Coordinator Marilena Onete

SPECIES MONITORING IN THE CENTRAL PARKS OF BUCHAREST

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Coordinator **Marilena Onete**

SPECIES MONITORING IN THE CENTRAL PARKS OF BUCHAREST

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AKNOLEDGEMENT:
Results obtained in the framework of:

LIFE-Environment

AIR Pollution ImpAct Surveillance and Warning System for URban Environment

(LIFE05ENV/RO/000106)

Acronym: LIFE AIR-AWARE

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Beneficiary:

THE NATIONAL METEOROLOGICAL ADMINISTRATION (NMA)

Parteners:

- ***ENVIRONMENTAL PROTECTION AGENCY – BUCHAREST (APM-B)***
- ***URBAN AND METROPOLITAN PLANNING CENTRE – BUCHAREST (UMPC-B)***
- ***AUTORITY FOR PUBLIC HEALTH OF BUCHAREST (ASP-B)***
- ***INSTITUTE OF BIOLOGY BUCHAREST, ROMANIAN ACADEMY (IB-AR)***
- ***METEO FRANCE***

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FOREWORD

In all cites of the planet, air pollution is the major environmental problem due to the industrial plants, power plants, domestic heating and especially motor traffic. Increased concentrations of air pollutants and the variety of pollutants have negative effects on the increasing population density in the relatively small area of a city. Air pollution harms not only human beings but also plants and animals living together in the city.

Bucharest is the capital and the largest city in Romania as area and population (2 million citizens, the urban area covering a 228 Km^2). Air pollution in Bucharest has a complex character because of the multiple sources types (traffic, thermal power plants, industry and extensive building construction), conditions and their spatial distribution.

Project Objectives:

- To build a pilot air quality monitoring and forecasting system enabling multi-impact supervising**,** warning, and land-use municipal planning, to ensure sustainable development of the rapidly expansive urban area.
- To identify air pollution location of impacts on human health, using special GIS referenced population health indicators and morbidity data.
- To point out air quality environmental risks by linking ambient air contamination cadastre with a dedicated bio-indicator cadastre in OpenGIS environment.
- To build a fast-flow (24 hours) information link, enabling feed-back of air quality status and forecast to the local enforcement authorities – Public Health Authority and Environmental Protection Agency - identifying sources of high emissions from diffuse (traffic or fugitive) and concentrated sources, in order to apply feed-back enforcement for emission reduction.
- To build a slow-flow (weekly) information link to a remotely accessed stochastic database enabling feed-back on air quality recorded parameters by applying feed-back information for mitigation strategies – land-use planning, traffic regulations, awareness of endangered species and environment.

The AIR AWARE System shall represent an extremely useful tool which will allow decision makers, having a knowledge-based decision for prevention and mitigation of air quality chronically and incidental hazards, in the benefit of both he population and the environment.

The main result of the project will be the development and implementation of a pilot air quality monitoring and forecasting system, which will assess the impact on the environment and on human health, and will warn the responsible institutions, in correlation with land-use municipal planning on short, medium and long term in Bucharest area. Also, the AIR AWARE System represents an extremely useful tool which will allow decision makers, having a knowledge-based decision for prevention and mitigation of air quality chronically and incidental hazards, in the benefit of both the population and the environment.

By the expected results, the AIR AWARE system will propose to reduce the chronic air pollution impact that affects Bucharest: the emission of pollution sources shall be identified, even from diffuse sources, in order to apply feed-back enforcement for emission reduction by the responsible authorities part of the system; the impact on human health and on bio-indicators shall warn the citizens, and the mitigation measures shall be implemented by the environmental authorities responsible with planning, these being also part of the system.

The team from the Institute of Biology, Bucharest had the following objectives within the framework of LIFE AIR-AWARE project:

Establishing the working sites according to the patterns of the measured air pollution data:

The working sites have been established based on a pilot area (Cişmigiu, Unirii and Izvor Parks) from the central region of Bucharest; Băneasa and Baloteşti forests as reference sites, in gradient rural-urban according with the dilution of the pollutant concentration.

- *Inventory of species from the selected sites using the major groups, which are known to contain useful bio-indicators: fungi, bryophytes, vascular plants, invertebrates.*

Based on the shortage of distributional data for plants and animals available for Bucharest, the first step has been to determine the existence of potential bio-indicators. The methodology consists in site visits, comprising transects within the sites using both qualitative and quantitative sampling, the species composition methods, which characterise the presence and occurrence of certain species, combined with biochemical methods which sample a species or population that occurs in the habitats. The sampling points have been localised using GPS, and positioned to include samples from the marginal zone of the green space (so as to detect any impact of major roads) and from the core zone of the green space where such impacts should be less pronounced. Chemical analysis of plant and insects samples have been performed in a specialised laboratory and correlated with pollution data supplied by the partners.

The biological material has been conserved, determined and prepared, using specific techniques, for chemical analysis in the laboratories of the Institute of Biology. The resultant species list identified the major bio-indicator species. The biology team for this project covers a wide range of taxonomic groups.

Passive bioindicator methods have been used, as well as accumulation and reaction indicators. The results allow an overview of general air pollution, manifested by effects upon naturally occurring (and where appropriate cultivated) plants and animals, as well as an overview of regional pollutant patterns, indexed by accumulation in selected species and groups of species.

The samples prepared for chemical analysis, have been conducted by an external but well-authenticated specialist laboratory (Toxicology-Chemistry Laboratory, Animal Diagnostic and Health Institute).

Sample mineralization has been done with a Perkin Elmer model Anton Paar microwave.

Heavy metals (Pb, Cd, Cu, Zn) from soil, plant and invertebrate samples have been analysed with Perkin Elmer AAnalyst 800 Atomic Absorption Spectrophotometer incorporating all spectrometer and atomizer components using graphite furnace or flame techniques.

- *Monitoring of the bio-indicator species belonging to these groups:*

The species identified as bio-indicators became the object of a monitoring programme. The monitoring methodology has been species/group specific.

- *Data integration in GIS*:

Resultant data from the survey and the monitoring programme have been included in the databases of the beneficiaries in order to achieve a better interpretation and an integrated image of patterns, trends and impacts in air quality.

This multidisciplinary and transdisciplinary approach of the air pollution in Bucharest is done for the first time in Romania, having a huge scientific and practical importance, bringing an important contribution at the European level too.

We express our special thanks to Elisabeta Bianu, Daniela Nica, Cristina Țoca, Adriana Panchiosu from the Toxicology-Chemistry Laboratory, Animal Diagnostic and Health Institute for performing chemical analysis.

Special tranks we address to our field and lab assistants: Rodica Iosif (also helping with the IB-AR project management), Eliza Murgan, Steluța State, Florentina Dumitrescu, Liliana Manea, Simona Plumb, Claudiu Avramescu, Dinu Constantinescu and Dumitru Lazăr.

Our gratitude goes to our project partners and to 3C Consulting SRL for being the best in project management and in making our life easier in LIFE.

MACROFUNGI IN URBAN ECOSYSTEM

Mogîldea Daniela

INTRODUCTION

In the recent decades, a large number of studies have noted a decrease of the number of macrofungi, particularly mycorrhizal fungi. The decrease of the surface of forests ecosystems, habitat fragmentation, ramming the soil, air pollution and climate change are the main factors with negative impact on macrofungi.

Many species of macrofungi tend to accumulate heavy metals. Thus, the concentration of heavy metals such as Cd, Pb, Cr, Cu, Zn, Mn and Fe in macrofungi collected from polluted areas is significantly higher than the concentration of heavy metals in macrofungi collected from unpolluted areas (Pop, 1997). The response of fungi to air pollutants depends on the species, the type of pollutant, type and stage of vegetation development and availability of different ions in soil solution (Pop, 1997). There are differences among species regarding the tolerance to heavy metals, but there also are differences within the same species (Rudawska, 2000). Hartley et al. (1999) found that Cd is the most toxic for ectomycorrhizal fungi (ECM), but the study of Rudawska et al. (2003) revealed that Cu and Pb appeared to have a grater impact on ECM fungi community than Zn and Cd. Heavy metals have the effect of reducing the fine root biomass and the number and types of ectomycorrhizal fungi (Rudanska et al., 2003).

Although the effect of air pollution on macrofungi cannot be noticed immediately, macrofungi may represent a useful tool for differentiation between polluted and unpolluted areas. The concentration of heavy metals such as Cd, Pb, Cr, Cu, Zn, Mn and Fe in macrofungi collected from polluted areas is significantly higher than that of macrofungi collected from unpolluted areas (Adriana Pop, 1997; Morandi, 1990). Macrofungi may be biomonitors of polluted areas, knowing that there is a significant correlation between the emission of Cd and Pb and the concentration of this heavy metals in fruit bodies (Samara et al., 2003). Bracket fungi such as *Ganoderma applanatum* growing in polluted areas may be long-term bio-monitors of the atmospheric pollutants (Pyatt, 1992).

The decrease in the number of fruit bodies of ECM fungi was related mainly to air pollution (Antibus & Linkins III, 1989 after Schaffers, 1987). Nevertheless, many species of ECM fungi are more tolerant to high concentrations of heavy metals than the host plants. ECM fungi can be used in phytoremediation (Turnau et al., 2006) because they have heavy metals binding properties and limit heavy metals absorption by plants (Leyval et al., 1997) and can be use to monitor heavy metals pollution (Carlile et al., 2001).

The lack of ECM fungi can be a tool for assessing the degree of stability of the ecosystem. *Russula mustelina* Fr. is a fungal bioindicator of air pollution in the forests (Mulgrew & William, 2000). Fellner (1989) and Fellner and Pešková (1995) have proposed ectomycorrhizal fungi as bio-indicators of the pauperization of forest ecosystems.

MATERIAL AND METHOD

Fruit bodies collection was done during 2006-2007.

In each forests, two 50 × 50 m plots have been investigated. In the three parks, collection has been done from their entire area, from March till October. Chemical analysis have been performed using washed and unwashed fruit bodies. Analysing unwashed biomass gives results on the concentration of heavy metals in fruit bodies together with atmospheric deposits of heavy metals on their surface. Half of the samples of *Ganoderma lucidum* sent for analysis have been washed with distilled water.

The fungal bioconcentration factors were calculated according to the following equation (Zhang et al., 2008):

BCF = fruit body concentration / substratum concentration

We used Hansen & Knudsen (1992), Garnweidner (1994), Grunert & Grunert (1991), Bon (2004), Sălăgeanu & Sălăgeanu (1985) for species identification. Nomenclature is in agreement with Index Fungorum.

RESULTS AND DISCUSSION

The formation of fruit bodies depends on the temperature and rainfall and on other driving variables. Thirteen species have been collected from all five sites. The species with a large number of fruit bodies detected in the parks, are in the following order: *Coprinellus micaceus, Ganoderma applanatum* and *Schizophilum commune.* In Băneasa forest we noticed an increasing number of fruit bodies of parasitic species *Fistulina hepatica* (Table 1).

Table 1: Species occurence for all studied sites (f -frequent; r- rare)

Family	Species	Cişmigiu Park	Izvor Park	Unirii Park	Băneasa forest	Baloteşti forest
Agaricaceae	*Agaricus campestris* var. *campestris* (L.)	r			r	
Agaricaceae	*Agaricus* sp.2		r			
Agaricaceae	*Agaricus* sp.3			r		
Boletaceae	*Boletus* sp.1				r	
Boletaceae	*Boletus chrysenteron* Bull.		r			
Boletaceae	*Boletus rubellus* Krombh		r			
Agaricaceae	*Bovista sp.*			r		
Psathyrellaceae	*Coprinellus micaceus* (Bull.) Vilgalys, Hopple & Jacq. Johnson	f				
Psathyrellaceae	*Coprinellus disseminatus* (Pers.) J.E. Lange	r				
Agaricaceae	*Coprinus comatus* (O.F. Müll.) Pers.		r			
Cortinariaceae	*Cortinarius* sp.	r				
Agaricaceae	*Cyathus striatus* (Huds.) Willd.	r			f	r
Fistulinaceae	*Fistulina hepatica* (Schaeff.) With.	r			f	
Polyporaceae	*Fomes fomentarius (L.)* J. J. Kickx	r				
Ganodermataceae	*Ganoderma applanatum* (Pers.) Pat.	f			f	
Ganodermataceae	*Ganoderma lucidum* (Curtis) P. Karst.	r			f	
Fomitopsidaceae	*Laetiporus sulphureus* (Bull.) Murrill	r				
Marasmiaceae	*Marasmius rotula* (Scop.) Fr.	r			r	f
Mycenaceae	*Mycena* sp 1	r				
Mycenaceae	*Mycena* sp 2		r			
Mycenaceae	*Mycena* sp 3			r		
Hymenochaetaceae	*Phellinus pomaceus* (Pers.) Maire	r				
Pluteaceae	*Pluteus cervinus* (Schaeff.) P. Kumm	r				
Polyporaceae	*Polyporus squamosus* (Huds.) Fr.	r				
Russulaceae	*Russula* sp.	r				
Schizophyllaceae	*Schizophyllum commune* Fr.	f	r	r	f	f
Sclerodermataceae	*Scleroderma verrucosum (Bull.)* Pers	f	r	r		
Stereaceae	*Stereum hirsutum* (Willd.) Pers.	r	r	r		
Polyporaceae	*Trametes versicolor* (L.) Lloyd	r				
Pluteaceae	*Volvariella bombycina* (Schaeff.) Singer	r				

Project duration was too short to observe a significant change in the composition of mycocoenoses. The main cause of the low diversity of fungi is the drought from 2007 when the hottest summer occurred, comparable with 1965 (Busuioc et al., 2007). Yet we noticed a large number of species and fruit bodies belonging to the lignicolous species (saprophytic and parasitic macrofungi) in all three parks (Figure 1) and in their vicinity.

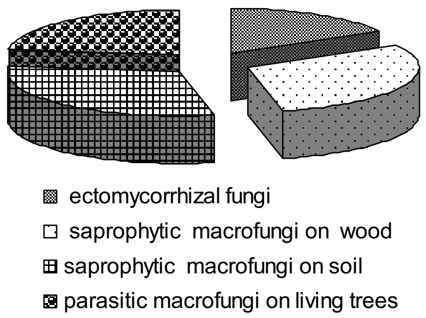

Figure 1: The percentage (%) of fungi categories in Parks

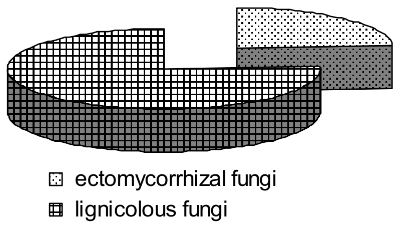

Figure 2: The percentage (%) of lignicolouse and mycorrhizal fungi in Parks

According to Fellner and Pešková (1995), there are three stages of disturbance of ectotrophic forest stability identified by the percentage between ECM fungi and lignicolous fungi and the degree of pauperization of the ectomycorrhizal mycocoenoses: Latent, Acute and Lethal. These changes in the percentage of ECM fungi and lignicolous fungi must be observed over a longer period of time. We must take in consideration, however, that this myco-bioindication method of Fellner and Pešková is for forest fungi, while in this case the fungi were collected from parks, which have a different structure because of the management of the urban ecosystems.

We can not accurately determine whether the high proportion of lignicolous fungi (Figure 2) is the effect of air pollutants, because of the complexity of the driving variables that act on fruit bodies' formation. A few fruit bodies of ECM fungi were collected from the studied area. This may be due to weather conditions, air pollution or to other human activities that do not have as a result air pollution, but which have an impact on the composition of mycocoenoses. We identified those activities with potential impact on fungi. Thus, organization of cultural events on the green space, access to green space and the ramming of the soil have negative impact on the development of soil macrofungi; the collection and removal of dead wood and leaf litter have a negative impact on the development of lignicolous fungi and of those growing on leaf litter; the mow of herbaceous layer above the soil affects the soil macrofungi due to the reduced soil moisture; planting of trees, or herbaceous plants may result in introduction of new species and of new individuals of the species already existing; activities that have a negative impact on fungi indirectly by affecting other components of the ecosystem. Mycocoenoses composition is the result of all these driving biotic and abiotic variables. Even so, the diversity of parasitic fungi is higher than that of ecomycorrhizal fungi and may indicate a weak viability of trees and a weak stability of this site.

Among the species encountered in these sites, perennial species of fungi as *Ganoderma applanatum* and *Fomes fomentarius* can be considered possible biomonitors of air pollution. Analysis of these perennial species can give us information on the concentration of heavy metals in a given period of time (years).

Although the fruit bodies were collected during two years, in 2007 we have not found fruit bodies of ECM fungi most likely due to increased temperatures and reduced precipitation. For this reason, a small number of fruit bodies have been used for the analysis of heavy metals. It is necessary to make another chemical analysis on a larger number of fruit bodies in the near future, to confirm these preliminary data. The chemical analysis pointed out higher concentrations of heavy metals in fruit bodies of *Boletus rubellus* and *Boletus chrysenteron* than those reported in other species. The data in these studies confirm the results of other specialists who have shown that the species of the genus *Boletus* accumulate heavy metals (Kovács, 1992).

Tingey (1989) considered that the species accumulating heavy metals are generally biomonitors. They provide information on the presence versus the absence of a pollutant and sometimes information on the quantity or intensity of exposure to the pollutant.

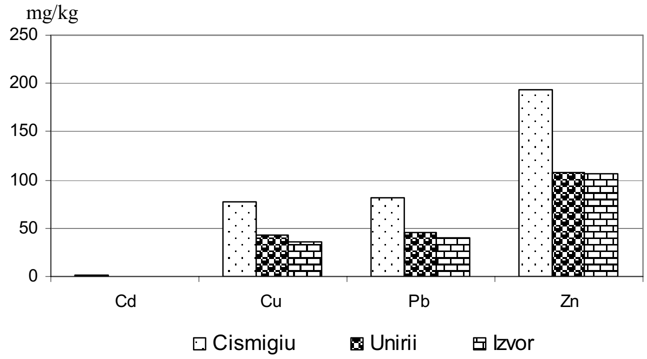

Figure 3: Mean concentration of heavy metals (ppm dw = mg/kg dw) in the soil of Bucharest central parks

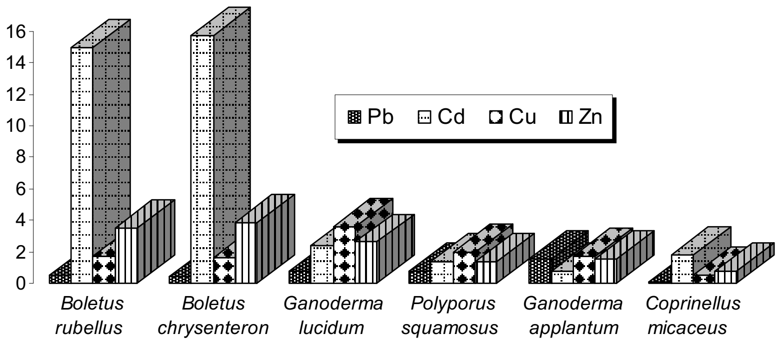

Figure 4: Bioacumulation factor (BCF) in fruit bodies and aerial depositions on fruit bodies

Analysing the heavy metal content in wood as substrate for *Ganoderma applantum*, we found 7.4 ppm for Pb, 0.59 ppm for Cd, 14 ppm for Cu and 50 ppm for Zn.

The chemical analysis revealed that Zn is the metal with the highest concentration in soil and that Cd is the metal with the lowest soil concentration (Figure 3), but the chemical analysis of the fruit bodies revealed the highest fungal accumulation factor in *Boletus* fruit bodies and aerial depositions on fruit bodies for Cd (Figure 4). The atmospheric deposition for Cd is low according to the data results for atmospheric deposition on *Ganoderma* fruit-bodies (Figure 5). This results are in accordance with the data obtain by Zhang et al. (2008) who found high BCF for Cd in *Boletus griseus*. The amount of Cd in fruit bodies is a consequence of the action of multiple factors, not only due to atmospheric pollution.

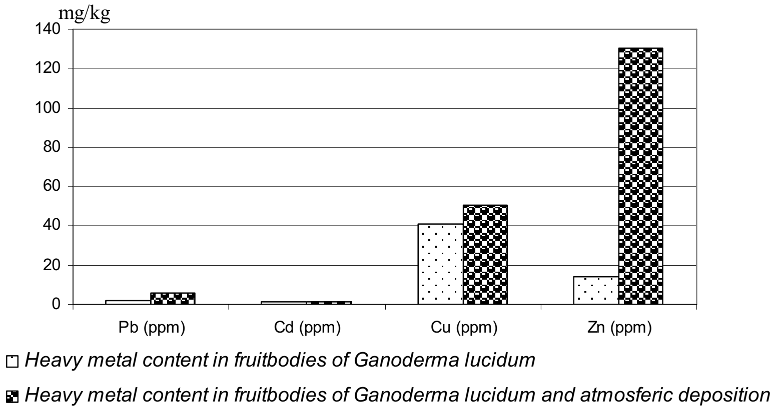

Figure 5: Heavy metal content (ppm d.w. = mg/kg d.w.) in *Ganoderma lucidum* and aerial depositions on fruit bodies

CONCLUSIONS

Twenty nine species have been collected from all five sites.

