Contribuţii Botanice, XLI, (1), **2006**
Grădina Botanică "Alexandru Borza"
Cluj-Napoca

DIVERSITY, DISTRIBUTION AND ECOLOGY OF THE LICHENS IN THE AIUD TOWN AREA (ALBA COUNTY)

GYÖRKÖS Levente, BARTÓK Katalin
Universitatea "Babeş-Bolyai", Facultatea de Biologie şi Geologie, Catedra de Taxonomie şi Ecologie,
str. Republicii, nr 42, **RO-400015 Cluj-Napoca**
e-mail: bartok_katalin@yahoo.com

Abstract: The lichen flora in the neighbourhoods of Aiud town (Bichiş, Răriști, Lopadea and Vălişoara forests) was for the first time investigated. A number of 40 lichen species, of which 27 epiphyte and 13 terriculous has been identified. The study area is moderately polluted with heavy metals, gases and large amounts of dust emitted by the metal-processing plant "Metalurgica" S.A. Aiud, the road traffic, agricultural and forestry-related activities. In direct correlation with the distance from the main polluting source, an increase in the specific diversity and in the number of neutrophilous and basiphilous lichens, as well as of the Index of Atmospheric Purity (IAP) was calculated. In all the habitats under study the lichen diversity varies in an inverse correlation with their abundance. The interspecific competition was observed only in the case of the epiphyte lichen species from the ecotone zone 1.

Keywords: Bichiş, Răriști, Lopadea, Vălişoara forests (Aiud town's neighbourhood), pollution, lichen diversity, abundance, ecology, IAP value, ecotone

Introduction

Cryptogams are organisms with a relatively simple structure and organisation, being thus more vulnerable to quantitative and qualitative changes of the environmental factors. More and more often, the term "cryptogam crust", or "biologic crust" is used in the references for defining the associations of organisms consisting of unicellular algae, filamentous cianobacteria, lichens and mosses [3].

Lichens are considered to represent the most "ambitious" colonisers of what would be considered as unfavourable areas for vital processes of most organisms, as well as the best indicators for the quality of the environment, especially concerning the atmosphere. The use of lichens for efficient monitoring of air quality started in the first decades of the last century, when their capacity of storing the air-born materials was evidenced [8, 5, 2, 11]. Based on the air pollution-induced changes in the patterns concerning the coverage of various substrates by lichens a new index was introduced for the air purity, which provided good results in ecological modelling.

The aim of our study was the investigation of epiphyte and terriculous lichens' diversity, distribution and ecology, as well as monitoring the changes of these parameters as a result of air pollution along the Arieş-Mureş couloir, between Aiud town and Vălişoara village.

Our study represents the first lichenological investigation in the area.

Materials and Methods

1. Physical-geographical characterisation of the study area; general features concerning vegetation

Our studies concerned the Arieş-Mureş couloir starting in the neighbourhoods of Aiud town an ending with the north-western border of Vălişoara village. In the period 1997-2001, four sites were monitored: Bichiş, Răriști, Lopadea and Vălişoara.

