignicolous substrata in the two investigated forests.

In both managed forests the synanthropic lichen species are prevailing especially on old trunk, which are better illuminated. The abundance and species richness are favoured both by light amount and rhytidome characteristics. A great importance should be given to the old growth stands for protection, preservation and conservation of rare and threatened lichen species.

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