The higher diversity of parasitic fungi comparing with ectomycorrhizal fungi may indicate a weak viability of trees and a weak stability the parks.

The species with a high number of fruit bodies in the parks are in the following order: *Coprinellus micaceus, Ganoderma applanatum* and *Schizophilum commune*.

The species of macrofungi that can be possible biomonitors of atmospheric pollutants are: *Ganoderma applanatum* and *Fomes fomentarius.*

The species *Boletus rubellus* and *Boletus chrysenteron* had the highest bioaccumulation factor for Cd and atmospheric deposition.

Further studies and monitoring of the fungi species are required.

The concentration of heavy metals in fungal species should be monitored in the polluted areas, because knowledge on heavy metal concentration in mushrooms is important from the bioindicative point of view and also for assessing the metals transfer along the food-chain.

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LICHEN AND BRYOPHYTES AS BIOINDICATORS OF AIR POLLUTION

Ioana Gomoiu, Sorin Ştefănuț

INTRODUCTION

Lichens are a unique life form, consisting of a relationship between fungus known as the mycobiont, and a photosynthetic partner, a cyanobacterium or a green alga, as the photobiont. This is a symbiotic association, such that the fungus provides moisture and shelter for the algal cells allowing them to live even in places that otherwise would not be suitable. The algal cells provide nutrients for the fungus cells. The fungus penetrates the cells of its partner with short, specialized hyphae that absorb the food produced by photosynthesis. Lichens are able to live in some of the harshest habitats on earth, due to this symbiotic relationship. Lichens are extremely widespread in nature, from arid desert to Arctic regions, growing on bare soil, tree trunks, sun baked rocks, etc. However, lichens grow very slowly, often less than one millimetre per year, and some of them are thought to be among the oldest living organisms on earth.

Lichens are very sensitive to pollutants and they are considered as indicators of air and water pollution. Typically, lichens are investigated from areas located near by a pollution source or from any areas of interest. Appropriate measures of lichen survival rate are recorded at each study location and are related to known or inferred pollution levels. Other studies imply the distribution of individual indicator species, frequency or abundance of individual species, species richness (total number of different species) and total lichen cover from a specific area.

In urban areas, lichens are considered to be highly sensitive to pollution caused by sulphur dioxide (SO_2) emissions from industrial and domestic sources and NO_x emission from intensive traffic. Nowadays in urban areas NO_x is considered as the major pollutant near the roads with intensive traffic. Sulphur content in *Hypogymnia physodes* ranged from 0.046 to 0.183% sulphur/lichen dry weight.

Nitrogen can be either nutrient or toxic compound depending on its type, quantity and on requirement of lichen species. Ellenberg (1988) used nitrogen compounds to establish nutrient status and toxiphoby. Wirth (1992) applied Ellenberg's method to separate nutrient-N effects from toxic effects of SO_2 in a scale of 1-9. Bruteig (1993) discovered nitrogen content levels in the lichens' thalli in the range 0.42 to 1.96% N/lichen dry weight. This value was ten times higher than sulphur content of thalli.

Biodiversity of the lichens in air polluted areas is very low but it can be increased by a good air quality. Recolonisation is affected by the rate of SO_2, NO_x, heavy metals decrease, nature and age of the substratum, lichen forms (foliose species appear to be more successful in recolonisation than crustose species), competitive nature of lichen. *Hypogymnia physodes* and *Parmelia sulcata* contain high concentration of Zn, Fe, Pb, respectively Mn, Zn. Cd in their thali.

Currently tropospheric O_3 is probably the gaseous pollutant of most concern for plants scientists. Estimates suggest that the tropospheric O_3 concentrations have increased substantially over the last few decades. The available literature shows that the adverse effects of O_3 on forests and crops have been accelerated over the last 10 to 15 years. Ozone is not bio-accumulated in plants or lichens and can only be detected by sensitive organisms. The major effects of O_3 on the terrestrial vegetation include visible foliar injury, reductions in growth and productivity, changes in crop quality and increased sensitivity to either abiotic or biotic stresses.

During the last few decades in Bucharest we noticed an increase in urbanization and intensive traffic with huge contribution to air pollution. Lichens are very sensitive bioindicators of the environmental status. Around the city centre, mainly in Cişmigiu, Izvor and Unirii Parks, our studies revealed different answers of the lichens to air pollution: absence of sensitive species, presence of moderate sensitive species, morphological changes, growth on specific host trees. The natural distribution of epiphytic lichens is influenced by the following factors: air pollution, climate, microclimate, eutrophication, dust accumulation, structure of the bark and its water-holding capacity.

A comparative study of the distribution of lichens in parks situated in the centre of Bucharest but having different ages indicates the role of lichens and green alga as bioindicators of air pollution.

Because of poikilohidry and major dependence for water, the liverworts, hornworts and bryophytes are very sensitive to polluting substances action and from this reason the bryophytes are used as bioindicator of air pollution. The bryophytes are used to indicate the presence of heavy metal elements and their concentration gradient for many reasons: the species are widely distributed and can be collected during the entire year; lack of cuticle and a root system and uptake of the nutrients directly from atmospheric deposition; they have a good heavy metals bioaccumulation ability; herbarium samples from same areas can by compared with fresh material.

The use of epigeic bryophytes (bryophytes growing naturally on the ground) has been recommended in Scandinavia for the assessment of heavy metal deposition on a regional scale (Steinnes et al., 1993). However, element concentrations in carpet forming bryophytes may be elevated by soil-blown dusts. Such contamination and possible misinterpretation of results would be particularly heightened in seasonally arid countries (Ruhling, 1995).

The technique for surveying atmospheric heavy metal deposition in bryophytes was developed in the late 1960's (Rühling & Taylor, 1968). The majority of studies have been made as multi-element investigation and only a few have been restricted to a particular metal.

MATERIALS AND METHODS

The methodology used to estimate or measure lichen's presence is the lichen cover. Estimation of lichen cover in relation to pollution patterns is a common procedure and involves total lichen cover or individual species cover. Evaluation of cover was made according to the following scale:

r = 1-5 colonies with very low cover
+ = a few colonies with low cover
1 = many colonies with low cover or a few colonies with high cover
2 = more colonies with 1/10 -1/4 cover on the first 2 m high of the trunk
3 = ¼ - ½ cover in the first 2 m high of the trunk
4 = ½ - ¾ cover
5 = more than ¾ cover

Techniques for lichen identification are the following: field examination using 10× hand lens; chemical analysis; microscopic examination of thalli in the laboratory.

In the first step of the project we appreciated the air pollution level using a qualitative method based on Hawskworth & Rose zone scale (1-9) and photographic record of lichens distribution according to their locations. They are very useful for the next steps of the project to assess air pollution by lichen diversity (photographic methods, Ellenberg method, Lallemnent method). Samples were taken from the bark of trees and lichens were identified in the laboratory according to chemical tests, morphology and microscopic characteristics. The results have been used to map zones of lichen presence and their association with qualitative levels of air pollution.

The bryophytes from Bucharest were monitored using the *in situ* sampling (Figure 1).

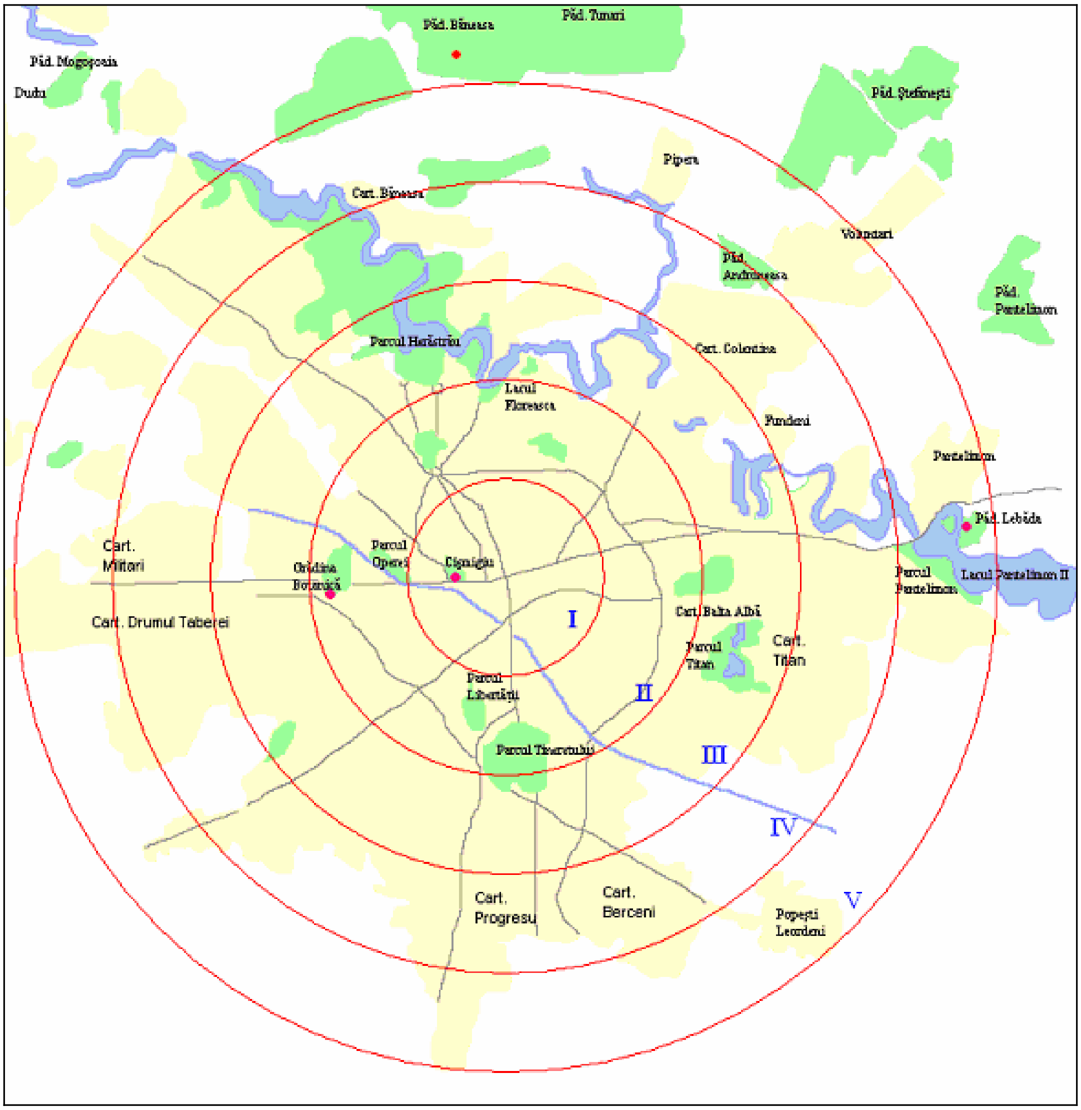

Figure 1: Map of Bucharest city; the division in five zones **(I-V).**

Species selection criteria include the availability of the species, their tolerance, their bioaccumulation characteristics and ease of sampling (Wolterbeek et all., 1996). Bucharest area was split in five zones, starting with the University Square as point 0 (Figure 1):

- I zone, Cişmigiu Park, Izvor Park and Unirii Square;
- II zone, Opera's Park, Tineretului Park and Botanical Garden;
- III zone, Titan Park, Bucharest Biology Institute, Ciurel Lake and a part of Herăstrău Park;
- IV zone, the northern part of Herăstrău Park and Sticlăriei Park;
- V zone, Pantelimon Park, Lebăda Forest and Pantelimon Lake.

The following forests around Bucharest City were selected as reference areas:

- Băneasa Forest, Ilfov County, especially;
- The forest around Prahova railway station, Prahova County;
- Călugăreni Forest, Giurgiu County;
- Bujoreni Forest, Teleorman County.

RESULTS AND DISCUSSION

A. LICHENS

For monitoring urban air pollution as part of the general biomonitoring program, are the methods using lichens. The biomonitoring program is based on the capability of lichens for assessing the impacts of heavy metals, the effects of sulphur and nitrogen compounds concentration.

Green algae (Chlorophyta) *Pleurococcus viridis* was identified on truncks of *Tilia* sp from Izvor park. It is already known the bioindication status both due to high SO_2 concentration in its body (>170 μg/m^3) and extend up to the trunk at 150 μg/m^3 SO_2 concentration.

Parmelia sulcata is nitrophilous, intermediate to tolerant at SO_2 (10 - >30 μg/m^3), sensitive to floride and sensitive to intermediate at Ozone.

Hypogymnia physodes is intermediate to tolerant at SO_2 (10 - >30 μg/m^3), absent at >40 μg/m^3 SO_2 levels and one of the most tolerant lichens at the pollution. It is also sensitive to fluoride and intermediate to tolerant at low pH.

Xanthoria parietina is intermediate to tolerant to SO_2 (46-14,8 μg/m^3), nitrophilous (25,9-22,2 μg/m^3), sulphate, nitrate and fluoride tolerant.

Location, lichen species, qualitative scale and lichen cover are presented in Table 1-3 for each park.

Table 1. Lichen cover and qualitative scale (Hawksworth & Rose' zone scale) from Cişmigiu Park (N: 44°26'; E: 26°05')

Species	Location Seconds (N/E)	Qualitative scale	Abundance	Host species (Substrate)
Hypogymnia physodes	05,8″/ 33,2″	5	+	*Sophora japonica*
	05,8″/ 33,2″	5	+	*Quercus rubra*
	05,7″/ 32,7″	5	+	
	05,6″/ 32,3″	5	+	
	05,7″/ 32,7″	5	+	
	05,8″/ 33,2″	5	+	*S. japonica*
	05,8″/ 34,0″	5	+	
	06,3″/ 32,7″	5	+	*Q. rubra*
	06,5″/ 32,3″	5	+	
	06,2″/ 31,6″	5	+	
	05,7″/ 35,1″	5	+	*Cornus mas*
	06,7″/ 35,9″	5	+	*Tuja* sp.
	06,8″/ 35,6″	5	3	*S. japonica*
	07,4″/ 35,9″	5	+	*Prunus mahaleb*
	07,4″/ 36,1″	5	+	
	07,3″/ 35,7″	5	+	
	07,7″/ 34,6″	5	3	*Q. rubra*
	07,4″/ 33,5″	5	3	*Cornus mas*
	07,3″/ 35,7″	5	2	*S. japonica*
	07,3″/ 35,7″	5	+	
	07,3″/ 35,7″	5	+	*Ulmus* sp.
	07,2″/ 32,1″	5	3	*Fraxinus excelsior*
	07,3″/ 31,7″	5	3	*Salix* sp.
	07,3″/ 30,8″	5	+	
	07,5″/ 29,3″	5	1	
	07,9″/ 28,8″	5	1	*S. japonica*
	08,2″/ 28,9″	5	+	
	07,6″/ 30,0″	5	+	*Salix* sp.
	07,8″/ 29,9″	5	+	*S. japonica*
	08,0″/ 29,8″	5	+	

	08,1″/ 29,7″	4	3	*F. excelsior*
	08,5″/ 29,4″	5	+	*Tisa* sp.
	08,4″/ 29,2″	5	3	
	08,7″/ 29,0″	5	4	*F. excelsior*
	08,1″/ 28,7″	5	1	*S. japonica*
	07,2″/ 29,5″	5	3	
	07,1″/ 30,2″	4	+	*F. excelsior*
	07,0″/ 30,5″	5	3	
	06,9″/ 31,2″	5	+	*Q. rubra*
	06,7″/ 31,5″	5	+	*C. mas*
	06,9″/ 31,7″	5	+	*F. excelsior*
	07,0″/ 32,0″	5	+	
	07,7″/ 31,8″	5	+	*Salix* sp.
	07,8″/ 31,9″	5	+	*F. excelsior*
	08,0″/ 32,5″	5	+	
	08,9″/ 32,6″	5	+	
	09,5″/ 32,5″	5	+	*S. japonica*
	09,7″/ 32,3″	5	+	
	09,8″/ 32,0″	5	+	*Salix* sp.
	10,6″/ 30,8″	5	3	
	13,3″/ 31,6″	5	3	*F. excelsior*
	13,5″/ 31,4″	5	3	
	13,7″/ 31,2″	5	+	
	14,1″/ 31,2″	5	+	*Gingo biloba*
	15,2″/ 27,2″	5	1	
	17,2″/ 25,7″	5	+	*Salix* sp.
	17,3″/ 26,6″	5	1	*Salix* sp.
H. physodes, Algae	05,8″/ 34,0″	5	+	
	06,2″/ 33,3″	5	1	*Q. rubra*
	05,1″ / 33,7″	5	3	
H. physodes, Candelaria concolor	05,0″/ 34,6″	5	3	
	07,1″/ 32,0″	5	3	
	07,4″/ 31,9″	5	3	*F. excelsior*
H. physodes, Lecanora sp	13,3″/ 31,7″	5	3	
H. physodes, Melanelia sp.	05,7″/ 35,3″	5	1	*Amygdalus communis*
	16,3″/ 24,8″	5	3	
	15,6″/ 26,6″	5	1	*Salix* sp.
	15,1″/ 27,8″	5	1	
H. physodes, Parmelia saxatilis	14,1″/ 28,5″	5	3	
	13,9″/ 28,8″	5	1	F. excelsior
	13,8″/ 29,0″	5	3	
H. physodes, P. saxatilis, Algae	06,2″/ 31,6″	5	+	
H. physodes, P. saxatilis, C. concolor	14,1″/ 27,8″	5	3	*Q. rubra*
H. physodes, P. saxatilis	12,6″/ 28,8″	5	3	
H. physodes, Xanthoria parietina	07,3″/ 35,7″	5	2	
	05,1″/ 1,7″	5	3	*C. sanguinea*
	05,3″/ 32,2″	5	+	*Morus alba*
	04,9″/ 35,4″	5	+	
	17,8″/ 22,6″	5	3	
	15,2″/ 22,7″	5	+	
P. saxatilis	15,3″/ 22,3″	5	+	*C. mas*
	15,8″/ 25,7″	5	+	
	14,6″/ 27,8″	4	+	
	13,1″/ 29,9″	4	+	*F. excelsior*
	12,8″/ 29,9″	5	+	
P. saxatilis, Algae	06,5″/ 32,3″	2	+	
	06,3″/ 32,7″	2	+	

	06,2″/ 33,3″	2	2	
	05,4″/ 32,1″	2	+	*Buxus* sp.
P. saxatilis, H. physodes	17,6″/ 25,6″	5	3	*F. excelsior*
	17,9″/ 25,5″	5	3	
	17,2″/ 25,7″	5	+	
	18,4″/ 25,2″	4	3	
P. sulcata, Algae	05,2″ / 32,5″	2	+	
	04,8″/ 34,6″	5	+	
P. sulcata, X. parietina	07,0″/ 30,0″	5	+	*Accacia triachantos*
	07,0″/ 31,1″	5	3	*Populus* sp.
	16,9″/ 25,6″	5	1	
	15,7″/ 23,7″	5	3	*Salix* sp.
	15,9″/ 24,5″	5	3	
	16,2″/ 24,5″	5	3	

Table 2: Lichen cover and qualitative scale (Hawksworth & Rose' zone scale) from Izvor Park (N:44°25′; E: 0,26°05′)

Species	Location Seconds (N/E)	Qualitative scale	Abundance	Host species (Substrate)
Parmelia saxatilis	58,7″/ 28,0″	5	+	*Tilia* sp.
	58,6″/ 27,8″	5	+	
	57,9″/ 25,3″	5	+	
P. saxatilis, Algae	59,5″/ 16,2″	2	r	
	59,5″/ 14,7″	2	r	
	59,7″/ 11,7″	2	r	
	57,7″/ 03,7″	2	r	*Robinia* sp.
P. saxatilis, Xanthoria parietina	52,8″/ 03,0″	5	r	*Quercus* sp.
X. parietina	50,8″/ 10,7″	5	r	
	58,2″/ 24,2″	5	+	
X. parietina, Algae	49,7″/ 23,1″	2	+	*Tilia* sp.
	49,7″/ 23,2″	2	+	
	49,7″/ 23,2″	2	+	
X. parietina, P. saxatilis	49,8″/ 21,4″	5	r	
	49,7″/ 22,7″	5	+	
	50,5″/ 27,6″	5	+	*Quercus* sp.
	50,5″/ 27,6″	5	+	

Lichen studies focused on monitoring of growth rate (Table 4) and chemical analysis for heavy metals quantitative evaluation (Table 5), shown that growth rate for fungi and lichens are specific for each species. Lichens have a low growth rate (Table 6) because they need water during the year but the rate of rainfall is not constant. Also temperature could have maximum values during summer (40-42°C) or minimum values during winter (-10°C). Lichen species used for monitoring the growth rate have as substrata the bark of the following tree: *Gleditsia triacanthos, Salix sp, Fraxinus excelsior* from Cişmigiu Park.