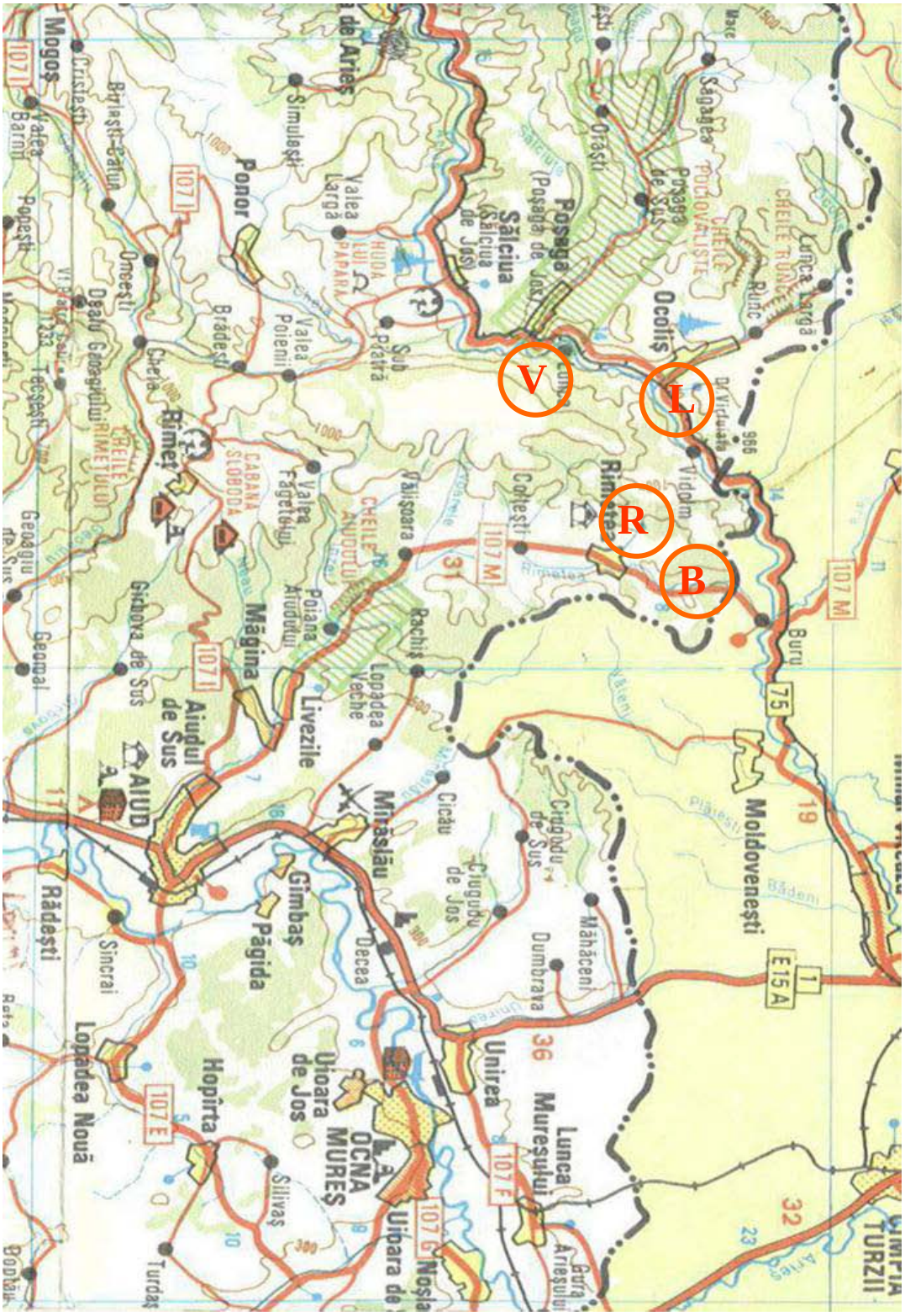

Fig. 1: Location of the investigated sites along the Arieș-Mureș couloir

The four sites are located at altitudes between 269–625 m, where precipitations average values range between 555–679 mm/year, and the annual average temperature is 9.6 °C [12].

The main soil types are specific for forest-steppe areas: typical brown luvic, pseudoglei, and lithic soils. The arboriculous flora – representing the substrate for the epiphyte lichen species – is dominated by *Quercus petraea* accompanied by *Q. robur* and *Carpinus betulus*. In the sunny areas, on calcareous substrates, *Q. pubescens* and *Q. cerris* show a massive development. Thus, the phanerogam vegetation can be grouped into the **Quercetum petraeae-cerris** Soó 57,association..

2. Polluting sources

The main source of pollution in the study area is represented by the integrated metal-processing plant "Metalurgica" S.A. Aiud, specialized in producing components and equipment for metallurgy, siderurgy, mining industry, chemical industry etc. Metallurgic industry is based on pyrometallurgical processes that release polluting heavy metals, gases and dust in the atmosphere. The main air polluting components in the case under study are represented by heavy metals: Hg, Pb, Cr, Ni, Zn, Cd, Cu, As; gases: CO, SO_2, NO_x, CH_4, CO_2, and high amounts of dust containing Fe (total), Si, Al, Ca, Mg, Mn, P, S, Zn, Cr and Ni.

Road traffic on the district road Aiud-Buru, as well as agricultural activities and forestry represent other polluting sources for the area.

3. Methodology

Mapping the epiphyte lichen species was performed by using 130 x 130 cm grid squares [6] subdivided into 20 units with a surface of 97.5 cm^2, leading to a total releve area of 3,900 cm^2. By using this grid, an inventory of the lichen species developed on the trees' bark was obtained, as well as data on their distribution. Sampling followed two transects along both sides of the forested areas, and also a third transect within the forest located equidistantly from the marginal transects.

The terriculous species were randomly mapped, on areas of 1 m^2.

4. Calculation methods

The Index of Atmospheric Purity (IAP) was used for investigating the pollution-induced changes. It was calculated as follows:

$IAP = \Sigma_n (Q \times f) / 10$ where:

Σ_n = total number of species in the releve
Q = ecological index corresponding to the accompanying species
F = frequency of each individual species

Data were processed by using the statistical computer programmes "Biodiversity Professional" Beta version [10], and EcoSim 600 [4]. The latter is an interactive software designed for testing null hypotheses and is widely used in studies of communities' ecology. EcoSim 600 establishes "pseudocommunities" [9] and then compares the statistical indices for the matrix build-up based on real data vs. those for the simulated matrices.

Results and Discussions

A total number of 40 lichen species has been identified in the four studied habitats, of which 27 epiphyte and 13 terriculous (Table 1). The table indicates also the corresponding thallus type, the habitat, as well as the ecological index for each species according to the

classifications of Ellenberg (1992) and Wirth (1995) based on their light (L), humidity (U), temperature (T), and pH of the substrate (R) preferences.

Table 1: List of lichen species, their habitats and ecological characterisation *via* ecological index

Species	Thallus type	Habitat	Ecological index value
Anaptychia ciliaris	*Fruticulous*	*Epiphyte*	**L7, U5, T5, R7**
Cetrelia olivetorum	*Folious*	*Epiphyte*	**L5, U7, T4, R5**
Chrysothrix candelaris	*Lepros*	*Epiphyte*	**L4, U4, T5, R3**
Cladonia cornuta	*Fruticulous*	*Ter*	**L0, U8, T5, R4**
Cladonia chlorophaea	*Fruticulous*	*Ter*	**L3, U5, T5, R5**
Cladonia fimbriata	*Fruticulous*	*Ter*	**L7, U0, T5, R4**
Cladonia furcata	*Fruticulous*	*Ter*	**L8, U3, T5, R4**
Cladonia rangiferina	*Fruticulous*	*Ter*	**L6, U6, T4, R5**
Cladonia rangiformis	*Fruticulous*	*Ter*	**L6, U5, T4, R8**
Cladonia squamosa	*Scvamos (steril)*	*Ter*	**L6, U7, T4, R2**
Collema auriforme	*Gelatinous*	*Ter*	**L4, U5, T6, R8**
Collema crispum	*Gelatinous*	*Ter*	**L7, U5, T7, R8**
Dermatocarpon miniatum	*Folious*	*Ter-sax*	**L8, U3, T0, R8**
Evernia prunastri	*Fruticulous*	*Epiphyte*	**L7, U3, T5, R3**
Flavoparmelia caperata	*Folious*	*Epiphyte*	**L6, U4, T6, R4**
Graphis scripta	*Crustos*	*Epiphyte*	**L3, U4, T5, R5**
Hypogymnia physodes	*Folious*	*Epiphyte*	**L9, U3, T0, R3**
Lecanora conizaeoides	*Crustos*	*Epiphyte*	**L7, U3, T3, R2**
Lepraria incana	*Lepros*	*Epiphyte*	**L4, U3, T5, R3**
Melanelia exasperatula	*Folious*	*Epiphyte*	**L7, U3, T5, R5**
Nephroma resupinatum	*Folious*	*Ter*	**L6, U9, T4, R5**
Peltigera canina	*Folious*	*Ter*	**L6, U5, T5, R6**
Umbilicaria grisea	*Folious*	*Ter-sax*	**L8, U5, T6, R4**
Parmelia saxatilis	*Folious*	*Epiphyte*	**L6, U5, T4, R3**
Parmelia sulcata	*Folious*	*Epiphyte*	**L7, U3, T0, R5**
Parmelia tiliacea	*Folious*	*Epiphyte*	**L7, U3, T6, R5**
Parmelina quercina	*Folious*	*Epiphyte*	**L8, U3, T5, R7**
Parmeliopsis ambigua	*Folious*	*Epiphyte*	**L6, U5, T4, R2**
Physconia distorta	*Folious-placoid*	*Epiphyte*	**L7, U3, T5, R6**
Platismatia glauca	*Folious*	*Epiphyte*	**L7, U5, T4, R2**
Pleurosticta acetabulum	*Folious*	*Epiphyte*	**L7, U3, T6, R7**
Pseudevernia furfuracea	*Fruticulous*	*Epiphyte*	**L8, U3, T4, R2**
Psora decipiens	*Lepros*	*Epiphyte*	**L9, U2, T0, R8**
Pyrenula nitida	*Crustos*	*Epiphyte*	**L3, U4, T6, R5**
Ramalina farinacea	*Fruticulous*	*Epiphyte*	**L6, U4, T5, R5**
Ramalina fastigiata	*Fruticulous*	*Epiphyte*	**L7, U6, T5, R6**
Ramalina fraxinea	*Fruticulous*	*Epiphyte*	**L7, U5, T5, R6**
Rinodina exigua	*Crustos*	*Epiphyte*	**L7, U3, T5, R7**
Usnea hirta	*Fruticulous*	*Epiphyte*	**L7, U5, T4, R3**
Xanthoria parietina	*Folious*	*Epiphyte*	**L7, U3, T5, R7**

For calculating and emphasizing lichens' diversity, the Shannon-Wiener diversity index was used, while software "Biodiversity Professional" provided data concerning abundance. The working hypothesis of a direct correlation between the habitat's distance from the polluting source and the diversity and abundance of species was based on previous knowledge on the highly sensitive behaviour and response of lichens to pollution, and the extinction of certain species in the proximity of urban areas. However, the results were contradictory: species diversity followed the predictable trend, *i.e.* it increased in a direct correlation with the distance

from the local source, but species abundance varied considerably, according to the intensity of the local anthropic impact.