Characteristics as bioindicators: thalus is strongly wrinkle, with white areas as an effect of photobiont damage who is unable to make photosynthesis; white areas are distributed on the central part of thalus and also on the edge of lobes; they become brownish to dark brown as an effect of necrosis; they can remain for a while on the bark and then fall down. *Parmelia sulcata* is a bioindicator of Cd as well as *Hypogymnia physodes* (Table 5).

Table 3. Lichen cover and qualitative scale (Hawksworth & Rose' zone scale) from Unirii Park (N: 44°25'; E: 0,26°05')

Species	Location Seconds (N/E)	Qualitative scale	Abundance	Host species (Substrate)
Hypogymnia physodes, Xanthoria parietina	39,3″/ 12,7″	5	2	*Quercus* sp.
	39,5″/ 12,2″	5	3	
	39,4″/ 12,8″	5	3	
	39,4″/ 12,9″	5	+	
	39,5″/ 12,2″	5	+	
H. physodes	40,3″/ 12,7″	5	+	
	39,2″/ 13,4″	5	+	
	39,5″/ 12,1″	5	1	
	41,1″/ 12,1″	5	+	
	42,3″/ 12,4″	5	+	
X. parietina	41,0″/ 04,3″	6	1	*Tilia* sp.
	39,5″/ 04,3″	6	+	*Quercus* sp.
	38,7″/ 04,0″	6	+	
	38,6″/ 04,0″	6	r	*Tilia* sp.
	38,2″/ 04,9″	6	r	
	38,5″/ 13,4″	6	r	
	38,8″/ 13,4″	6	r	
	38,4″/ 13,2″	6	r	*Quercus* sp.
X. parietina, H. physodes	40,3″/ 12,6″	5	2	
	40,6″/ 12,5″	5	1	
	40,4″/ 12,6″	5	+	
	40,6″/ 12,4″	5	+	
	40,8″/ 12,3″	5	+	
	39,0″/ 13,4″	5	+	*Tilia* sp.
X. parietina, Parmelia saxatilis	40,8″/ 04,1″	4	1	
	40,4″/ 04,0″	4	+	
	40,1″/ 04,3″	4	2	
	40,0″/ 04,3″	4	2	
	38,7″/ 13,2″	6	+	

Table 4: Monitoring of lichens' growth rate (N: 44°26'; E: 26°05')

Lichens	Location seconds (N/S)	Substrate (Plant Species)	Growth rate (mm)
Parmelia sulcata	07,1″/30,3″	*Gleditsia triacanthos*	2,0
Xanthoria parietina			1,0
Hypogymnia physodes	08,0″/30,5″	*Salix* sp.	1,0
X. parietina			1,0
P. sulcata	07,0″/31,6″	*Fraxinus excelsior*	2,0
X. parietina			2,0
P. sulcata	09,7″/32,3″		2,0
X. parietina			2,0

Table 5: Heavy metal concentration (ppm dw = mg/kg dw) in lichen talus from different sites

Lichens	Location	Pb	Cd	Cu	Zn
Parmelia sulcata	Baloteşti Forest	23,96	1,18	11,59	28,72
		21,8	0,57	7,14	24,90
		30,7	0,65	6,69	27,21
		45	1.12	8,96	61,5
		28,71	0,81	8,86	40,77
		24,1	1,03	11,99	25,60
		33,61	0,76	11,39	30,69
Xanthoria parietina	Cişmigiu Park	42	0,95	12,56	47,91
	Izvor Park	50,16	0,54	26,15	50,99
		28,3	2,7	70,3	152
Hypogymnia physodes	Cişmigiu Park	70,6	2,65	37,76	89,70
		28,83	0,70	20,58	53,98
		32,5	11	101,4	216

Table 6: Assessing lichens' growth rate

Lichens	Location (N/S in seconds)	Diameter (mm)	Host species (Substrate)
Hypogymnia physodes	N 58,1" / E 24,5"	139 - 140	*Quercus rubra*
Xanthoria parietina	N 58,6" / E 24,8"	170	
X. parietina	N 57,1" / E 23,4"	154,5 - 163,5	*Fraxinus americana*
Parmelia sulcata, X. parietina	N 07,0" / E 31,6"	150	
Parmelia sulcata, X. parietina	N 09,7" / E 32,3"	244/148	
X. parietina, P. sulcata	N 55,4" / E 23,0"	146 - 158	*Acer platanoides*
X. parietina, H. physodes	N 52,1" / E 21,8"	128 - 190	
H. physodes, X. parietina	N 08,0" / E 30,5"	85	*Salix* sp
P. sulcata, X. parietina	N 07,1" / E 30,3"	184 li/	*Gleditsia triacanthos*

Xanthoria parietina: small stratified foliose or occasionally fruticose liches, corticate above and bellow, sorediate or isidiate, lobes closely appressed to loosely attached or semi-erect, elongate, averaging to 0,3-2 mm wide, thin. Upper surface of thalus is orange or orangish. Lower surface of thalus is whitish with short and simple rhizines. Medulla is white and photobiont is green. Apothecia are located on upper surface, with orange disc. Spores are two celled, ellipsoid, colourless and distributed eight per each ascus.

Characteristics as bioindicators: very irregular and thin thalus, necrosis areas brown coloured, low number of isidia. *Xanthoria parietina* collected from Izvor Park is a bioindicator of Pb (50,16 mg/kg), Cu (26,5 mg/kg) and Zn (50,99 mg/kg).

B. BRYOPHYTES

Published data concerning bryophytes from Bucharest exist since 1901, when Radian S.Ş. reported two *Riccia* species from Ciurel-Grozăveşti area. Over one century the following liverwort species were indicated in Bucharest area: *Frullania dilatata* (Botanical Garden), *Lunularia cruciata* (Botanical Garden Greenhouses), *Marchantia polymorpha* (Cişmigiu, Botanical Garden) and subsp. *ruderalis* Bischl. et Boisselier (Cişmigiu), *Metzgeria furcata*, *Porella platyphylla* (Botanical Garden), *Radula complanata* (Băneasa Forest), *Riccia cavernosa* (Dâmboviţa's pools from Grozăveşti) and *R. fluitans* (Ciurel and Grozăveşti).

The research activities concerning the liverworts of Bucharest were made since 1998 to present. Along the research period, 2006-2007, we collected the following species from Bucharest:

- *Marchantia polymopha* subsp. *ruderalis* from Cişmigiu Park (zone I), on soil (Figure 2);

- *Conocephalum salebrosum* from Botanical Garden (zone II), on soil, new for Bucharest Flora;
- *Frullania dilatata* from Lebăda Forest (zone V), on oak bark.

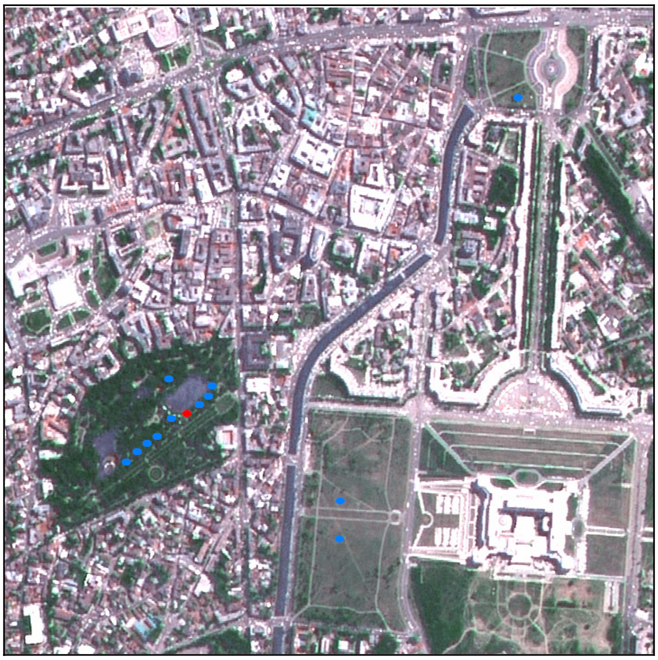

Figure 2: The zone I map with bryophytes (blue spots) and liverwort (red spot) collected species.

In Băneasa Forest we frequently identified the liverwort *Radula complanata*. In Călugăreni Forest, Bujoreni Forest and the forest around Prahova rail station we collected *Frullania dilatata, Porella platyphylla* and *Radula complanata* liverworts.

We could not find in Bucharest, zones I-V, the species: *Metzgeria furcata*, *Porella platyphylla*, *Radula complanata*, *Riccia cavernosa* and *R. fluitans*.

From the literature and from the field trips, we found the following species:

- *Conocephalum salebrosum* Szweyk., Buczkowska & Odrzykoski in Botanical Garden, 5.VII.2005, leg. & det. Ştefănuţ S. [BUCA B3177];
- *Frullania dilatata* (L.) Dumort. In Botanical Garden (Ştefureac 1982: 200); ♂ - Pantelimon, Lebăda Forest, 2.V.2005, leg. & det. Ştefănuţ S. [BUCA B3176], 9.X.2005, leg. & det. Ştefănuţ S. [BUCA B3307];
- *Lunularia cruciata* (L.) Lindb. In Botanical Garden, in Greenhouses (Radian 1915: 193);
- *Marchantia polymorpha* L. In Cotroceni, on wall of Botanical Institute and Botanical Garden, 04.1896, 14.01.1909 (Radian 1915: 194); Artilery scool, 20.IV.1901, leg. Calafeteanu S. (Radian 1915: 194); Ştirbei Vodă Street, 15.V.1903 (Grinţescu G.P. 1922: 142); Botanical Garden, 1960 (Ştefureac & Lungu 1961: 273-275; Ştefureac 1982: 197, 200);
- subsp. *ruderalis* Bischl. et Boisselier (♂) in Cişmigiu Park, 3.IV.2004, leg. & det. Ştefănuţ S. [BUCA B2937], ♂ - 6.VII.2005, leg. & det. Ştefănuţ S. [BUCA B3178].
- *Metzgeria furcata* (L.) Dumort. In Bucharest, on *Ginkgo biloba* (Ţopa 1978: 47);
- *Porella platyphylla* (L.) Pfeiff. In Botanical Garden, under *Madotheca* (Ştefureac 1982: 197, 200);
- *Radula complanata* (L.) Dumort. In Băneasa Forest (Racoviţă A. 1941: 154); Băneasa Forest, 1995, det. Ştefănuţ S. (!).

- *Riccia cavernosa* Hoffm. † in Dâmbovița bank at Grozăveşti, 13.X.1900, leg. E.C. Teodorescu, det. Radian S.Ş., under *R. crystallina* L. (Radian 1901: 40; Radian 1915: 189);
- *Riccia fluitans* L. in Bucureşti, † - Ciurel and Grozăveşti, 13.10.1900, leg. E.C. Teodorescu (Radian 1901: 40; Radian 1915: 189); Sabar Valley between Odăi and Măgurele, 28.X.1900, leg. E.C. Teodorescu, det. Radian S.Ş. (Radian 1901: 40; Radian 1915: 189);

CONCLUSIONS

Lichens are among the best bioindicators of air pollution (carbon dioxide, nitrogen oxides, ammonia, sulphur dioxide, aromatic hydrocarbons and heavy metals). Their thalli respond in short time to the impact of air pollution: in the initial phase their thalli present whitish spots having different dimensions showing absence of photosynthesis; in the next phase appear necrosis areas in which the thallus is brown and thinner.

Pleurococcus viridis, known as bioindicator of SO_2 concentration in the algal body has been identified on truncks of Tilia sp. from Izvor Park.

Hypogymnia physodes is a bioindicator of Pb, Cd, Cu, Zn.

Parmelia sulcata is a bioindicator of Cd.

Xanthoria parietina is a bioindicator of Pb, Cu, Zn.

In spite of the fact that we found a new liverwort species (*Conocephalum salebrosum*) for Bucharest Flora, the number of liverworts reported from Bucharest decreases along the time:

- The epiphytic species *Frullania dilatata, Porella platyphylla, Radula complanata* had not been found again in the I-IV zones.
- The hygrophilous liverworts species, *Riccia fluitans, Riccia cavernosa* and *Ricciocarpus natans*, had not been found again in the vicinity of Ciurel, Herăstrău and Pantelimon lakes and Dâmbovița River.
- *Marchantia polymopha* subsp. *ruderalis* and *Conocephalum salebrosum* might be use as biomonitors of heavy metals, especially for Pb.

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HEAVY METAL CONTENT ASSESSMENT IN PLANTS

Marilena Onete, Mihaela Paucă-Comănescu

INTRODUCTION

An air pollutant is known as a substance (natural or man-made) in the air that can cause harm to humans and the environment (EPA, 2008).

From different sources, the pollutants from the atmosphere are transported by wind turbulence from one area to other, over landscape, on the vegetation. Pollutants change their chemical and physical form in the atmosphere. This transformation influence the rates of removal from the atmosphere by precipitation (wet deposition) and by direct deposition as gases and aerosol on the terrestrial and marine surface (dry deposition) (Fowler, 2002).

As component of the biosphere, the soil represents a geochemical sink of the contaminants and a natural buffer controlling the transport of chemical elements and substances from the atmosphere, hydrosphere and biota (Harrison & Chirgawi, 1989).

Some species or varieties of natural and cultivated plants are very sensitive to certain air pollutants, showing sometimes more or less specific, well-visible and measurable symptoms, serving as biological indicators for the possible presence of certain air polluting substances. Various plant species or varieties may accumulate air pollutants, without changing these substances. Thus, air pollutants can be analyzed physically and chemically (qualitatively and quantitatively) following accumulation in plants (Posthumus, 1983).

Heavy metals (Zn, Cu, Pb, Cd) occur naturally in plants, playing or not a role in their metabolism. Many plant species and genotypes have a great tolerance to different heavy metals and a great selectivity in absorbing them from the soils. Some plant species may accumulate extremely large amounts of pollutants in their tissues without showing symptoms of toxicity (Szaro et al., 2002).

Certain soil and plants factors (low pH, low P content of soil, organic ligands) are known to promote both heavy metals uptakes by roots and their translocation into plants tops (Jimura et al., 1977; Guilizzoni, 1991).

Due to their great ability to adapt to variable chemical properties of the environment, plants can accumulate heavy metals, in or on their tissues. Thus, plants are intermediate reservoirs through which heavy metals from soil, and partially from water and air, move to man and animals. The fate of the anthropogenic heavy metal in soils is hazardous for man and animals from two sources: food chain and inhalation of the soil dust. This basic environmental problem relates to the quantities of accumulated metals in plant parts used as food. The metal forms in plants seem to have a decisive role in metal transfer to other organisms (Agrawal et al., 1988; Breckle et al., 1992; Omasa et al., 2007).

Heavy metals entering plant tissues are active in metabolic processes, but can also be stored as inactive compounds in cells and membranes (Alfani et al., 1996). The tops of all plants are collectors for all air pollutants. Assessed against background values obtained for unpolluted vegetation, the chemical composition of the plants may be a good indicator for contaminated areas (Kabata-Pendias & Dudka, 1991).

MATERIAL AND METHOD

Following the inventory of all plant species from 2006, in 2007, the studies in the parks were carried out in areas according with Figure 1, 2 and 3. The separation in different shaped areas is due to man-made paths bordered (or not) by benches. The use of the quadrates was not appropriate in Cişmigiu due to the irregularity of the areas. The quadrates method could be used in Unirii and Izvor but we intended to use the same methods for all three parks.

An exact list of all plant species with an attendant visual estimate of their sociability and abundance is taken from the samples areas (Onete & Paucă-Comănescu, 2008). After the inventory of the species from every park and also from the reference forests (Băneasa and Baloteşti) and using the knowledge on the bioindicators of air pollution, we established the bioindicator species as follows:

- the presence of the species in all parks and in the references forests (Băneasa and Baloteşti), not having knowledge on the species indication status;
- the presence of the species only in all three parks, but they are known as bioindicators/bio-accumulators;
- the presence of the species only in one park but they are known as bioindicators/bio-accumulators;
- the presence of the species only in one park and in both reference forests, having knowledge on the species indication status.

Using the knowledge on the species present in central parks and their status, we established the biomonitors under Bucharest conditions. Location data have been collected with GPS Garmin E-Trex Summit for every site and every sample collection on transect, the area of every site has been measured.

We recorded plants population variability (where was suitable) and visible injuries on plants. Based on literature and field observations, the bioindicator species where established.

The bioindicators have been statistically correlated with air pollution data provided by the partners, calculating thus the air accumulation factors (AAF) (Mulgrew & William, 2000) according to the following equation:

$$AAF\ (m^3/g) = PAc\ (mg/g\ dry\ weight)/CA\ (mg/m^3)$$

Where:

PAc = atmospheric contribution of the metal in individuals

CA = concentration of the metal in the atmosphere.

Correlating statistically the heavy metals concentration in soil and plant, we calculated soil accumulation factor (SAF):

$$SAF = PAc\ (mg/kg\ dry\ weight)/SA\ (mg/kg\ dry\ weight)$$

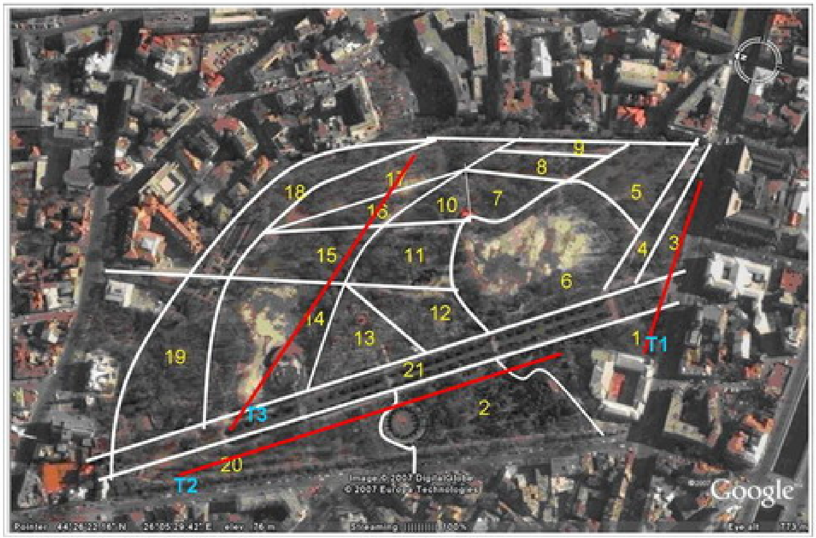
Where:

SA = concentration of the metal in the soil.

The air pollution data provided by partners were limited. Because it was not possible to record the air pollutant *in situ* in parks and forests, to estimate the accumulation factor, we used air pollution data only for Pb from the automatic monitoring stations installed at Cercul Militar, Drumul Taberei, Lacul Morii and Baloteşti forest. The first three stations are at the edge of the area comprising the three central parks, therefore we used the average monthly concentrations from air monitoring stations. Only the data for 2007 had to be used because soil and plants samples have been collected for chemical analysis in 2007. Using air pollution data from 2007 and only leaves from trees and the annual development of perennial herbaceous, we record the heavy metal intake by plant during 2007 vegetation season.

Soil and plants samples have been chemically analysed for heavy metals quantitative evaluation as follows (Figures 1, 2, 3):

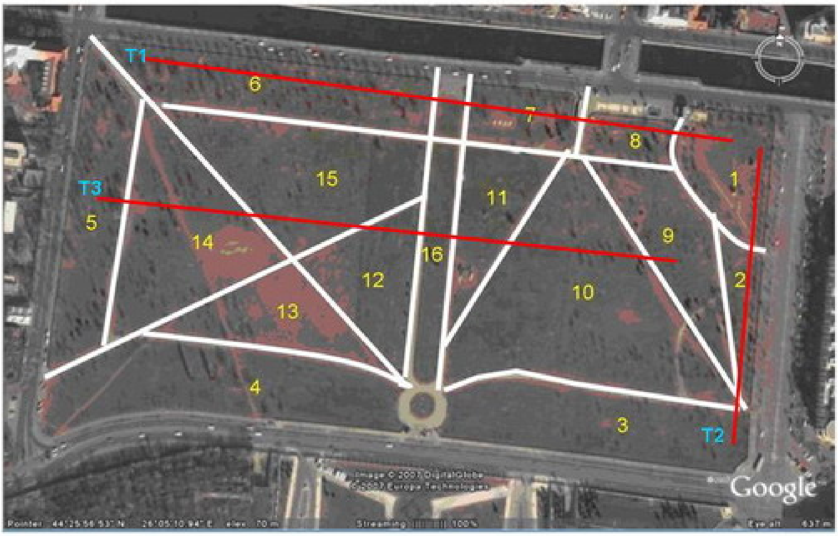
- on transects for soil (T1, T2 respectively T3)
- from sites established for vegetation



site	area (ha)
C1	0,93
C2	1,30
C3	0,27
C4	0,20
C5	0,51
C6	1,38
C7	0,32
C8	0,23
C9	0,21
C10	0,33
C11	0,62
C12	0,65
C13	0,61
C14	1,63
C15	0,46
C16	0,38
C17	0,96
C18	0,71
C19	1,28
C20	1,12
C21	1,33
TOTAL	15,41

C1	C3	C4	C5	C9	C8	C17	C18	C19	C2	C20	C21	C7	C10	C11	C12	C13	C14	C15	C16	C17
Regina Elisabeta Bd.			*Rigas Str.*	*Victor Eftimiu Str.*	*Victor Eftimiu Str – toward middle*	*Sipotul Fantanilor Str.*	*Stirbei Voda Bd.*		*Schitul Magureanu Bd.*		*Schitul Magureanu Bd. - toward middle*	*middle*					*middle - toward Stirbei Voda Bd.*			

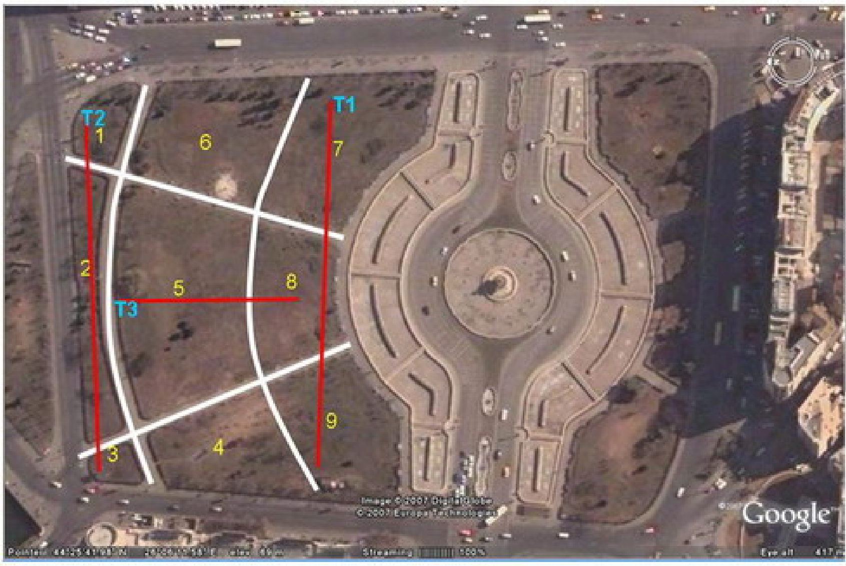
Figure 1: Cişmigiu Park, position of the sites, areas length, streets and boulevards' proximity



site	area (ha)
I1	0,61
I2	0,29
I3	1,11
I4	1,46
I5	1,06
I6	1,02
I7	0,38
I8	0,24
I9	0,83
I10	2,23
I11	0,58
I12	0,66
I13	0,61
I14	1,20
I15	1,28
I16	0,49
TOTAL	14,03

I1	I2	I3	I3	I4	I4	I5	I6	I7	I8	I1	I9	I10	I10	I11	I12	I13	I14	I15
Libertatii Bd.			*Natiunile Unite Bd.*		B.P. Hasdeu Bd.		*Splaiul Independentei Bd.*				*Libertatii Bd.-toward the middle*		middle					

Figure 2: Izvor Park, position of the sites, areas length, streets and boulevards' proximity



site	area (ha)
U1	0,07
U2	0,16
U3	0,03
U4	0,24
U5	0,56
U6	0,32
U7	0,39
U8	0,24
U9	0,32
TOTAL	2,34

U1	U6	U7	U7	U8	U9	U9	U4	U3	U1	U2	U3	U8	U5
I.C. Bratianu Bd.			*Unirii Bd.*			*George Cosbuc Bd.*			*Splaiul Independentei Bd.*			*middle*	

Figure 3: Unirii Park, position of the sites, areas length, streets and boulevards' proximity

On each transect, for the general characterization of vegetation sites, five soil samples have been collected using a Corer device with 10 cm diameter and 10 cm length.

Soil relative humidity have been analyzed using the gravimetric methods.

Soil and plants samples for performing chemical analysis were collected on transects close to all edges of the park, near by the major roads and on transects throughout the middle of the park. Due to the richness of the vegetation at the edge of the park, the air pollution should be diminished through the middle of the park (especially for Cişmigiu Park where plant biodiversity is higher).

Vegetation samples have been separated in two components: washed with double distilled water and unwashed leaves presenting the normal state from the field. The dust deposition on leaves of some species was thick and allowed chemical analysis to estimate metal deposition on the surface of the leaf and the leaf metal content. The analysis of washed leaves samples provided the elemental concentration in leaf tissue. The analysis of unwashed leaves will reflect heavy metal content in dust from leaf surface and leaf tissues. To estimate only the heavy metal content in depositions we calculated the difference:

Content in deposition = content in unwashed leaf – content in washed leaf

The samples were dried, grinded with Planetary Ball Mill PM 100, sieved and kept in plastic bags for further analysis.

RESULTS AND DISCUSSIONS

The availability of heavy metals to organisms in the environment is dependent on a number of factors including pH, and chemical speciation (Jimura et al., 1977). Chemicals are taken up by plants from soils and transferred through the terrestrial food chain (Pascoe et al., 1996). The most important soil factors influencing plant chemical accumulation are soil pH and element concentration. The soil solution is thought to be directly available for uptake by plants (TOXNET, 2008).

Since the main routes of heavy metals absorption for mammals are via respiration and ingestion, factors that are reported to affect dietary heavy metal absorption include age, sex, chemical form, levels of protein, the presence of other elements, etc. (Nriagu, 1981).

Soil chemical and physical properties and chemical elements speciation determine the fate of heavy metals generated by various sources once the elements reach the surface of the soil. Contaminants can persist in soil much longer than in other components of the biosphere. The metals accumulated in soils are depleted slowly by different processes (leaching, plant uptake, erosion, etc.). According to Jimura et al. (1977), the first half-life of heavy metals (calculated for soil in lysimetric conditions), varies greatly:

- Zn – 70-510 years
- Cd – 13-1100 years
- Cu – 310-1500 years
- Pb – 740-5900 years

The complete removal of metallic contaminants from soil is almost impossible.

In surface soils, the permissible level of trace elements, particularly heavy metals, depends on the local conditions. The maximum acceptable concentrations (MAC) and the phytotoxic level of heavy metal concentration is different with different soils and measurements (Table 1).

Table 1: Proposed maximum acceptable concentrations (MAC) of heavy metals (ppm d.w.) in agricultural soils given by various authors (following Kabata-Pendias & Pendias, 1992)

Element	1	2	3	4	5	6	7
Cd	-	5	3-5	-	3	-	8
Cu	23	100	100	125	100	60	100
Pb	20	100	100	400	100	-	200
Zn	110	300	300	250	300	70	400

Legend:
d.w. – dry weight; 1 – acceptable levels for production of healthy food, value given for soluble pool of the element (Goncharuk & Sidorenko, 1986); level considered as phytotoxic: 2 (El-Bassam & Tietjen, 1977), 3 (Kabata-Pendias, 1979), 4 (Kitagishi & Yamane, 1981), 5 (Kloke, 1980), 6 (Kovlskiy, 1974), 7 (Linzon, 1978).

Soil productivity is basic for human survival, therefore the mankind has to maintain the ecological and agricultural functions of the soil.

In Romania, the heavy metals content in different soil types was determined by Răuță et al. (1985) and by Băjescu & Chiriac (1962, 1968) (Table 2).

Table 2: Content of the heavy metals (ppm d.w.) in different soil types (according to Răuță et al., 1985 and Băjescu & Chiriac, 1962, 1968)

Soil type \ Element	Zn		Cd		Cu		Pb	
	range	mean	range	mean	range	mean	range	mean
Podzols and sandy soil	25-188	61	0,5-1,6	0,9	3-34	18	-	-
Loamy and clay soils	37-101	75	0,3-1,4	0,7	9-44	27	14-33	21
Kastanozems and brown soils	27-113	57	-	-	8-32	17	8-20	15
Various soils	35-115	61	-	-	-	-	-	-
Soil polluted by metal-processing industry*	3000		12		1387		3170	

* Maximum of content

Bucharest city, covering 260 km^2 of the central area of the Romanian Plain, has a complex soil cover formed by eight types: fluviosols, regosols, entiantrosols, chernozems, preluvosols, luvosols, gleiosols and stagnosols. Entiantrosols has been entirely anthropic occupying 48.5% of city area predominately in city centre where most of the soil is covered with asphalt and buildings. The other predominant soil types (clay-loamy and eu-bazic), mainly occurring outskirt and half-central areas of the city, are developed in semi-natural conditions (Lăcătuşu et al., 2008).

The origin of street dust in Bucharest is mainly accessory (intra-city) and less elementary (from external sources like: rivers margins, natural river terraces with loess levels, degraded soils, etc.). The highest values of soil Cu content are in the central area of the city and in the industrial areas. For Zn, high values have been found in Eastern and Southern Bucharest, in the centre (700 mg/kg) and belt line of the city, near by arterial roads. In the east and centre of the city, Lăcătuşu et al. (2008) recorded the highest values of Pb content in the soil.

Air pollution data provided by Bucharest Environmental Protection Agency show the air average annual Pb concentration (μg/m^3 = mg/kg = ppm) decreasing along 2004-2008 in different sites from Bucharest and rural area (Măgurele, Baloteşti) (Figure 4A). In 2007, when soil, plant and animal samples have been collected, the mean monthly Pb concentration in Bucharest and Baloteşti (as reference forest) is variable along the year, and as we expected the values are lower in Baloteşti Forest comparing with the city (Figure 4B).

According to Council Directive 1999/30/EC, and Romanian Government Order 592 from 25 June 2002 the annual limit value of Pb release in the atmosphere is 0.5 μg/m^3 for the protection of human health.

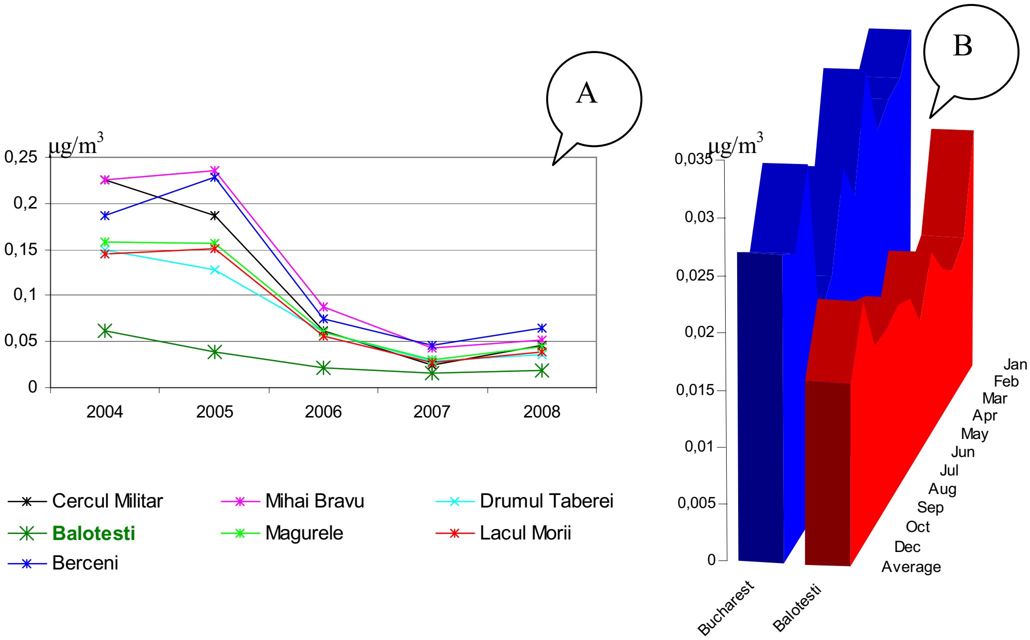


Figure 4: Air average annual Pb concentration (μg/m^3) in:
A: along 2004-2008 in different sites from Bucharest and rural area (Măgurele, Baloteşti);
B: in 2007, from January to December in Bucharest (entire city) and Baloteşti (as reference forest)

The natural vegetation had mainly disappeared, being replaced by planted species (especially trees brought from China, Japan, America, etc.). Remains of the natural vegetation adapted to the modified conditions of the city: either fertilisation or lack of the nutrients, changes in soil pH, increased temperature, pollution, etc.

Soil relative humidity in parks is lower than in forests; in parks, the asphalt or concrete alleys or/and paths without vegetation and surrounding high circulated boulevards heat up the atmosphere increasing the water evaporation from the soil (Figure 5).

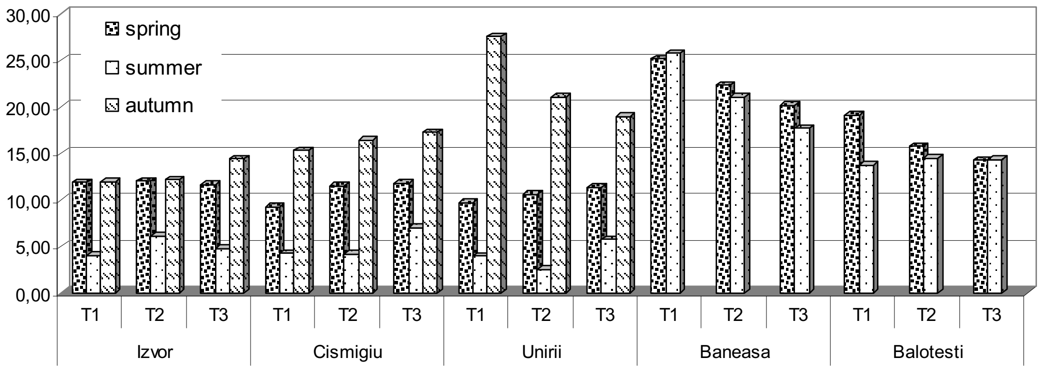


Figure 5: Soil relative humidity (%) on transects in packs and forests in 2007

During summer, the soil is cracked and nude or with scarce vegetation; where vegetation exists, it is dry (till late in September or even October), but in spring and autumn, the vegetation is green with perennial plant population having better development in November. We can argue that the plants changed their phenology in the city.

During the autumn, when the environmental conditions are more suitable to plant life, late flowering and individuals with vegetative spread (clonal plants) were observed occupying the former bare soil from summer: *Achillea millefolium, Agrostis stolonifera, Cynodon dactylon, Dactylis glomerata, Polygonum aviculare, Trifolium pratense, Trifolium repens, Potentilla reptans* etc.

For instance, *Fragaria viridis* flowers usually in May – June but we found fruits in November 2007. Perennial *Phleum pratense* flowers normally in June-August; we found a good development of the population in November 2007 following the mowing of the entire vegetation and very hot period in summer, when the vegetation cover was represented by scarce individual of *Cichorium intybus* and *Medicago sativa*. Other annual relatives of *Phleum*, for instance *Setaria viridis*, develop together in the same period of year, when abiotic factors (including soil and air humidity) offer them the optimal conditions for growing and development.

The chemical analysis of the soil revealed that the content in heavy metal is very different in different sites from all three parks.

In Cişmigiu Park, the highest values of Zn have been found on transect 1 close to Regina Elisabeta Boulevard, especially in C21 site where it is only the lawn without any tree curtain toward the boulevard (Figure 6a). The samples collected by or from the middle of the park have a lower content in Zn. The same behaviour have Pb and Cu. Cd had very low values. These values exceeding 100 mg/kg for Cu and Zn, 50 mg/kg for Pb and 5 mg/kg for Cd reveals that the heavy metals are accumulated in Cişmigiu park soil, especially Zn (Figure 6b).

In Izvor Park, the highest values of heavy metals in soil have been found on transect 2, close to Libertății Bulevard, showing Zn and Pb accumulation in the soil. These values of heavy metals accumulation in the soil are lower then the values of heavy metal accumulation in Cişmigiu soil.

In Unirii Park, the highest values of heavy metals have been found on transect 3, situated in the middle of the park. These values are lower then the values found in the soil from Cişmigiu Park.

We suspect that In Cişmigiu Park, where plant diversity is high, heavy metals have been accumulated in soil due to wet or dry deposition.

In Unirii and Izvor Parks, there is a possibility that heavy metals re-enter in the particles suspended in the air due to scarce vegetation and to the paths created by humans, trampled vegetation from both parks. The soil in these parks is sandy and dry clay and every wind blow brings in the air a lot of dust.

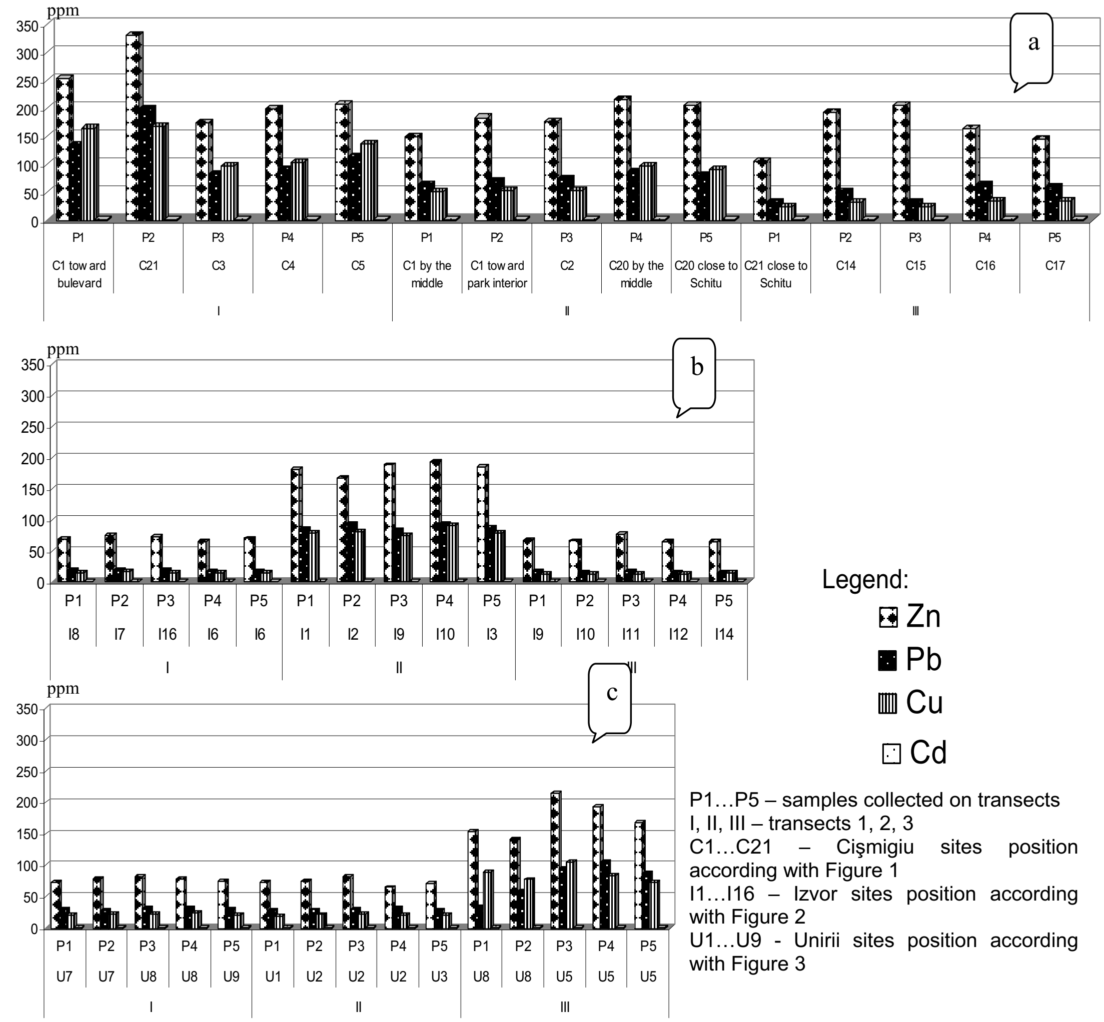


Figure 6: Heavy metals content (ppm d.w. = mg/kg d.w.) in soil from Cişmigiu (a), Izvor (b) and Unirii (c) parks in 2007

The mean values of heavy metals content in the soils of the central parks (Table 3) are:

- about two times lower than the values fund by Lăcătuşu et al. (2008) on the streets in central Bucharest (700 mg/kg for Zn);
- higher than acceptable concentrations (MAC) of heavy metals in agricultural soils acceptable levels for production of healthy food given by Goncharuk & Sidorenko (1986) (Pb – 20 mg/kg; Zn – 110 mg/kg). The average Pb and Cu concentration in Cişmigiu Park is four times higher than MAC and from Izvor and Unirii Parks is almost two times higher than MAC. Zn concentration is two times higher than MAC in Cişmigiu Park (see also Table 1);

- within the range considered as phytotoxic given by different authors according to Kabata-Pendias and Pendias (1992): Zn: 110 – 300(400) mg/kg; Pb: 20 - 100 (200) mg/kg; Cu: 23-100 mg/kg; Cd: 3-8 mg/kg (see also Table 1);
- higher than the range of content of the heavy metals (ppm dw) in different soil types according to Răuță et al. (1985) and Băjescu & Chiriac (1962, 1968) (see also Table 2);

The range values show differences between max and min values from different site, their diversity on heavy metal contain. Zn has higher values in Cişmigiu comparing to Izvor and Unirii and also comparing to the values of content in different types of soils.