Bichiş forest (Fig. 2a) is characterised by very low diversity values, below 1.1 – the minimum value (0.7) being registered in site 7; on the contrary, the abundance values were high (Fig. 2b). Site 7 is located at about 2.5 km from the polluting source in Aiud; however lichen's diversity was not affected by the urban impact, but by the agricultural usage of Lintur herbicide that led to the extinction of some lichen species, or to decolouring effects or partial damage of some thalluses.

The high abundance/density may be explained by the presence of tolerant species and the lack of other species that might have threatened the former.

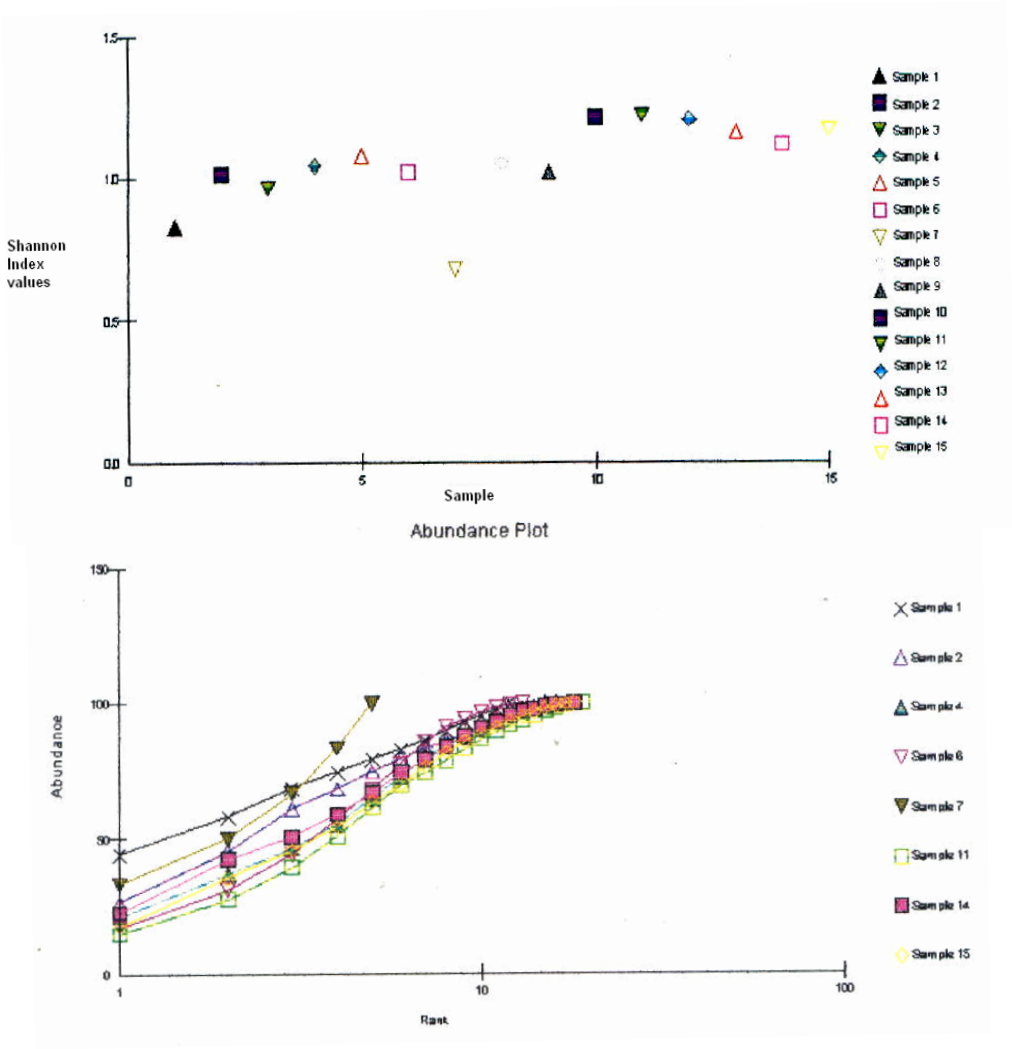

Fig. 2: Diversity (a) and abundance (b) of lichen species in Bichiş forest

The highest diversity values (1.4) for the lichen species was recorded in Vălişoara forest (Fig. 3a), where no permanent anthropic activity takes place. The forest is a relatively isolated area, located furthest from both the industrial area of Aiud, and the district road.