Table 3: Mean value and range of heavy metals (mg/kg = ppm d.w.) in the soil of central parks

Element	Cişmigiu		Unirii		Izvor	
	average	range	average	range	average	range
Cd	0,79	0,47 - 1,21	0,48	0,36 - 0,8	0,59	0,44 - 0,78
Cu	77,59	24,6 - 168,5	43,02	19,16 - 105	35,88	12,32 - 89,74
Pb	82,16	32,3 - 199,8	44,93	27,68 - 104,6	40,27	15,02 - 92,87
Zn	193,60	104,6 - 330,3	107,96	64,81 - 214,5	106,84	63,94 - 194

Cu and Pb also have higher values in Cişmigiu comparing to Unirii and Izvor and also to the values of content in different types of soils. We argue that due to Cişmigiu Park structural complexity, aerial depositions (wet and dry) are kept at the soil level, the high diversity vegetation not allowing the dust particles together with pollutant to re-suspend in the air.

Calculating soil accumulation factor in plants based on heavy metal analysis of plants and soil from every park, we can argue that the metal uptake from soil is different with different plants species (Table 4).

Table 4: Soil accumulation factor (SAF) for analysed heavy metals in plants from central parks

Species	Site	Pb	Cd	Cu	Zn
Trees & shrubs					
Ailanthus altissima (Miller) Swingle	I5	0,058	0,593	0,085	0,108
Amygdalus communis L.	C4	0,042	0,481	0,001	0,048
	C8	0,024	0,127	0,001	0,061
Berberis julianae C.K. Schneider	C3	0,050	0,405	0,001	0,078
Betula pendula Roth	C2	0,010	0,127	0,001	0,075
Buxus sempervirens L.	C4	0,093	0,380	0,002	0,081
	C17	0,024	0,468	0,001	0,055
	C18	0,027	0,139	0,007	0,048
Catalpa bignonioides Walter	C4	0,015	1,000	0,001	0,046
	C9	0,045	0,177	0,002	0,070
Cornus sanguinea L.	C3	0,046	0,278	0,001	0,033
	C8	0,041	0,304	0,001	0,071
	C17	0,029	0,671	0,000	0,040
	C18	0,018	0,342	0,003	0,035
	U4	0,050	0,521	0,073	0,091
Corylus avellana L.	C2	0,072	0,481	0,003	0,147
Corylus colurna L.	C1	0,051	0,241	0,001	0,065
Euphorbia myrsinites L.	C3	0,040	0,443	0,001	0,064
Fraxinus americana L.	U5	0,037	0,583	0,050	0,061
Fraxinus angustifolia Vahl.	U6	0,035	0,458	0,060	0,070

Fraxinus excelsior L.	C2	0,007	0,316	0,001	0,060
	I14	0,066	0,763	0,142	0,073
Gleditsia triacanthos L.	C6	0,041	0,127	0,001	0,080
Hedera helix L.	C8	0,019	0,127	0,000	0,090
	C17	0,016	0,570	0,000	0,102
	C19	0,012	0,734	0,003	0,043
	I2	0,082	0,475	0,084	0,207
Ligustrum vulgare L.	U3	0,039	1,000	0,080	0,118
Mahonia aquifolium (Pursh) Nutt.	C3	0,042	0,203	0,002	0,090
Malus medzweltzkyana Dieck	C3	0,037	0,253	0,001	0,036
	C4	0,022	0,430	0,001	0,049
Morus alba L.	C2	0,021	0,329	0,001	0,051
Paulownia tomentosa (Thunb.) Stend.	I2	0,058	0,169	0,222	0,081
Pinus sylvestris L.	U7	0,024	0,563	0,024	0,132
	I9	0,036	0,373	0,055	0,086
Platanus hispanica Miller ex. Muench.	I15	0,057	0,305	0,048	0,074
Populus nigra L. cv. *italica* Moench.	I14	0,123	0,797	0,102	0,416
	C3	0,014	0,418	0,001	0,059
Quercus robur L.	U8	0,049	0,583	0,103	0,116
	I4	0,087	1,407	0,175	0,159
Quercus robur L. - regeneration	I4	0,089	0,373	0,192	0,097
Quercus rubra L.	C3	0,041	0,405	0,002	0,104
	C17	0,041	0,671	0,001	0,109
	U8	0,028	0,542	0,077	0,065
	I4	0,064	0,475	0,033	0,057
	I13	0,036	0,644	0,111	0,191
Rhus hirta (L.) Sudworth	U5	0,047	0,688	0,057	0,050
Rosa canina L.	I3	0,073	0,678	0,157	0,110
Rubus caesius L.	C18	0,028	0,418	0,003	0,038
Sambucus nigra L.	C15	0,019	0,823	0,003	0,049
Sophora japonica L.	C9	0,007	0,278	0,000	0,035
Taxus baccata L.	C18	0,021	0,354	0,002	0,079
Thuja orientalis L.	C3	0,027	0,165	0,001	0,059
	C6	0,017	0,190	0,001	0,061
	C9	0,106	0,709	0,001	0,090
	C10	0,018	0,506	0,001	0,062
Tilia cordata Miller	U9	0,089	0,417	0,167	0,108
	I6	0,197	0,593	0,170	0,172
	I7	0,222	1,153	0,293	0,191
Tilia tomentosa Moench.	C8	0,037	0,291	0,001	0,049
	I14	0,088	0,492	0,099	0,085
Ulmus glabra Hudson	I5	0,059	0,797	0,155	0,144
Ulmus minor Miller	C7	0,042	0,278	0,001	0,076
	C17	0,065	0,506	0,001	0,066
Viburnum rhytidophyllum Hemsl.	C18	0,031	0,215	0,005	0,100
Herbaceous					
Achillea millefolium L.	I10	0,010	0,390	0,129	0,179
Chelidonium majus L.	C19	0,025	0,671	0,140	0,033
Cynodon dactylon (L.) Pers.	C6	0,003	0,658	0,043	0,089
	I10	0,025	0,322	0,078	0,050
Geum urbanum L.	C1	0,101	0,215	0,303	0,094
Glechoma hederacea L.	C18	0,011	0,481	0,042	0,091
Lamium amplexicaule L.	C19	0,033	0,582	0,940	0,030
Medicago sativa L.	I14	0,082	0,814	0,086	0,102
Phragmites australis (Cav.) Steudel.	I5	0,057	0,407	0,052	0,112
Plantago lanceolata L.	C1	0,036	0,873	0,048	0,038
	C18	0,015	0,190	0,037	0,054

Polygonum aviculare L.	I12	0,006	0,322	0,067	0,154
	U5	0,026	0,667	0,084	0,144
Portulaca oleraceaL.	I2	0,022	0,339	0,040	0,081
	U9	0,014	2,125	0,041	0,124
Setaria viridis (L.) Beauv.	C1	0,015	0,342	0,035	0,169
	I1	0,051	1,729	0,073	0,212
Taraxacum officinale Weber ex. Wiggers	C1	0,040	0,329	0,088	0,070
	C17	0,013	0,127	0,021	0,040
	C19	0,033	0,278	0,003	0,020
	C2	0,011	0,215	0,015	0,032
	C3	0,039	0,203	0,060	0,053
Trifolium repens L.	C2	0,007	0,304	0,024	0,040
Veronica arvensis L.	C1	0,005	0,380	0,082	0,067

In the same park, the uptake of the metals is different both among sites and due to distance to the main traffic road. For instance, *Buxus sempervirens* L. individual analysed from Cişmigiu Park, accumulate more Pb and Zn from the site near by traffic road than, the individuals from inside parks. The aerial deposition on leaves is also higher in the site closer to the traffic road (Figure 9). Table 6 highlights plant species from different sites and soil accumulation factor.

For Pb. the highest values of SAF are for: *Populus nigra* L. cv. *italica* Moench. (I14 - 0.123). *Tilia cordata* Miller (I6 - 0.197; I7 - 0.222); *Thuja orientalis* L. (C9 - 0.106); *Geum urbanum L.* (C1 - 0.101) all of these species located in sites close to the major traffic roads.

Catalpa bignonioides Walter (C4 – 1); *Ligustrum vulgare* L. (U3 – 1); *Quercus robur* L. (I4 - 1.407); *Tilia cordata* Miller (I7 - 1.153); *Portulaca oleracea L.* (U9 - 2.125); *Setaria viridis (L.) Beauv.* (I1 - 1.729) species have the highest Cd accumulation in all three parks.

Cu accumulation is higher at the following species: *Fraxinus excelsior* L. (I14 - 0.142); *Paulownia tomentosa* (Thunb.) Stend. (I2 - 0.222); *Populus nigra* L. cv. *italica* Moench. (I14 - 0.102); *Quercus robur* L. (U8 - 0.103; I4 - 0.175); *Quercus robur L. – regeneration (*I4 - 0.192); *Quercus rubra* L. (I13 - 0.111); *Rosa canina* L. (I3 - 0.157); *Tilia cordata* Miller (U9 - 0.167; I6 - 0.170; I7 - 0.293); *Ulmus glabra* Hudson (I5 - 0.155); *Achillea millefolium* L. (I10 - 0.129).. The highest Cu accumulation is in the herbaceous species from Cişmigiu Park: *Lamium amplexicaule* L. (C19 - 0.940) close to Ştirbei Vodă Bd. and *Geum urbanum* L. (C1 - 0.303) close to Regina Elisabeta Bd.

Zn accumulation is higher at the following species: *Ailanthus altissima* (Miller) Swingle (I5 - 0.108); *Corylus avellana* L. (C2 - 0.147); *Hedera helix* L. (C17 - 0.102; I2 - 0.207); *Ligustrum vulgare* L. (U3 - 0.118); *Pinus sylvestris* L. (U7 - 0.132); *Quercus robur* L. (U8 - 0.116; I4 - 0.159); *Quercus rubra* L. (C3 - 0.104; C17 - 0.109; I13 - 0.191); *Rosa canina* L. (I3 - 0.110); *Tilia cordata* Miller (U9 - 0.108; I6 - 0.172; I7 -0.191); *Ulmus glabra* Hudson (I5 - 0.144); *Achillea millefolium* L. (I10 - 0.179); *Medicago sativa* L. *(*I14 - 0.102) ; *Phragmites australis* (Cav.) Steudel. *(*I5 - 0.112); *Polygonum aviculare L. (*I12 - 0.154; U5 - 0.144); *Portulaca oleracea L. (*U9 - 0.124). The highest values have been found at *Populus nigra* L. cv. *italica* Moench. (I14 - 0.416) and *Setaria viridis* (L.) Beauv. (C1 - 0.169; I1 - 0.212).

The metal concentration in plants is affected by prevailing weather conditions, the water solubility of deposited metal-containing particulates, the nature of the plant surface, plants root uptake of the metals, etc. (Bache et al., 1991).

Using the list of plant species diversity from the three parks, we recorded the behaviour of plant species at different pollutant according to various authors (Table 5).

Table 5: Plant species present in studied sites and their behavior at different pollutant according to various authors

Species	Pb		Cd	Cu	Zn	heavy metal			References
	sensible	resistant	resistant			resistant	accumulator	sensitive	
Trees									
Acer platanoides L.					+				Kovacs et al., 1982
Acer pseudoplatanus L.			+	+	+	+		+	Grill et al., 1988; Watmough & Dickinson, 1995; Günthardt-Goerg & Vollenweider, 2002; Ionescu et al., 1973
Aesculus hippocastanum L.						+	+		Tomašević et al., 2008; Ionescu et al., 1973
Ailanthus altissima (Miller) Swingle						+			Gatti, 2008
Betula pendula Roth								+	Kovacs, 1992c
Corylus colurna L.							+	+	Tomašević et al., 2008; Ionescu et al., 1973
Fraxinus excelsior L.								+	Kovacs, 1992c; Ionescu et al., 1973
Gleditsia triacanthos L.	+								Ionescu et al., 1973
Juglans regia L.	+								Ionescu et al., 1973
Morus alba L.	+								Ionescu et al., 1973
Pinus sylvestris L.				+					Helmisaari et al., 1995; Ionescu et al., 1973
Platanus hispanica Miller ex. Muench.									Ionescu et al., 1973
Populus nigra L.						+	+		Kovacs, 1992c; Ionescu et al., 1973; Baranowska et al., 2002
Prunus cerasifera (Caririere) C.K.Schneid.	+								Ionescu et al., 1973
Quercus robur L.							+		Kovacs, 1992c
Robinia pseudoacacia L.	+				+	+			Kovacs, 1992c; Kovacs et al., 1982; Ionescu et al., 1973
Salix alba L.							+		Kovacs, 1992c
Sophora japonica L.	+								Kovacs, 1982
Tilia cordata Miller								+	Kovacs, 1992c; Ionescu et al., 1973
Tilia platyphyllos Scop.	+								Ionescu et al., 1973
Tilia tomentosa Moench.	+			+	+		+		Kovacs et al., 1982; Kovacs, 1992c
Shrubs – trees									
*Sambucus nigra*L.							+		Kovacs, 1992c
Shrubs									
Syringa vulgaris L.	+								Ionescu et al., 1973
Herbaceous									
Achillea millefolium L.						+			Pilegaard & Johnsen, 1984
Festuca rubra L.								+	Pilegaard & johnsen, 1984
Phragmites australis (Cav.) Steudel.	+						+		Kufel, 1978; Ali et al., 2008
Silene vulgaris (Moench.) Garke				+					Antonovics et al., 1971
Taraxacum officinale Weber ex. Wiggers	+		+	+	+				Czarnowska & Milewska, 2000; Baranowska et al., 2002
Urtica dioica L.	+		+	+	+				Ionescu et al., 1973; Baranowska et al., 2002

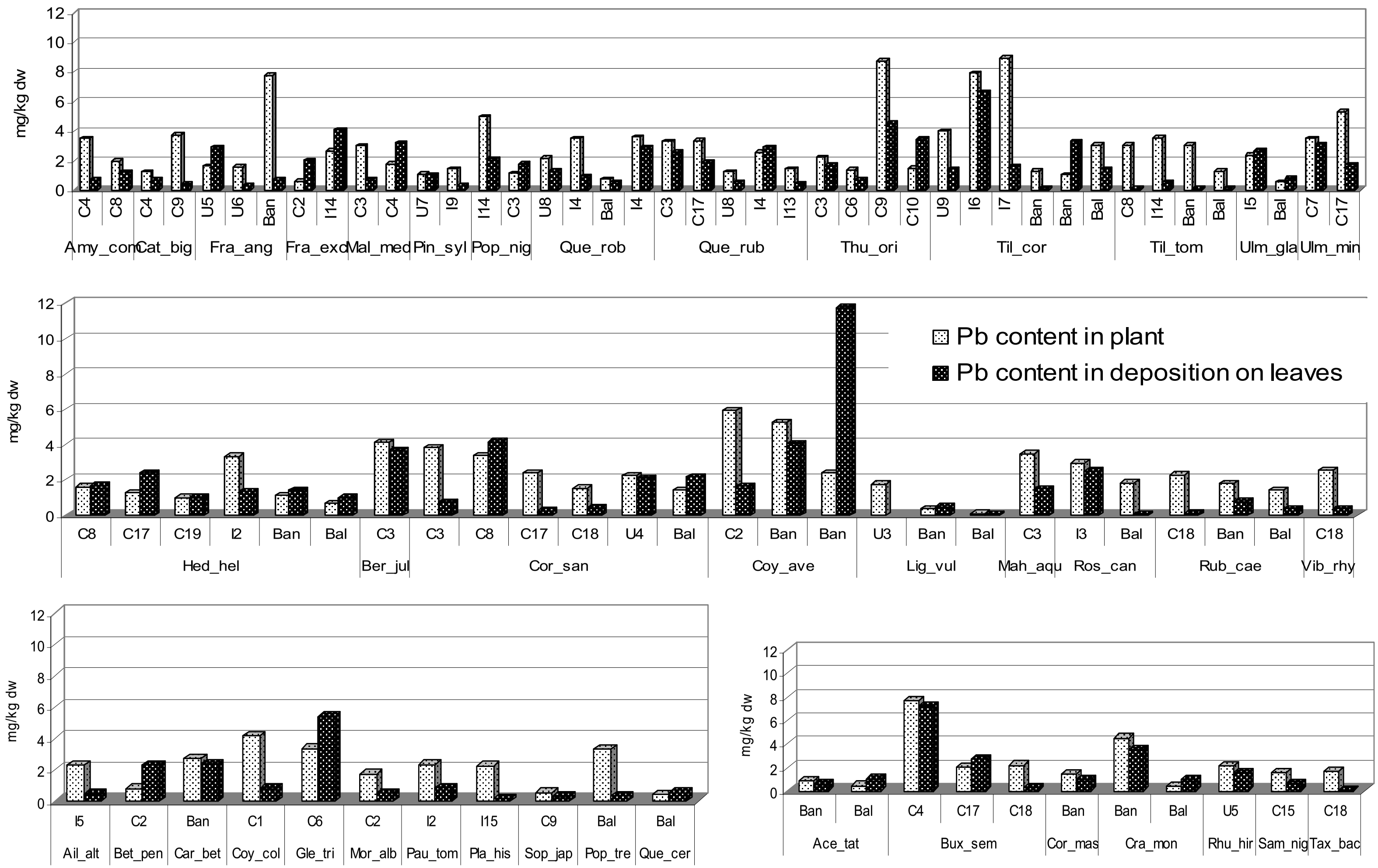


Figure 7: Pb content in plants tissues and in dusts from trees and shrubs leaves.

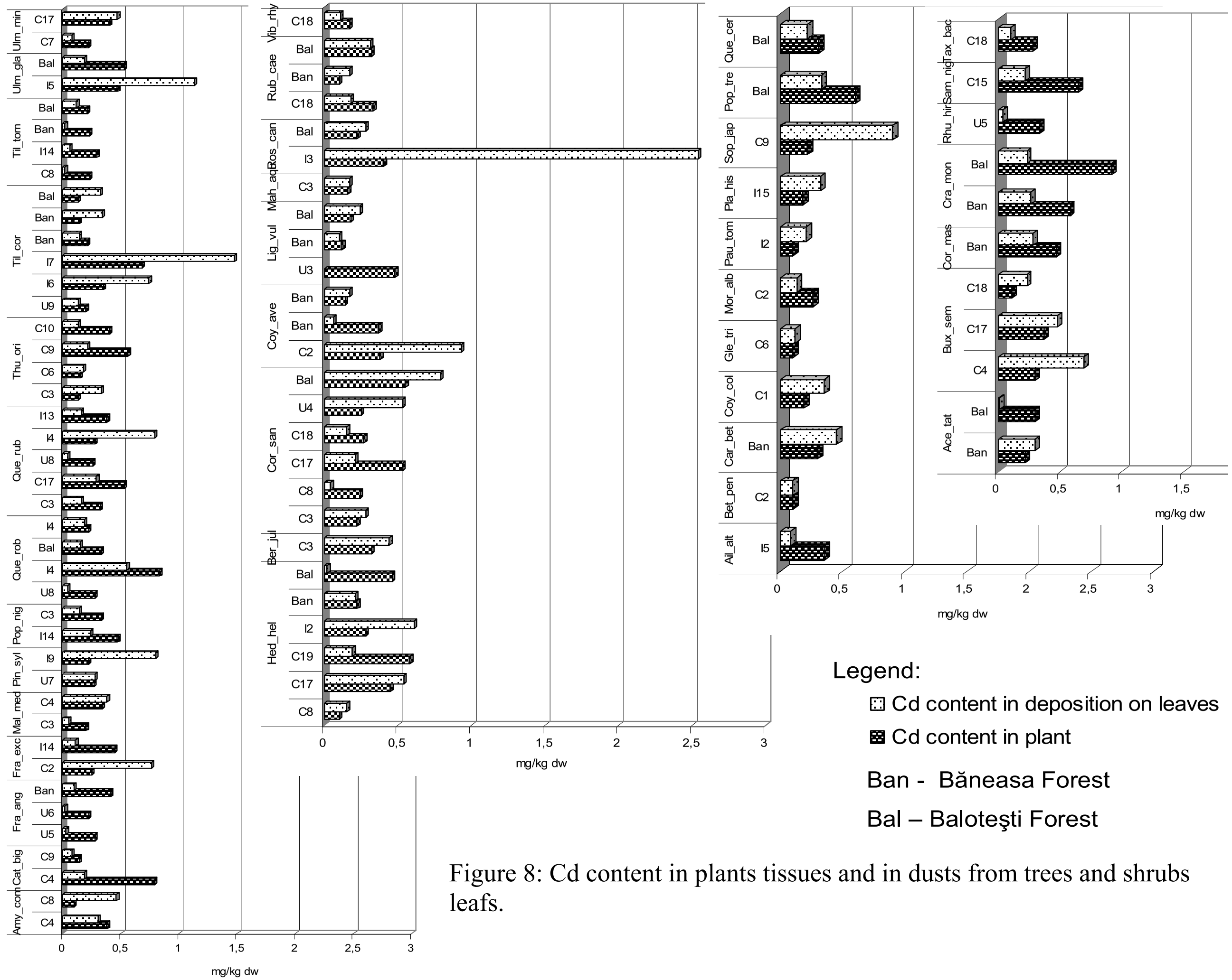


Figure 8: Cd content in plants tissues and in dusts from trees and shrubs leafs.