In the same time, the lichens from Vălişoara forest show lower abundance values as compared to those from Bichiş forest (Fig. 3b), in spite of the higher distance of the former from the polluting source. For the moment, this fact cannot be reasonably explained.

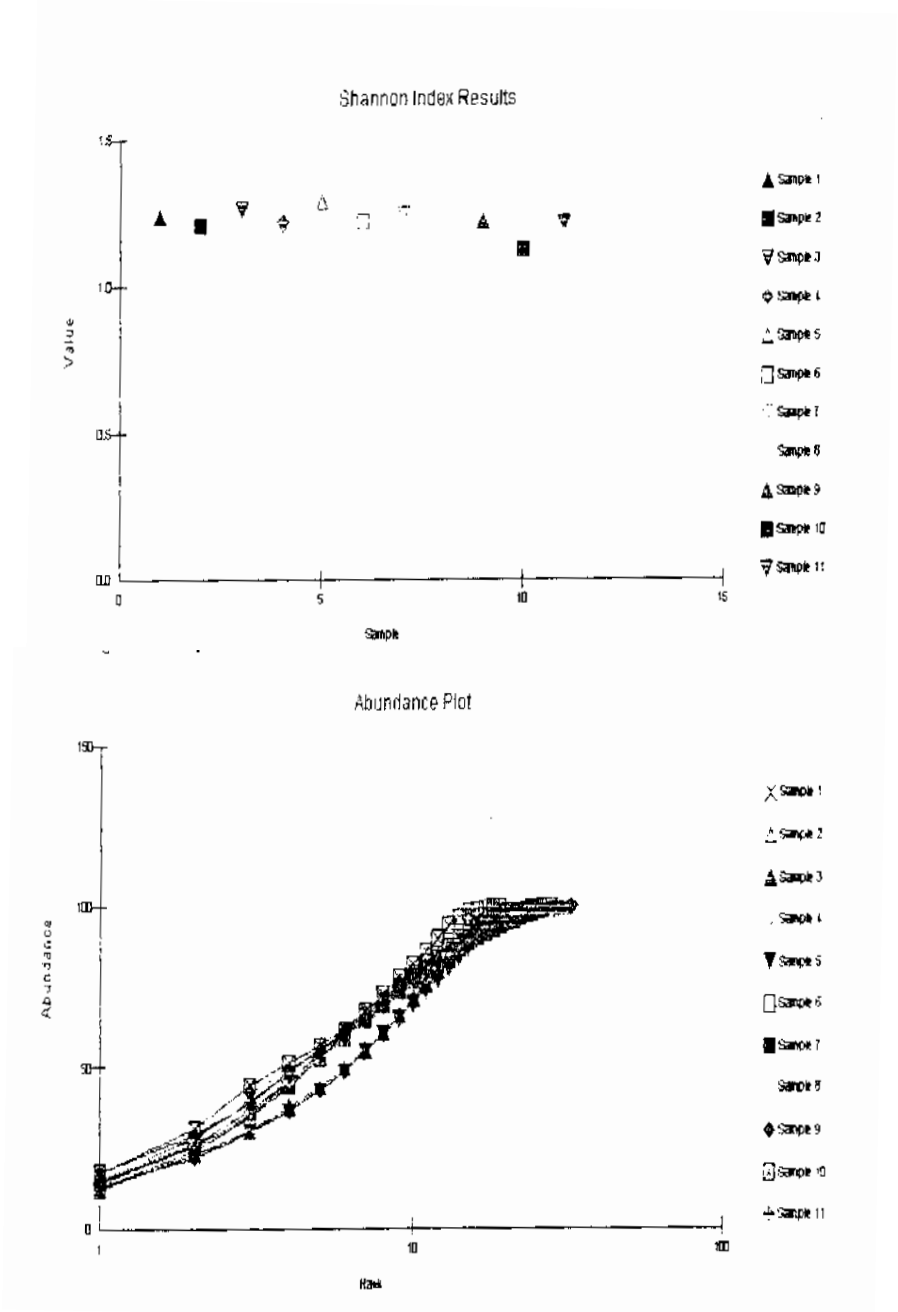

Fig. 3: Diversity (a) and abundance (b) of lichen species in Vălişoara forest

Intermediate diversity values were recorded in the Răriști and Lopadea forests; the corresponding graphs are not included, for limiting the paper's extent.

By taking only the macrolichens - which are more sensitive to the effect of the environmental stress - into account, and by excluding the species with crustose thalluses (the leprose-granular subgroup), a good positive correlation (r = 0.832) was obtained between the number of lichen species and the distance from the polluting source ("Metalurgica" S.A. Aiud). Accordingly, the largest number of species has been identified in the Vălişoara ecosystem, located furthest from Aiud town and lacking any type of anthropic activity.