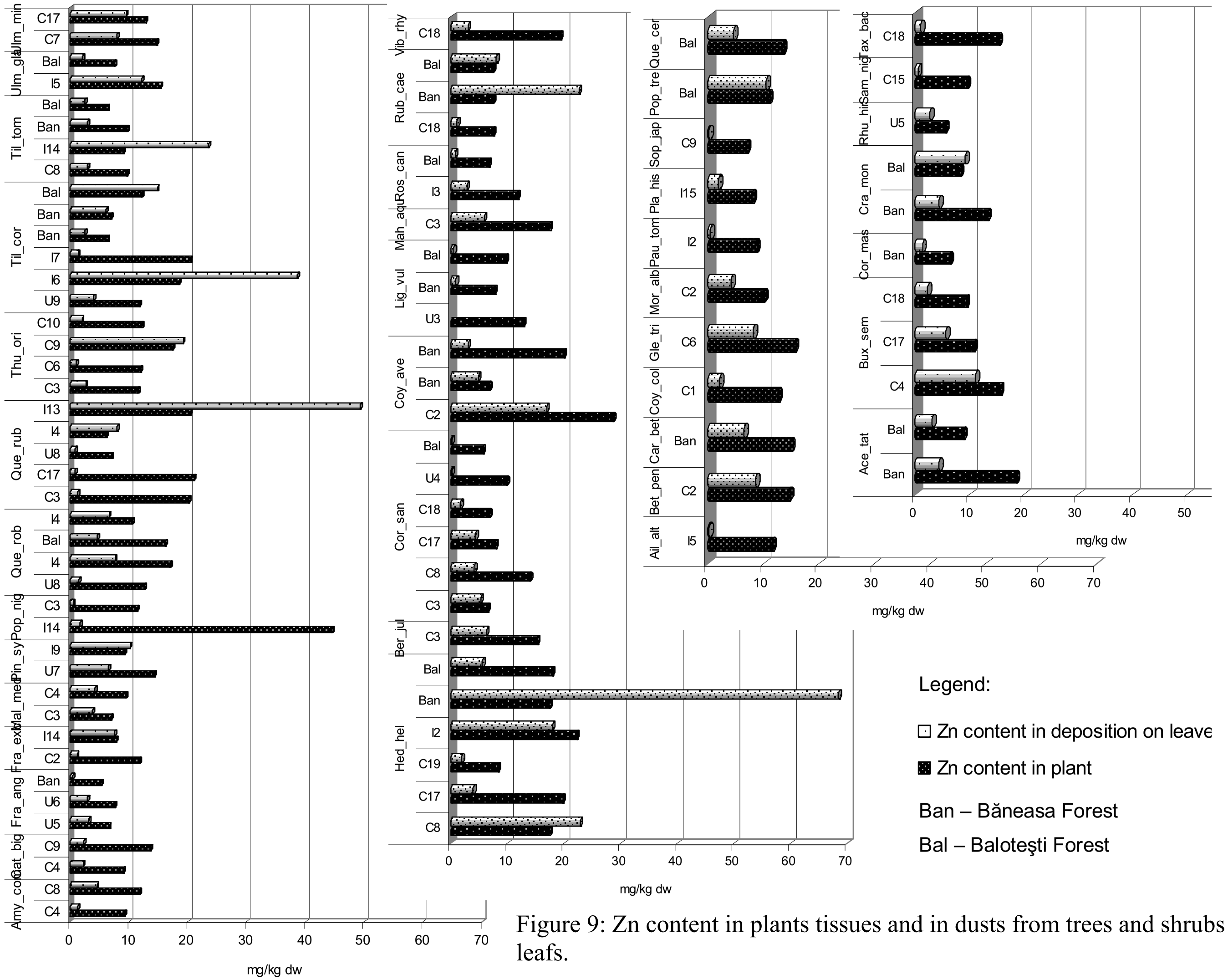


Figure 9: Zn content in plants tissues and in dusts from trees and shrubs leafs.

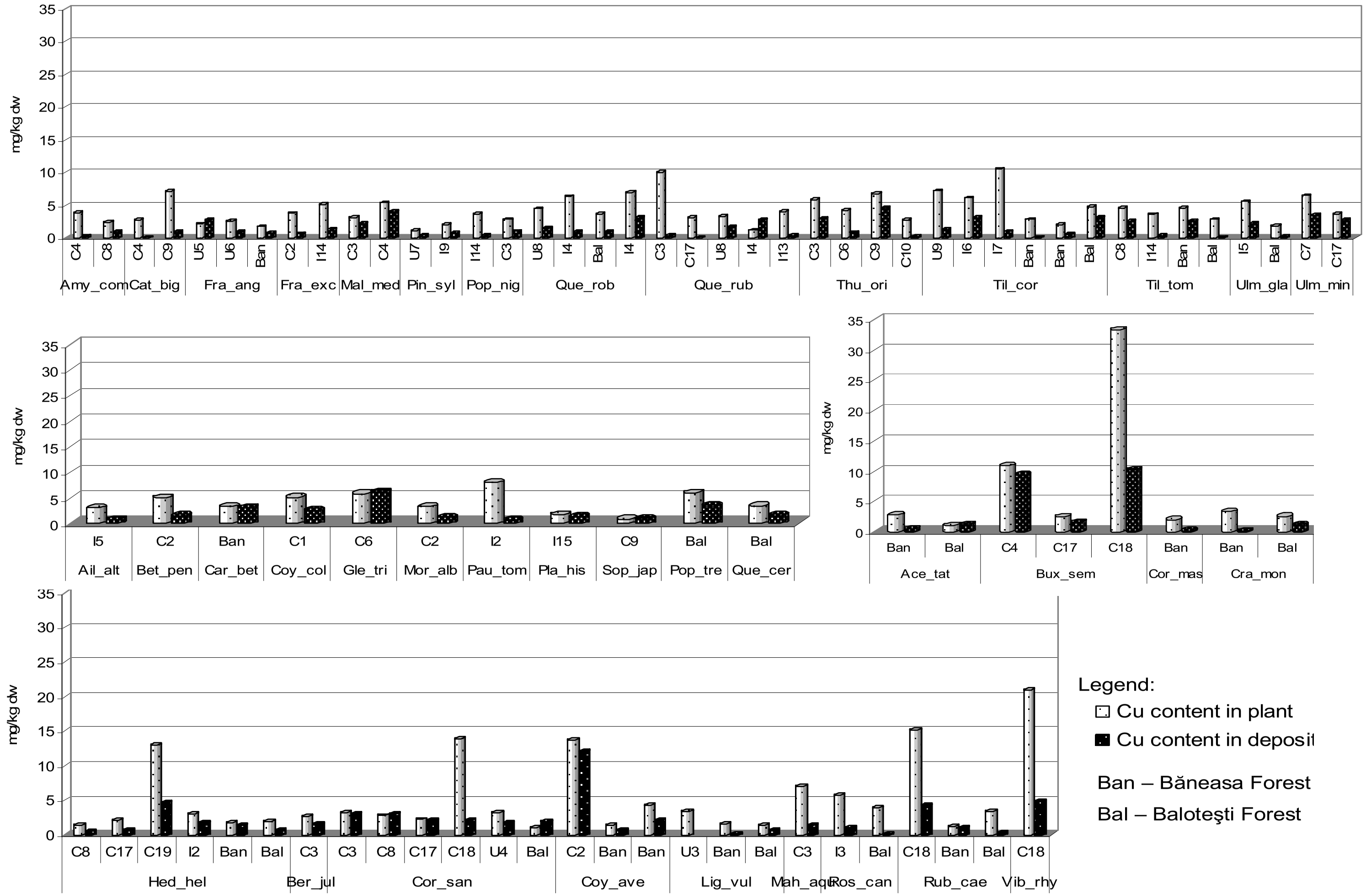


Figure 10: Cu content in plants tissues and in dusts from trees and shrubs leaves

Following more field and literature researches new data might appear, but we can argue that *Achillea millefolium* L., *Populus nigra* L, *Quercus robur L.* are heavy metal resistant and bio-accumulator species, showing the particular conditions of Bucharest central park pollution.

The highest value of Pb concentration in plants tissues is in *Fraxinus angustifolia* from Băneasa Forest, *Thuja orientalis* from Cişmigiu Park and *Tillia cordata* from Izvor Park. Higher than for other species is Pb concentration in dust on the leaves of *Tillia cordata* from Izvor Park and *Coryllus avelana* from Băneasa Forest. These two species have broad wide surface leaves.

Cd concentration in deposition on leaves is highest in *Rosa canina* and *Tillia cordata* from Izvor Park (Figure 7). *Quercus robur* from Izvor Park and *Crataegus monogyna* from Baloteşti Forest have the highest Cd concentration in their tissues.

Zn concentration in plants tissues and in deposition on leaves is high in *Populus nigra* from Izvor Park and *Coryllus avelana* from Cişmigiu Park (Figure 8).

Cu concentration in plants tissues and in deposition on leaves is high in *Buxus sempervirens* and *Viburnum rhytidophyllum* from Cişmigiu near by Ştirbei Vodă Boulevard (Figure 9).

Metal uptake in higher vascular plants takes place through their root system, additionally through the leaves and, therefore, it is difficult to distinguish whether the accumulated elements originate from the soil or from the air (Harrison & Johnston, 1987; Verma & Singh, 2006).

The heavy metal concentration in plants tissues as well as in the soil is affected by atmospheric trace metal concentrations.

Knowing Pb concentration in air for several monitoring stations from Bucharest, we calculated air accumulation factor (AAF) in the tissues and in the dust from the analyzed plants growing in Bucharest's central parks (Table 6). As have shown above, we have analyzed all the heavy metals but we couldn't calculate AAF, not having their concentration in the air.

Because in some species the chemical analysis used the leaves with dust on them (unwashed leaves), we can show that some species have a higher heavy metal content then others (Table 6): *Hedera helix* L. accumulate Zn, *Parthenocissus tricuspidata* (Sieb. et Zucc.) Planch. and *Morus nigra* L. accumulate Cu.

Table 6: Total heavy metal in and on unwashed leaves of some species

Species	**Site**	**Pb**	**Cd**	**Cu**	**Zn**
Parthenocissus tricuspidata (Sieb. et Zucc.) Planch.	C3	6,03	0,29	14,41	18,75
Hedera helix L.	C3	3,41	0,25	4,06	38,66
	C6	1,42	0,10	5,00	27,70
Cornus sanguinea L.	C4	3,60	0,75	6,30	17,34
Tilia cordata Miller	C11	6,74	0,13	9,17	15,29
Morus nigra L.	C1	6,35	0,12	16,53	24,08
Aesculus hippocastanum L.	C4	9,50	0,15	7,04	20,84
Cornus mas L.	C3	6,52	0,13	6,65	11,68

Air accumulation factor is very variable with plant species and sites (Table 7). The analyzed species from reference forests (Baloteşti and Băneasa Forests) and central parks, we have found the following species that present a high AAF: *Berberis julianae* C.K. Schneider (C3 - 0.111 m^3/kg in plants tissue); *Buxus sempervirens* L. C4 - 0.208 m^3/kg in plants tissue; C4 - 0.195 m^3/kg in deposition); *Catalpa bignonioides* Walter (C9 - 0.101 m^3/kg in plants tissue); *Cornus mas* L. (C3 - 0.103 m^3/kg in plants tissue; C8 - 0.112 m^3/kg); *Corylus avellana* L. (C2 - 0.160 m^3/kg in plants tissue; Ban - 0.142 m^3/kg in plants tissue; 0.109 m^3/kg and 0.316 m^3/kg in deposition); *Corylus colurna* L. (C1 - 0.113 m^3/kg in plants tissue); *Crataegus monogyna* Jacq. (*Ban* - 0.122 m^3/kg in plants tissue); *Fraxinus angustifolia* Vahl. (Ban - 0.210 m^3/kg in plants tissue); *Fraxinus excelsior* L. *(*I14 - 0.111 m^3/kg in deposition); *Populus nigra* L. cv. *italica* Moench. *(*I14 - 0.134 m^3/kg in plants tissue); *Thuja orientalis* L. (C9 - 0.236 m^3/kg in plants tissue); 0.122 m^3/kg in deposition); *Tilia* *cordata* Miller *(*U9 - 0.108 m^3/kg in plants tissue; I6 - 0.214 m^3/kg in plants tissue and 0.178 m^3/kg in deposition; I7 - 0.241 m^3/kg in plants tissue); *Ulmus minor* Miller (C17 - 0.144 m^3/kg in plants tissue).

We can say that these species are accumulators of heavy metal pollutants from the air (bio-accumulators).

Table 7: Pb air accumulation factor (m^3/kg) in the tissues and in the dust from analyzed plants from central parks and reference forests.

Species	Abbreviation	Site	In plants	In depositions	State
Trees & shrubs					
Acer tataricum L.	*Ace_tat*	*Ban*	0,024	0,015	Cultivated
		Bal	0,013	0,028	
Ailanthus altissima (Miller) Swingle	Ail_alt	I5	0,063	0,012	Native, cultivated
Amygdalus communis L.	Amy_com	C4	0,094	0,019	Cultivated
		C8	0,054	0,033	
Berberis julianae C.K. Schneider	Ber_jul	C3	0,111	0,099	Cultivated
Betula pendula Roth	Bet_pend	C2	0,022	0,062	Native, cultivated
Buxus sempervirens L.	Bux_sem	C4	0,208	0,195	Cultivated
		C17	0,054	0,074	
		C18	0,059	0,009	
Carpinus betulus L.	*Car_bet*	*Ban*	0,074	0,064	Native, cultivated
Catalpa bignonioides Walter	Cat_big	C4	0,034	0,019	Cultivated
		C9	0,101	0,011	
Cornus mas L.	*Cor_mas*	*Ban*	0,038	0,026	Native, cultivated
Cornus sanguinea L.	Cor_san	C3	0,103	0,020	Native, cultivated
		C8	0,091	0,112	
		C17	0,065	0,007	
		C18	0,041	0,011	
		U4	0,061	0,056	
		Bal	0,038	0,058	
Corylus avellana L.	Coy_ave	C2	0,160	0,044	Native, cultivated
		Ban	0,142	0,109	
		Ban	0,065	0,316	
Corylus colurna L.	Coy_col	C1	0,113	0,022	Cultivated
Crataegus monogyna Jacq.	*Cra_mon*	*Ban*	0,122	0,094	Native
		Bal	0,010	0,027	
Euphorbia myrsinites L.	Eup_myr	C3	0,088	0,003	Cultivated
Fraxinus americana L.	Fra_ame	U5	0,045	0,078	Cultivated
Fraxinus angustifolia Vahl.	Fra_ang	U6	0,042	0,009	Native
		Ban	0,210	0,019	
Fraxinus excelsior L.	Fra_exc	C2	0,016	0,055	Native, cultivated
		I14	0,072	0,111	
Gleditsia triacanthos L.	Gle_tri	C6	0,091	0,145	Cultivated
Hedera helix L.	Hed_hel	C8	0,043	0,045	Native, cultivated
		C17	0,035	0,065	
		C19	0,027	0,027	
		I2	0,090	0,036	
		Ban	0,031	0,039	
		Bal	0,018	0,027	
Ligustrum vulgare L.	Lig_vul	U3	0,047	0,000	Native, cultivated
		Ban	0,010	0,013	
		Bal	0,003	0,002	
Mahonia aquifolium (Pursh) Nutt.	Mah_aqu	C3	0,094	0,040	Cultivated
Malus medzweltzkyana Dieck	Mal_med	C3	0,082	0,021	Cultivated
		C4	0,048	0,087	
Morus alba L.	Mor_alb	C2	0,047	0,014	Cultivated
Paulownia tomentosa (Thunb.) Stend.	Pau_tom	I2	0,064	0,023	Cultivated

Pinus sylvestris L.	Pin_syl	U7	0,030	0,028	Native, cultivated
		I9	0,039	0,008	
Platanus hispanica Miller ex. Muench.	Pla_his	I15	0,062	0,005	Cultivated
Populus nigra L. cv. *italica* Moench.	Pop_nig	I14	0,134	0,057	Cultivated
		C3	0,031	0,049	
Populus tremula L.	*Pop_tre*	*Bal*	0,090	0,009	Cultivated
Quercus cerris L.	*Que_cer*	*Bal*	0,012	0,015	Native, cultivated
Quercus robur L.	Que_rob	U8	0,059	0,035	Native, cultivated
		I4	0,095	0,025	
		Bal	0,021	0,015	
Quercus robur L. – regeneration	Que_rob	I4	0,097	0,078	
Quercus rubra L.	Que_rub	C3	0,090	0,070	Cultivated
		C17	0,090	0,051	
		U8	0,034	0,016	
		I4	0,070	0,079	
		I13	0,039	0,012	
Rhus hirta (L.) Sudworth	Rhu_hir	U5	0,057	0,043	Cultivated
Rosa canina L.	Ros_can	I3	0,080	0,068	Native
		Bal	0,049	0,002	
Rubus caesius L.	Rub_cae	C18	0,061	0,002	Native
		Ban	0,049	0,021	
		Bal	0,038	0,010	
Sambucus nigra L.	Sam_nig	C15	0,043	0,017	Native, cultivated
Sophora japonica L.	Sop_jap	C9	0,015	0,008	Cultivated
Taxus baccata L.	Tax_bac	C18	0,046	0,001	Cu;tivated
Thuja orientalis L.	Thu_ori	C3	0,061	0,046	Cultivated
		C6	0,037	0,019	
		C9	0,236	0,122	
		C10	0,040	0,094	
Tilia cordata Miller	Til_cor	U9	0,108	0,039	Native, cultivated
		I6	0,214	0,178	
		I7	0,241	0,044	
		Ban	0,035	0,004	
		Ban	0,029	0,088	
		Bal	0,083	0,038	
Tilia tomentosa Moench.	Til_tom	C8	0,082	0,003	Native, cultivated
		I14	0,096	0,015	
		Ban	0,082	0,003	
		Bal	0,035	0,004	
Ulmus glabra Hudson	Ulm_gla	I5	0,064	0,072	Native, cultivated
		Bal	0,015	0,022	
Ulmus minor Miller	Ulm_min	C7	0,094	0,084	Cultivated
		C17	0,144	0,047	
Viburnum rhytidophyllum Hemsl.	Vib_rhy	C18	0,068	0,010	Cultivated
Herbaceae					
Arctium minus (J. Hill) Bernh.	*Arc_min*	*Bal*	0,004	0,007	Native, ruderal
Chelidonium majus L.	*Che_maj*	*C19*	0,055	0,027	Native, ruderal
Cynodon dactylon (L.) Pers.	*Cyn_dac*	*C6*	0,005	0,046	Native, ruderal
Dactylis glomerata L.	*Dac_glo*	*Bal*	0,011	0,011	Native
Geum urbanum L.	*Geu_urb*	*Bal*	0,033	0,009	Native, ruderal
		Ban	0,164	0,009	
		C1	0,224	0,060	
Glechoma hederacea L.	*Gle_hed*	*Bal*	0,018	0,017	Native
		C18	0,025	0,019	
Lamium amplexicaule L.	*Lam_amp*	*C19*	0,072	0,027	Native, ruderal
Medicago sativa L.	*Med_sat*	*I14*	0,088	0,073	Native
Phragmites australis (Cav.) Steudel.	*Phr_aus*	*I5*	0,061	0,097	Native
Plantago lanceolata L.	*Pla_lan*	*C1*	0,080	0,072	Native, ruderal
		C18	0,032	0,075	
Polygonum aviculare L.	*Pol_avi*	*U5*	0,031	0,002	Native, ruderal

		I12	0,006	0,025	
Portulaca oleracea L.	*Por_ole*	*Bal*	0,015	0,005	Native, ruderal
		U9	0,017	-	
		I2	0,023	0,012	
Setaria viridis (L.) Beauv.	*Set_vir*	*C1*	0,032	0,011	Native, ruderal
Taraxacum officinale Weber ex. Wiggers	*Tar_off*	*C1*	0,088	0,004	Native, ruderal
		C2	0,025	0,027	
		C3	0,085	0,064	
		C17	0,027	0,023	
		C19	0,072	0,001	
Trifolium repens L.	*Tri_rep*	*C2*	0,015	0,009	Native, ruderal
Veronica arvensis L.	*Ver_arv*	*C1*	0,01	0,004	Native

Legend: Bal – Baloteşti forest; Ban – Băneasa forest; I, U and C – see Figure 1, 2 and 3

The leaves of *Buxus sempervirens* and *Thuja orientalis* are narrow but they allow to the deposition to cover entire abaxial and adaxial faces of leaves. The highest metal concentration has been found in the thick layer deposited on the leaves.