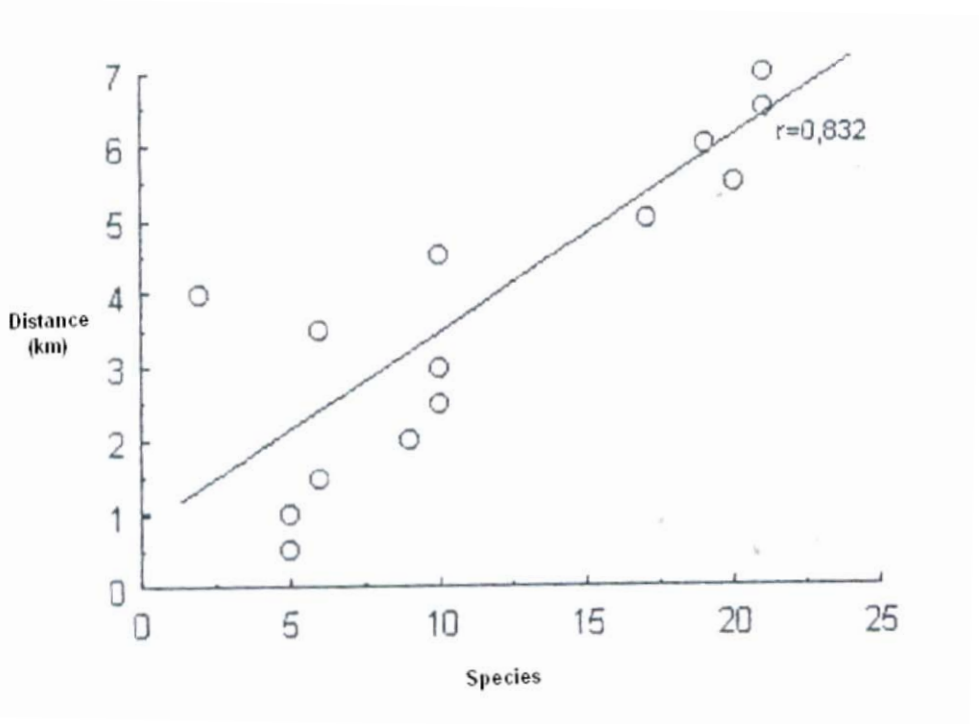

Fig. 4: Correlation between the number of lichen species and the distance from the polluting source

The chemical reactions of the substrate and of precipitations influence the lichen's growth. Fig. 5 shows that the number of acidophilous species decreases with distance from the polluting source (from 65 % in the Bichiş forest to 27 % in the Vălişoara forest), while the number of neutrophilous (Bichiş: 28 %, and Vălişoara: 35 %), and basiphilous species (Bichiş: 0.7 %, and Vălişoara: 38 %) increases.

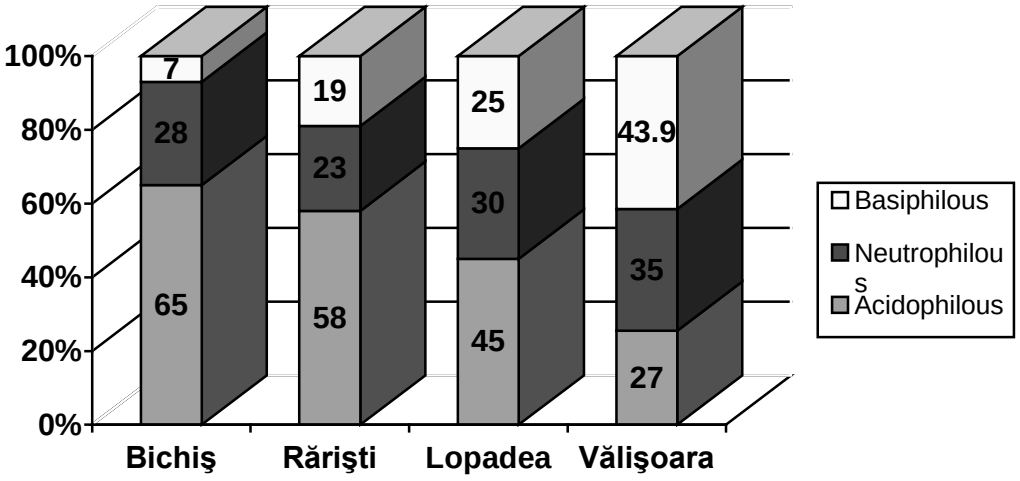

Fig. 5: Modification of the specific composition according to the substrate's pH values

The changes in the qualitative structure of the habitats determine modifications in the species' diversity and abundance, leading to the occurrence of areas with high ecological tension. These ecotones occur at the interface between two habitats with distinctive qualitative and quantitative features.

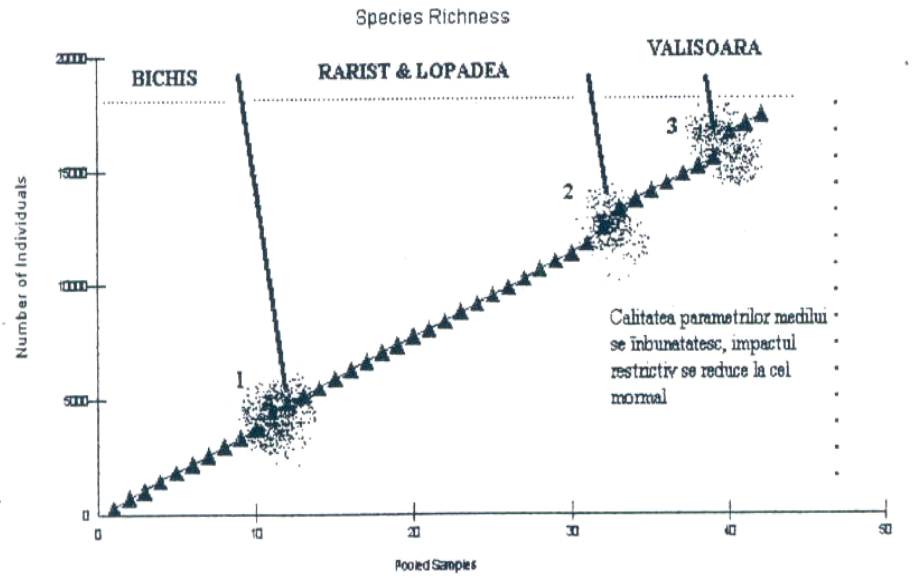

Fig. 6: Areas of ecological tension (ecotones)

Our results emphasised potential ecotones located at the borders between the studied habitats (Fig. 6). The loops in the graph suggest the occurrence of three ecotone areas; however, only the ecotone between the Bichiş and Rărişti forests shows clearly distinctive features, also indicated by the results of the interspecific competition analysis. Our data show that a transition area exists between Bichiş and Rărişti forests, which have distinctive ages: the former is 55 years in average, while the latter is about 75 years old. The lichen communities were modified according to the age of the substrate. An ecotone developed in this transition area, as a result of the competition between the species in the neighbouring ecosystems and the overlap of the spatial niches.

By processing the frequency of appearance of species (1000 simulations for each matrix), it could be noticed that the competition for the spatial niche can be statistically proven only in the case of the lichen species located on the southern side of the bark, at a maximum height of 1 m.

It is worth to mention that only a few species among the 27 epiphytes identified in the studied area are included in the list of species sensitive to pollution or other environmental stress factors. Thus, we can state that only four competing species are of interest in the case of our study: *Parmelia saxatilis, P. sulcata, Flavoparmelia caperata,* and *Evernia prunastri.*

The Index of Atmospheric Purity (IAP) is calculated based on transformed values according to a pre-established bonity scale; accordingly, a value is assigned to the number of species in each investigated section that refers to the actual frequency and coverage. In the first stage of the mapping, an IAP value was found for each releve; subsequently, these values were used for the calculation of the average value corresponding to each site. As much as lower is the IAP value the area is poorer in species and individuals.

The IAP value increases with the distance from the polluted source located in Aiud: the lowest value (1.2) was recorded for the Bichiş forest, while the highest (5.2) for the Vălişoara forest.

The IAP values calculated in 1997 are significantly similar with the ones calculated in 2000. The only exception is represented by site 7, where the land usage has changed from pasture to agricultural land and, as a result, herbicides were extensively used. These treatments led to a drastic decrease of lichen's frequency and coverage.