A practical application of living organisms as bio-indicators for monitoring of environmental pollution has been observed for many years in various countries. Among medicinal species are mentioned dandelion *(Taraxacum officinale)* and black poplar *(Populus nigra)*. Using herbs in medical treatment of various illnesses people should be aware that apart from the pharmacological effect they can be also toxic because of the presence of heavy metals and other impurities. This phenomenon should be disseminated for people awareness, to prevent collecting medicinal herbs near communication routes (Baranowska et al., 2002).

In the central parks from Bucharest, in some species close to the major traffic roads, we have found injuries on the leaves of *Aesculus hippocastanum* L. (from Cişmigiu Park)(Figure 9), *Tilia cordata* Miller (from Izvor Park) (Figure 10), *Carpinus betulus* L. (from Izvor Park)(Figure 11), *Quercus rubra* L. (from Izvor Park)(Figure 12) adult trees.

Anomalies of leaf have been found in: *Carpinus betulus* L. (Figure 15) from Izvor Park near by Splaiul Independenței Boulevard, *Corylus avellana* L. (Figure 16) from Cişmigiu Park near by Regina Elisabeta Boulevard.

Both coniferous and deciduous trees can be used in the detection of aerial heavy metal pollution. Coniferous trees indicate pollution over a longer time period. Growth rings may reflect annual variations in metal concentrations in the surrounding environment (Kovács, 1992c).

Broad-leaved tree species regarded as sensitive to metal contamination include *Betula pendula, Fraxinus excelsior*, *Tilia cordata.* As bioaccumulative indicators, Kovács (1992c) recommends: *Ailanthus* sp., *Tilia tomentosa, Sambucus nigra, Quercus robur*, etc. *Populus nigra* sp. *italica* (Italian poplar) has been recommended as a particularly suitable bioindicator of heavy metal burden in Europe. Amongst many of its appropriate features, this species is genetically homogeneous, easily identifiable and ubiquitously distributed.

Herbaceous plants in central parks are mainly ruderal. Kovács (1992b) recommended the use of ruderal plants as accumulator indicators due to their ability to accumulate metals in high quantities without visible injury.

Figure 9: *Aesculus hippocastanum* L. adult tree from Cişmigiu Park near by Regina Elisabeta Boulevard (photos from left to right: normal leaves, leaves injuries) (Photo: M. Onete)

Figure 10: Leaves injuries of *Tilia cordata* Miller adult tree from Izvor Park near by Splaiul Independenței Boulevard (Photo: M. Onete)

Figure 11: Leaves injuries of *Quercus rubra* L. adult tree from Izvor Park near by Splaiul Independenței Boulevard (Photo: M. Onete).

Figure 12: *Carpinus betulus* L. adult tree from Izvor Park close to Splaiul Independenței Boulevard (photos from left to right: normal leaf and fruits, leaves injuries, abnormality)(Photo M. Onete)

Figure 13: *Corylus avellana* L. adult tree from Cişmigiu Park close to Regina Elisabeta Boulevard (photos from left to right: normal leaves, abnormality of leaves) (Photo: M. Onete)

Figure 14: Injuries on leaves of *Aesculus hippocastanum* L. trees from Virtuții Street (Bucharest, Sector 6) (Photo: M. Onete)

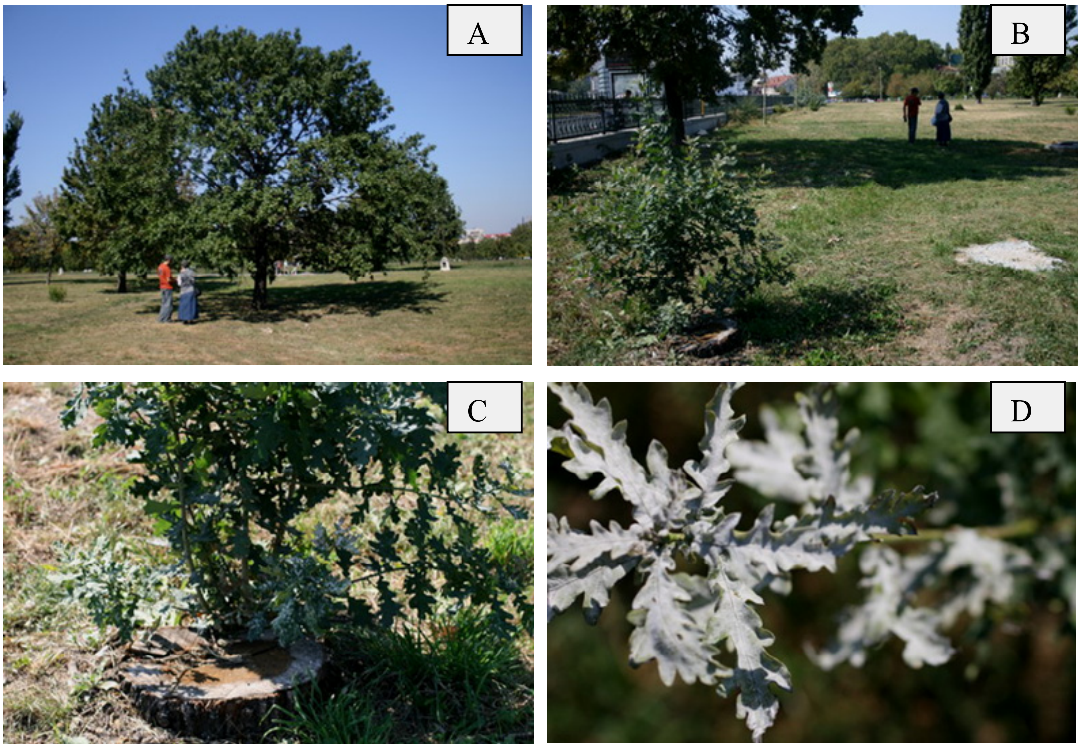


Figure 15: *Quercus robur* L. from Izvor Park, old tree (A), regeneration from cut trunk (B and C), leaves affected by fungi (D)(Photo: M. Onete)

Figure 16: Dust and galles of mite *Eryophytes lateannulatus* Schulze on *Tilia cordata* Miller leaves from Izvor Park near by Splaiul Independenței Boulevard (Photo: M. Onete)

Figure 17: Dust on leaves of *Quercus cerris* L. from Baloteşti Forest (Photo: M. Onete)

CONCLUSIONS

Air pollution from both local and distant sources has impacts on the environment as dry and wet deposition.

The combination of natural stress factors over-intensified in the city (higher temperature, less precipitation, *etc.*) and the intensification of pollution cause the decrease of plant resistance to the stress factors and their eventual death. The specific richness clearly decreases and plant populations further reduce their distribution areas already affected by fragmentation (due to trampled trails made by humans as short-cuts to the engineered asphalt paths). Due to particular abiotic conditions in the city, the plants changed their phenology i.e. during the autumn, when the environmental conditions are more suitable for plant life; late flowering and individuals with vegetative spread (clonal plants) were observed occupying the bare soil created during summer.

Chemicals are taken up by plants from soils and transferred through the terrestrial invertebrates and vertebrates (including humans) via respiration and ingestion. First half-life of heavy metals can take hundreds to thousands years, therefore the complete removal of metallic contaminants from soil is almost impossible. During their evolution (phylogeny) and course of life (ontogeny) plants have developed mechanisms that have resulted in adaptation and accommodation to new or chemically imbalanced environments.

Plants influence and are influenced by their environment. The chemical composition of plants reflects, in general, the element composition of the growth media.

Air pollution data decreased along 2004-2008 in different sites from Bucharest and rural area (Măgurele, Baloteşti). The forests around Bucharest city have the buffer and absorption role for aerial pollutant. Thus, as we expected, the heavy metals concentration has lower values in Baloteşti Forest compared with the central area of the city. The origin of street dust in Bucharest is mainly accessory (intra-city) and less elementary (from external sources like: rivers margins, natural river terraces with loess levels, degraded soils, etc.). The highest values of heavy metals concentration in soil have been found in the central area of the city, in industrial platform areas, near the intense traffic/communication roads.

In the central parks of Bucharest (Cişmigiu, Izvor and Unirii), the heavy metal concentration in the soil is highly heterogeneous being different at the entire park level, micro-site level and even at the point-like level. The heavy metal input can come both from atmospheric dry and wet depositions and from the soil itself (usually being brought from other sites more or less polluted). The proximity of intense traffic roads as major and intensive source of air pollution, leads to depositions on the soil and vegetation, influencing the heavy metal concentration in the soil. We suspect that in Cişmigiu Park, due to high plant diversity, heavy metals have been accumulated in soil also being washed out from the vegetation by rain or by plant watering. Also, aerial depositions (wet and dry) are kept at the soil level in Cişmigiu Park, the high diversity of vegetation not allowing the dust particles together with the pollutants to re-suspend in the air. In Unirii and Izvor Parks, there is a possibility that heavy metals re-enter in the particles suspended in the air due to scarce vegetation and to the paths created by humans, trampled vegetation from both parks. The soil in these parks is sandy and dry clay and every wind blow brings in the air a lot of dust together with pollutants.

Soil accumulation factor of heavy metals in plants shows that the metal uptake from soil is different with different plants species. In the same park, the uptake of the metals is different both with different sites and with the distance to the main traffic road. The leaves aerial deposition is also higher in the site situated in the vicinity of the intense traffic road.

Trees in Bucharest parks are mainly cultivated and some are native but usually cultivated in parks, margins of the roads, green fens, etc. The heavy metal accumulation depends on their distance from the source of pollution (main boulevards) and their availability for metal uptake.

The leaf surfaces of the trees may govern the extent of accumulation of particles. The strongest metal accumulators possessed rougher surfaced leaves which gave rise to the effective trapping and retention of particles.

Herbaceous plants in the central parks are mainly ruderal and only a few can be recommended as accumulator indicators.

In Băneasa and Baloteşti forests, the trees and shrubs close to the un-asphalted roads present leaves covered with dust due to cars traffic in those areas.

For the same species presented in all investigated site, in gradient urban – rural, the heavy metal concentration is increasing in the individuals from central parks.

People should be aware about:

- the importance of plants as bio-accumulator of aerial pollutants.
- medicinal plants, apart from the pharmacological effect, can be also toxic because of the presence of heavy metals in their tissues. This knowledge should prevent collecting medicinal herbs near communication routes.

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EDAPHIC MITE POPULATIONS (ACARI, ORIBATIDA)

Viorica Honciuc

INTRODUCTION

The ecological studies regarding the mites fauna from temperate forest ecosystems have been done in Romania (Călugăr & Vasiliu, 1980; Honciuc, 1992, 1993; Vasiliu & Ivan, 1993; Honciuc & Stănescu, 2000, 2003; Stănescu & Honciuc, 2005, 2006), as well as in other regions of the earth by different researches (Balogh, 1972; Andre et al., 1982; Balogh & Mahunka, 1983; Schatz, 1983; Marshall et al., 1987; Niedbala, 1990, 1992; Honciuc & Lundqvist, 2004) in almost all types of forests. The systemic approach (Botnariuc, 1999) in ecological researches of these types of ecosystems shows the implication of each biotic or abiotic factor to the structure and dynamics of an ecosystem. Regarding the forests, the most complex ecosystems, the ratio between these components determines the homeostasis. From the multitude of the biological systems of a forest ecosystems, the soil mites fauna (Arachnida: Acari-Oribatida) can be considered one of the main link in sustaining the ecological equilibrium. At the soil level, each group of mites activates in different ways. Oribatids are known by their high number of individuals and by the role of their trophic categories (macrophytophagous, microphytophagous and panphytophagous). They can be saprophagous and secondary consumers, they can decompose the organic matter and be involved in soil structure and in turnover process.

Mites, arthropods belonging to the group living in soil, are widely distributed, with high abundance and species diversity (Schatz, 1983; Marshall et al., 1987; Honciuc, 1992; Karppinen et al., 1992; Vasiliu & Ivan, 1993; Evans, 1992). They live in different habitats: soil, litter, in nests of birds, on plants, on animals and even in storehouses. In soil they found the most favourable bio-edaphic conditions for the development of all populations. Their presence depends on: soil structure, presence of organic matter, type of humus and on some abiotic factors as temperature, humidity and pH. In forest ecosystems, the rich population of saprophagous oribatids, is due to the favourable bio-edaphic conditions, which create many habitats and microhabitats good for their development, in comparison with other ecosystems from temperate area (i.e. urban areas, mining areas; agro-ecosystems, meadows, polluted areas etc.), where the environmental factors don't allow a proper development of these populations (Niedbala et al., 1990; Honciuc & Stănescu, 2000; Ruf et al., 2003; Weigmann, 1987).

The ecological importance of these microarthropods from soil of different ecosystems has been highlighted by the acarologists around the world in many researches. The scientists used several and different methods, the structural and dynamical differences analysis of the mite populations being one of the principal methods.

MATERIAL AND METHODS

For oribatid soil fauna sampling, in each ecosystem we determined a specific surface. From each surface we collected 15 samples with a MacFadyen corer, from a depth of 10 cm. Each sample was separated in two layers: litter-fermentation and soil. The samples were collected from three transects for each area (T_1-near to the main road, T_2- the lateral side of the studied area and T_3–in the middle of the studied area), for all three areas, nine transects in all.

Extraction was done with a modified Berlese-Tullgren extractor, in ethylic alcohol and the mites samples were clarified in lactic acid. Following the taxonomical identification, the numerical abundance was the basis for the quantification of other statistical parameter: average (x), variance (s^2), standard error of the average (s), standard deviation of the average (s'), variation coefficient (CV %); numerical density (x/sq.m.); relative abundance (Ar%); constancy (C%). The mites fauna was identified on the species level.

The species identified from the urban and forestry ecosystems are mentioned in the tables from the results, with their presence in every area.

Samples with identified oribatid species and individuals are kept on slides and deposited in collection of Ecological Station from Posada, Department of Ecology, Taxonomy and Nature Conservation, Institute of Biology of Romanian Academy.

RESULTS AND DISCUSIONS

In parks, the natural vegetation had mainly disappeared, being replaced by cultivated native and ornamental. The studied forest ecosystems Baloteşti and Băneasa are characterized both by the dominance of native trees and herbaceous species (Onete & Paucă-Comănescu, 2008 and this volume).

Taking into account that our studies have focused on the natural population of saprophagous-decomposer mites (Ord. Oribatida) from 3 parks considered polluted urban areas, compared with other populations of the same taxonomic group, but from the areas with semi-natural forests, the results are presented from this ecological point of view.

From Tables 2, 3, 4 and 5 we can observe that in all studied ecosystems the taxonomic structure shows the presence of 108 species of Oribatida, according to the taxonomic classification of Balogh (1972), Gyliarov & Krivolutskii (1975), Marshall et al. (1987), Niedbała (1992), Subias & Balogh (1989). In parks, the taxonomic identification shows the presence of 83 oribatid species (40 species in Cişmigiu, 40 species in Unirii, 33 species in Izvor). In the forest ecosystems the oribatids are represented by 55 species (34 species in Baloteşti and 42 species in Băneasa forests).

From the structural point of view, the oribatid mites fauna is characterized by the presence of the common species for the parks, common species for the forests, and of course, common species for all types of studied areas.

In the parks we identified the following common oribatid species*: Zygoribatulla terricola* V.der. Hammen, 1952; *Tectocepheus sarekensis* Trägårdh I., 1910*; Tectocepheus velatus* (Michael A. D., 1880); *Epilohmannia cylindrica* (Berlese), 1904; *Medioppia obsoleta* (Paoli G., 1908); *Dissorhina ornata* (Oudemans A. C., 1900); *Ceratozetes mediocris* Berlese, 1908; *Oribatulla tibialis* Nicolet H., 1855; *Hermanniella dolosa* Grandjean, 1931; *Eulohmannia ribagai* Berlese, 1910; *Trichoribates novus* (Sellnick M., 1928).

The common oribatids for the two forests are: *Berniniella bicarinata* Paoli, 1908; *Ramusela insculpta* (Paoli G., 1908); *Oribatella berlesei* (Michael A.D., 1898); *Phthiracarus globosus* (C.L. Koch, 1841); *Belba pseudocorynopus* Märkel, 1960; *Carabodes femoralis* (Nicolet H., 1855); *Ctenobellba pectinigera* (Berlese), 1908.

We determined 24 oribatids which are common to all studied ecosystems: *Berniniella bicarinata* Paoli, 1908;*Carabodes femoralis* (Nicolet H., 1855); *Ceratoppia bipilis* (Hermann J.F., 1804); *Ceratozetes minutissimus* Willmann, 1951; *Ctenobelba pectinigera* (Berlese), 1908; *Epilohmannia cylindrica* (Berlese), 1904; *Globozetes tricuspidatus* Willmann, 1923; *Medioppia obsoleta* (Paoli G., 1908); *Minunthozetes semirufus* C.L.Koch, 1841; *Nanhermannia elegantula* Berlese, 1913; *Ophidiotrichus vindobonensis* Piffl, 1960; *Oribatulla tibialis* Nicolet H., 1855; *Peloptulus phaenotus* C.L.Koch, 1844; *Protoribates lophotrichus* (Berlese, 1904); *Protoribates monodactylus* (Haller, 1804); *Punctoribates punctum* (C.L.Koch, 1839); *Ramusela insculpta* (Paoli G., 1908); *Scheloribates laevigatus* (C.L.Koch, 1836); *Steganacarus magnus* (Nicolet H., 1855); *Suctobelbella baloghi* (Forsslund K.-H., 1958); *Tectocepheus sarekensis* Trägårdh I., 1910; *Tectocepheus velatus* (Michael A.D., 1880); *Tropacarus carrinatus* (C.L.Koch, 1841); *Tropacarus pulcherrimus* (Berlese, 1887).

In the the studied ecosystems, based on the classification criteria, following the statistical researches (Lehmann & D'Abrera 1998; Honciuc, unpublished observations, 2000) and analysis of the relative abundance (Ar %) and constancy (C%) of the identified species, the mite populations have been separated in dominance and constancy classes. Within the structure and functions of the terrestrial ecosystems, the mite species from the highest classes of dominance and constancy are the most important in population's structure and in the decomposing process.

In the parks, as shown in Tables 1-3, the oribatid fauna is grouped in accordance with the values of the relative abundance and constancy, showing a better image on their role in structure and functions of these ecosystems. In urban areas the specific spectrum of oribatid fauna is defined by the presence of the same dominance and constancy categories.

In Cişmigiu, the studies revealed species *Trichoribates trimaculatus* (C.L.Koch, 1836) as eudominant-euconstant and *Zygoribatulla terricola* V.der. Hammen, 1952, as eudominant and constant. The following category of the dominant species consists of 4 oribatids: *Tectocepheus velatus* (Michael A. D., 1880), *Protoribates lophotrichus* (Berlese, 1904), *Ramusella insculpta* (Paoli G., 1908), *Ceratozetes minutissimus* Willmann, 1951, constant, at the same time. As subdominant but constant, we identified 4 species, as shown in Table 1, and from these only species *Tectocepheus sarekensis* Trägårdh I., 1910, is better represented from the structural point of view.

In Unirii park (Table 2) three species are included in the eudominant-euconstant category: *Zygoribatulla terricola* V.der. Hammen, 1952; *Tectocepheus velatus* (Michael A. D., 1880); *Minunthozetes semirufus* C.L. Koch, 1841. From the dominant-euconstant class were noticed two species: *Punctoribates punctum* (C.L.Koch, 1839) and *Scheloribates laevigatus* (C.L.Koch, 1836), and as subdominant 6 species, of which *Epilohmannia cylindrica* (Berlese), 1904 and *Trichoribates trimaculatus* (C.L.Koch, 1836) are also euconstant (see Table 2).