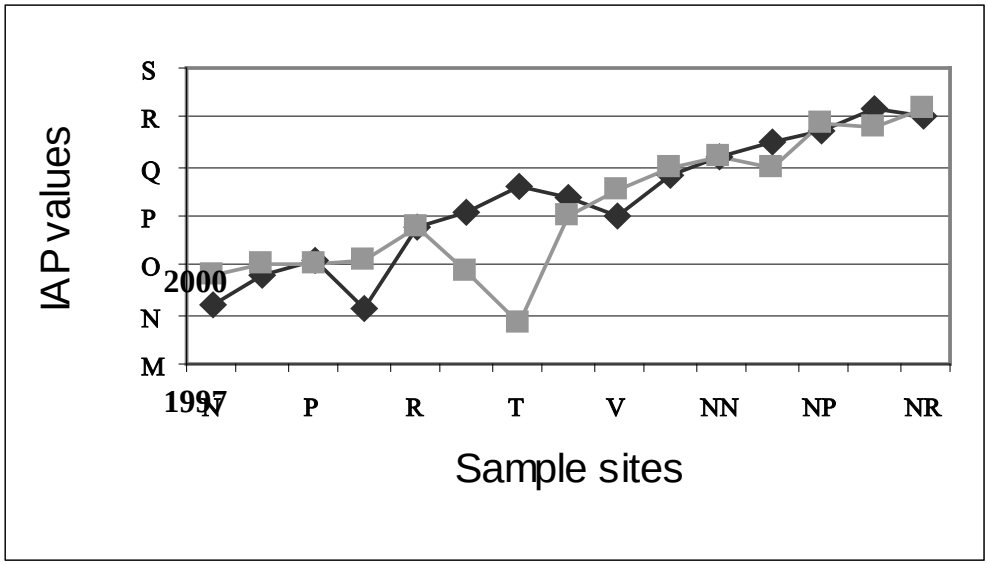

Fig. 7: Changes of the IAP values according to the distance from the polluting source

Conclusions

The southern couloir between Arieş and Mureş was first time studied for its lichen flora; the investigated area is moderately polluted, especially by the metal-processing plant "Metalurgica" S.A. Aiud and to a lesser degree by other anthropic activities (agriculture, forestry). Pollution has led to changes recorded by the lichen flora. In a positive correlation with the distance from the polluting source, an increase of the lichens' diversity, number of neutrophilous and basiphilous species, and IAP values was registered. In all the studied habitats, lichen species diversity is negatively correlated with their abundance. The interspecific competition was emphasised only in the case of the epiphyte species located in the ecotone zone 1.

REFERENCES

1. Bartók, K., 1985, Cartarea poluării atmosferice pe baza sensibilității lichenilor, *Contrib. Bot. Cluj*: 51 – 57.
2. Bartók, K., 1992, Aplicarea cercetărilor lichenologice în monitoringul poluării, *Ocrot. Nat. Med. Înconj*., **36**, (1): 41 – 46.
3. Eldridge, D.J., 1999, Morphological groups: a framework for monitoring microphytic crusts in arid landscape, *Journal of Arid Environments*, **41**: 11 – 25.
4. Gotelli, N.J., Enstminger, G.L., 2001, Ecosim: Null models software for ecology. Version 6.0. Acquired Intelligence Inc. & Kesey – Bear.
5. Hale, M.E., 1983, *The Biology of Lichens*. 3rd Edition. Ed. E. Arnold.
6. Kovács, M., 1987, *A levegőszennyeződés és hatásai a növényzetre*. Mezőgazdasági Kiadó, Budapest.
7. Le Blanc, F., De Sloover, J., 1970, Relations between industrialization and the distribution and growth of epiphytic lichens and mosses in Montreal, *Canadian Journal of Botany*, **48**, (8): 1485 – 1497.
8. Nash, H.T., 1996, *Lichen Biology*. Cambridge University Press.
9. Pianka, E.R., 1993, The structure of lizard communities, *Annual Review of Ecology and Systematics*, **185**: 27 – 39.
10. Podani, J., 1997, *Bevezetés a többváltozós biológiai adatfeltárás rejtelmeibe*. Ed. Scientia, Budapest.
11. Skye, E., 1968: Lichens and air pollution. *Acta Phytogeografica Suecica*, **52**, Uppsala: 64 – 124
12. xxx, 1980, *Monografia județului Alba*, Edit. Sport Turism, Bucureşti.

DIVERSITATEA, DISTRIBUȚIA ŞI ECOLOGIA LICHENILOR DIN APROPIEREA ORAŞULUI AIUD (JUDEȚUL ALBA)

(Rezumat)

Flora de licheni din împrejurimile Aiudului (pădurile Bichiş, Răriști, Lopadea şi Vălişoara) a fost studiată, pentru prima dată, de noi. S-au identificat 40 specii de licheni, dintre care 27 specii au fost epifite, iar 13 tericole. Zona este moderat poluată cu metale grele, gaze şi cantități considerabile de praf de la uzina „Metalurgica" SA Aiud, de circulația rutieră şi de activități agroforestiere. Odată cu creştera distanței față de sursa principală de poluare s-a înregistrat creşterea diversității specifice, creşterea numărului de specii neutro- şi bazifile, precum şi a indexului IAP. În toate habitatele studiate, diversitatea lichenilor variază invers proporțional cu abundența acestora. În zona studiată fenomenul de concurență interspecifică se manifestă numai în cazul speciilor de licheni epifiți din zona ecoton 1.