Table 1. Structural indices: relative abundance (Ar%) and constancy (C%) and ecological characteristics of the Oribatid mite species in Cişmigiu park

Oribatid species	Indices		Ecological characteristics	
	Ar	C	Habitats trophyc relations	Biogeography
Zygoribatulla terricola ∗ V.der. Hammen, 1952	16.33	60	lowns; planted forest; panphy.	S-Eur
Trichoribates trimaculatus (C.L.Koch, 1836)	13.47	100	lowns; moss.; panphy	Pal.; nearct.
Tectocepheus velatus (Michael A. D., 1880)	8.16	80	lowns; forests; euryök.; panphy.	pal.; nearct.; subarct.; Austr.,
Protoribates lophotrichus (Berlese, 1904)	6.53	100	xero.; forests; panphy	Hol
Ramusella insculpta (Paoli G., 1908)	6.53	60	laws; rare forests.; xero.; panphy	Eur.
Ceratozetes minutissimus Willmann, 1951	5.71	100	lowns; forests; panphy	Eur
Tectocepheus sarekensis Trägårdh I., 1910	4.08	100	lowns; rare forests; panphy.	hol.; arkt.; trop
Epilohmannia cylindrica (Berlese), 1904	2.04	60	lawns; xero.; microphy	Eur.; C-As.; N-Am.; Oc.
Punctoribates punctum (C.L.Koch, 1839)	2.04	60	lawns; rare forests; helio.; panphy.	Hol.
Pergalumna minor (Willmann, 1938)	2.04	40	lawns; rare forests; panphy.	S-Eur
Galumna obvia (Berlese A., 1915)	1.63	60	forests; panphy	C-S-Eur.
Scheloribates laevigatus (C.L.Koch, 1836)	1.63	60	lowns; rare forests; panphy	Pal.
Medioppia obsoleta (Paoli G., 1908)	1.63	60	forests; lowns; euryök.; panphy.	Eur.
Peloptulus phaenotus C.L. Koch, 1844	1.22	40	forests; mesophyl lawns.; panphy	Pal.; Eur.;W.-sibir.; S.-As.
Damaeobelba minutissima Sellnick, 1928	1.22	20	lowns; forests; planted forests; microphy	S-Eur
Trichoribates oxypterus Berlese, 1910	1.22	20	lowns; forests; planted forests; panphy	S-Eur.
Oppiella nova (Oudemans), 1902	0.82	40	forests; semi-kosmop.; micophy	Eur.;trop.; hol.;
Suctobelbella baloghi (Forsslund K.-H., 1958)	0.82	40	forests; coniferous; micophy	Hol.; Eur.
Phthiracarus dubinini Feider et Suciu, 1957	0.82	40	forests; macrophy.	R.
Fosseremaeus laciniatus (Berlese), 1836	0.82	20	meadow; forest in park;	R

			microphy.	
Multioppia laniseta Moritz, 1966	0.82	20	forest; meadow; microphy	Eur.
Oppia serratirostris Golosova, 1970	0.82	20	forests; medow; microphy	S-E-Eur.; sibir
Perlohmannia dissimilis (Hewitt), 1908	0.82	20	lown; meadow; forest in parks; micophy	Eur.
Dissorhina ornata (Oudemans A. C., 1900)	0.82	20	forests; euryök.; panphy	Pal.; N-Am
Lohmannia lanceolata turcmenica ∗ Bul.-Zachv.,1960	0.41	20	meadow; mycrophy	S-W-Asia
Galumna elimata (C.L.Koch, 1841)	0.41	20	forests; kosmo.; helio.;higro.; panphy.	Eur.
Ceratozetes mediocris berlese, 1908	0.41	20	meadow; forests; panphy	Hol.
Oribatulla tibialis Nicolet H., 1855	0.41	20	forests; lawns; mikrophy., panphy.	Hol
Amerobelba decedens Berlese, 1908	0.41	20	meadow; shrubs; panphy	S-Eur
Chamobates spinosus Sellnick M., 1928	0.41	20	forests; panphy	Eur.
Eulohmannia ribagai Berlese, 1910	0.41	20	deciduous forests; icrophy.	hol
Eupelops acromios (Hermann L. van der1804)	0.41	20	forests; moss; panphy	Eur.; W-Sibir; E-As; N-Af.
Euphthiracarus cribrarius (Berlese A., 1904)	0.41	20	forests; macrophy	Eur
Nanhermannia nannus (Nicolet H., 1855)	0.41	20	moss; hygro.; panphy.	Pal.; neotrop.; nearct.; subarct.
Oppia fallax Paoli, 1908	0.41	20	forests; moist lawns; microphy.	Hol
Steganacarus magnus (Nicolet H., 1855	0.41	20	forests; macrophy	Eur.; Cauc.; N-Am.
Suctobelba trigona (Michael A. D., 1888)	0.41	20	forests; moss; panphy.	Eur.; eurosibir.; kauk.; W.-As.
Trichoribates novus (Sellnick M., 1928)	0.41	20	moss; helio.;higro.; panphy	Hol.
Tropacarus pulcherrimus (Berlese, 1887)	0.41	20	forests; macrophy	C-S-Eur
Anachypteria sp.	0.41	20	-	-
Immatures	11.42	80		

Legend:

* first record of the species;

hygro.= hygrophilous; mesohygro.= mesohygrophylous; xero.= xerophylous; helio.= heliophylous; xeroterm.= xerotermphylous; euryök.= cosmopolitan; makrophy.= makrophytophagous; mikrophy.= mikrophytophagous; panphy.= panphytophagous; pal.= palearctic; hol.= holarctic; arkt.= arctic; nearkt.= nearctic; eurosibir.= euro Siberian; sibir.= Siberian; kauk.= Caucasian; magreb.= magrebien; orient.= oriental; trop.= tropical; neotrop.= neotropical; C-S-E-W-N = European; R = Romania; N.-Am.= North-American; As.= Asian; Austr.= Australian.

Table 2. Structural indices: relative abundance (Ar%) and constancy (C%) and ecological characteristics of the Oribatida mite species in Unirii park

Oribatid species	Indices		Ecologycal characteristics	
	Ar	C	Habitats trophyc relations	Biogeography
Zygoribatulla terricola ∗V.der. Hammen, 1952	12.26	100	lowns; planted forest; panphy	S-Eur
Tectocepheus velatus (Michael A. D., 1880)	12.26	100	lowns; forests; euryök.; panphy.	pal.; nearct.; subarct.; Austr.,
Minunthozetes semirufus C.L. Koch, 1841	11.42	80	coniferous forest; panphy.	Hol
Punctoribates punctum (C.L.Koch, 1839)	6.96	100	lawns; rare forests; helio.; panphy.	Hol.
Scheloribates laevigatus (C.L.Koch, 1836)	5.01	80	lowns; panphy	Pal.
Epilohmannia cylindrica (Berlese), 1904	4.46	100	xero.- lowns; microphy.	Eur.; C-As.; N-Am.; Oc.

Trichoribates trimaculatus (C.L.Koch, 1836)	3.34	100	xero.lowns; moss.; panphy	Pal.; nearct.
Ophidiotrichus vindobonensis Piffl E., 1960	3.34	40	lawns; xeroterm.; panphy.	C-Eur
Dissorhina ornata (Oudemans A. C., 1900)	2.79	40	silv.; euryök.; panphy	Pal.; N-Am
Protoribates monodactylus (Haller, 1804)	2.23	40	forests; lowns; mesohygro.; euryök; mikrophy.; panphy.	Pol
Pergalumna longior (Willmann, 1928)	1.67	40	forest; meadow; panphy	Eur.
Medioppia obsoleta (Paoli G., 1908)	1.39	60	forests; lowns; euryök.; panphy.	Eur.
Achypteria oudemansi Hammen, 1952	1.11	40	rare forest; panphy	Eur.
Lohmannia lanceolata turcmenica Bul.-Zachv.,1960	1.11	40	meadow; mycrophy	S-W-Asia
Adoristes ovatus (C.L.Koch, 1840)	1.11	20	forests; lowns; panphy	Eur.; N-Am.
Ceratoppia bipilis (Hermann J. F., 1804)	1.11	20	forests; euryök.; panphy.	Pal.
*Galumn*a sp.	1.11	20	-	-
Stachyoppia muscicola Balogh, 1961	1.11	20	moss; micophy	S-Asia
Ramusella insculpta (Paoli G., 1908)	0.84	40	laws; rare forests.; xero.; panphy	Hol.
Microppia minus (Paoli G., 1908)	0.84	20	forests; moist lawns; microphy	Hol
Protoribates capucinus Berlese, 1908	0.56	40	forests; shrubs; meadow; panphy	Eur.
Psudachypteria magnus Sellnick, 1928	0.56	40	forests; lawns; macrophy	Eur.; pal
Protoribates lophotrichus (Berlese, 1904)	0.56	20	forests; xero.; panphy	Hol
Pergalumna minor (Willmann, 1938)	0.56	20	forests; panphy	Eur.
Cerachipteria sp.	0.56	20	-	-
Ceratozetes mediocris berlese, 1908	0.56	20	meadow; forests; panphy	Hol.
Ceratozetella minimus (Sellnick, 1928)	0.56	20	forests; meadows; panphy	Eur.
Cultroribula biculltrata Berlese A., 1908	0.56	20	lowns; microphy.	C-Eur.; Sibir.; N-Am.
Haplophthiracarus pavidus Berlese, 1913	0.56	20	shrubs; forests; macrophy	Eur
Oribatulla tibialis Nicolet H., 1855	0.56	20	lowns;forest; mesohygro.; euryök; mikrophy., panphy.	Pal.; nearct
Hermanniella dolosa Grandjean, 1931	0.56	20	forests; panphy	C-S-Eur;Cauc.; N-As.; magreb.
Tropacarus carrinatus (C.L.Koch, 1841)	0.56	20	forest; macrophy	Eur.; Eur-sibir.;magreb
Tropacarus sp	0.56	20	-	-
Oribotritia sp.	0.56	20	-	-
Phthiracarus sp	0.56	20	-	-
Globozetes tricuspidatus (Willmann, 1953)	0.28	20	forests; panphy	C-E-Eur.
Lauroppia falcata (Paoli G., 1908)	0.28	20	forests; moist lowns; microphy.	Hol
Ctenobelba pectinigera (Berlese), 1908	0.28	20	deciduous forests; panphy	C-S-Eur.
Scutovertex minutus (C.L. Koch, 1836)	0.28	20	forests; microphy	Eur; magreb
Zygoribatula frisie (Oudemans), 1900	0.28	20	medow; shrubs; panphy	Eur.; S-Asia
Immatures				

Legend:

* first record of the species;

hygro.= hygrophilous; mesohygro.= mesohygrophylous; xero.= xerophylous; helio.= heliophylous; xeroterm.= xerotermphylous; euryök.= cosmopolitan; makrophy.= makrophytophagous; mikrophy.= mikrophytophagous; panphy.= panphytophagous; pal.= palearctic; hol.= holarctic; arkt.= arctic; nearkt.= nearctic; eurosibir.= euro Siberian; sibir.= Siberian; kauk.= Caucasian; magreb.= magrebien; orient.= oriental; trop.= tropical; neotrop.= neotropical; C-S-E-W-N = European; R = Romania; N.-Am.= North-American; As.= Asian; Austr.= Australian.

Table 3. Structural indices: relative abundance (Ar%) and constancy (C%) and ecological characteristics of the Oribatida mite species in Izvor park

Oribatid species	Indices		Ecologycal characteristics	
	Ar	C	Habitats-trophyc relations	Biogeography
Punctoribates punctum (C.L.Koch, 1839)	52.1	100	lawns; rare forests; helio.; panphy.	Hol.
Galumna obvia (Berlese A., 1915)	6.28	80	forests; panphy	C-S-Eur.
Tectocepheus sarekensis Trägårdh I., 1910	4.88	100	kosmop.; panphy.	Hol.; arkt.; trop
Ramusella insculpta (Paoli G., 1908)	4.19	100	laws; forests.; xero.; panphy	Hol.
Medioppia obsoleta (Paoli G., 1908)	3.02	100	forests; lowns; euryök.; panphy.	Eur.
*Zygoribatulla terricola** V.der. Hammen, 1952	2.09	100	lowns; planted forest; panphy	S-Eur
Carabodes femoralis (Nicolet H., 1855)	2.09	20	forest; euryök.; panphy.	Pal.
Ceratozetes contiguus Jeleva, 1962	1.63	60	forests; medows; panphy	S-Eur
Tectocepheus velatus (Michael A. D., 1880)	1.16	60	forests; lowns; euryök.; panphy.	Pal.; nearct.; subarct.; Austr.,
Protoribates capucinus Berlese, 1908	1.16	40	Forests; meadow; panphy	Eur.
Euphthiracarus sp.	0.93	40	-	-
Nanhermannia elegantula Berlese, 1913	0.93	40	meadow; moss; deciduous forests; panphy.	Eur; Am
Scheloribates laevigatus (C.L.Koch, 1836)	0.93	20	lowns; forests; euriök.; myrmec.; kopro.; panphy	Pal.
Pergalumna altera (Oudemans, 1915)	0.47	40	forests; medow; panphy	Eur
Ceratozetes sp.	0.47	20	-	-
Phthiracarus pallidus Feider et Suciu, 1957	0.47	20	forests; macrophy.	R.
Galumna sp.	0.23	20	-	-
Hermanniella dolosa Grandjean, 1931	0.23	20	forests; microphy	C-S-Eur.; Cauc.; N.-As.; maghreb
Eulohmannia ribagai Berlese, 1910	0.23	20	deciduous forests; microphy.	Hol
Trichoribates novus (Sellnick M., 1928)	0.23	20	lowns; helio.;higro.; panphy	Hol.
Belba corynopus (Herm.), 1804	0.23	20	forests; microphy	Hal
Berninniella bicarinata Paoli, 1908	0.23	20	forests; meadow; microphy	Eur
Lauroppia neerlandica Oudemans A. C., 1900	0.23	20	forests;moss.; microphy.; panphy	Pal.
Lohmannia sp.	0.23	20	-	-
Oribotritia sp.	0.23	20	-	-
Phthyracarus anonymum Grandjean F., 1933	0.23	20	forests; macrophy	Pal.; Ethiop.; neotrop.;
Rhyzotritia ardua ardua (Koch, 1841)	0.23	20	forests; macrophy	Hol
Oribotritia berlesei (Michael, 1898)	0.7	60	forests; macrophy	Eur.
Galumna elimata (C.L.Koch, 1841)	0.7	60	forests; kosmo.; helio.; higro.; panphy	Eur.
Scheloribates distinctus Mihelčič, 1964	0.7	40	deciduous forest; panphy	S-Eur
Dissorhina ornata (Oudemans A. C., 1900)	0.7	40	forests; euryök.; panphy	Pal.; N-Am
Trichoribates trimaculatus (C.L.Koch, 1836)	0.7	40	moss; xero; panphy	Pal.; nearct.
Oppia chitinophincta Kulijev, 1962	0.7	20	forests; meadow; microphy	E-Eur
Immatures	4.65	60		

Table 4. Structural indices: relative abundance (Ar%) and constancy (C%) and ecological characteristics of the Oribatida mite species in Baloteşti forest ecosystem

Oribatid species In Balotesti forest	Indices A	Indices C	Ecologycal characteristcs: Habitats-trophic relations	Ecologycal characteristcs: Biogeography
Medioppia obsoleta (Paoli G., 1908)	16.38	100	forests; lowns; euryök.; panphy.	Eur.
Tectocepheus velatus (Michael A. D., 1880)	11.86	20	lowns; forests; euryök.; panphy.	Pal.; nearct.; subarct.; Austr.,
Oribatulla tibialis Nicolet H., 1855	9.60	100	lowns; forests; euryök; mikrophy., panphy.	Pal.; nearct
Tropacarus pulcherimus (Berlese, 1887)	5.65	80	forests; macrophy	C-S-Eur
Scheloribates laevigatus (C.L.Koch, 1836)	4.80	100	forests; euriök.; myrmec.; kopro.; panphy	Pal.
Ramusela insculpta (Paoli G., 1908)	3.11	80	forests; xero.; panphy	Pal.
Berniniella bicarinata Paoli, 1908	3.11	40	forests; microphy	Eur; sibir.
Metabellba pulverulenta (C.L.Koch, 1840)	2.82	60	forests; mirmec.; microphy.	Pal., N.-Am
Punctoribates punctum (C.L.Koch, 1839)	2.54	60	lawns; rare forests; helio.; panphy.	Hol.
Oribatella berlesei (Michael A.D., 1898)	2.54	40	forests; panphy	Eur.
Ceratoppia bipilis (Hermann J. F., 1804)	2.26	60	forests; lowns; euryök.; panphy.	Pal.
Tectocepheus sarekensis Trägårdh I., 1910	2.26	60	kosmop.; panphy.	hol.; arkt.; trop
Damaeollus ornatissimus (Berlese), 1904	1.58	40	forests; moist hayfields; mycrophy	S-Eur.
Suctobelbela baloghi (Forsslund K.-H., 1958)	1.41	20	forests; microphy.	Pal.
Zetorchestes michronychus (Berlese, 1883)	1.13	60	forests; panphy	C-S-Eur.; sibir.
Hypochthonilella pallidula (C.L.Koch sensu Willmann C., 1931)	1.13	40	forests; kosmop.; microphy.	Trop.
Ceratozetes fusifer Mihelčič F., 1956	0.85	60	forests; panphy	Eur.-sibir
Oribotritia serrata Feider et Suciu, 1958	0.85	40	forests; microphy.;panphy	R.
Ophidiotrichus vindobonensis Piffl E., 1960	0.85	40	xeroterm.; panphy	C-Eur
Suctobelba aliena Moritz, 1970	0.56	40	forests; microphy.	C-S-Eur.
Ceratozetes minutissimus Willmann, 1951	0.56	40	medows; forests; panphy	Eur
Oribatulla pannonicus Willmann C., 1949	0.56	40	deciduous forests; panphy	C-Eur.
Chamobates cuspidatus (Michael A. D., 1884)	0.56	40	forests; panphy.	Pal.; nerct.
Oribotritia sp	0.56	40	-	-
Phthiracarus globosus (C.L. Koch,1841)	0.56	20	forests; macrophy.	Eur.; orient.; As.
Nothrus biciliatus C.L. Koch, 1841	0.28	20	moss; panphy	Hol; Eur; E-As;N-Am
Belba pseudocorynopus Märkel, 1960	0.28	20	coniferous forests; panphy	C-S-Eur
Carabodes femoralis (Nicolet H., 1855)	0.28	20	forests; euryök; panphy	Pal.
Ctenobelba pectinigera (Berlese), 1908	0.28	20	deciduous forests; panphy	C-S-Eur.
Epilohmania cylindrica (Berlese), 1904	0.28	20	xero.- lowns;	Eur.; C-As.; N-

			microphy.	Am.; Oc.
Eremaeus oblongus Koch, 1836	0.28	20	forests; moss layer; panphy	Eur; N-Af.; N-Am.
Liacarus vombi Dalenius P., 1950	0.28	20	meadow; rare forests; panphy	Eur.; Sc
Peloptulus phaenotus C.L. Koch, 1844	0.28	20	forests; mesophyl lawns.; panphy	Pal.; Eur.;W.-sibir.; S.-As.
Protoribates lophotrichus (Berlese, 1904)	0.28	20	forests; xero.; panphy	Hol
Immatures	13.84	100		

Legend:

* first record of the species;

hygro.= hygrophilous; mesohygro.= mesohygrophylous; xero.= xerophylous; helio.= heliophylous; xeroterm.= xerotermphylous; euryök.= cosmopolitan; makrophy.= makrophytophagous; mikrophy.= mikrophytophagous; panphy.= panphytophagous; pal.= palearctic; hol.= holarctic; arkt.= arctic; nearkt.= nearctic; eurosibir.= euro Siberian; sibir.= Siberian; kauk.= Caucasian; magreb.= magrebien; orient.= oriental; trop.= tropical; neotrop.= neotropical; C-S-E-W-N = European; R = Romania; N.-Am.= North-American; As.= Asian; Austr.= Australian.

Table 5. Structural indices (the relative abundance-Ar%, and constance C%) and ecological characteristics of the Oribatida mite species in Băneasa forest ecosystem near Bucharest

Oribatid species	Indices		Ecologycal characteristcs	
	Ar	C	Habitats- trophyc relations	Biogeography.
Ceratoppia bipilis (Hermann J. F., 1804)	17.41	100	forests; nidicol; euryök; panphy.	Pal.
Damaeollus ornatissimus (Berlese), 1904	7.59	100	forests; moist hay fields; microphy	S-Eur.
Hypochthonilella pallidula (C.L.Koch sensu Willmann C., 1931)	7.28	100	forests; kosmop.; microphy.	Trop.
Metabellba pulverulenta (C.L.Koch, 1840)	6.33	80	forests; mirmec.; microphy	Pal., N.-Am
Oribatulla pannonicus Willmann C., 1949	5.38	80	forests; xero.; panphy.	C-Eur.
Tectocepheus velatus (Michael A. D., 1880)	3.80	80	xero-lowns; forests; euryök.; panphy.	Pal.; nearct.; subarct.; Austr.,
Berniniella bicarinata Paoli, 1908	3.16	80	forests; microphy	Eur; Sibir.
Scheloribates laevigatus (C.L.Koch, 1836)	3.16	40	forests; lowns; euriök.; panphy	Pal.
Oribatella berlesei (Michael A.D., 1898)	2.85	60	forests;panphy	Eur
Achypteria coleoptrata (Linné, 1758)	2.85	40	forests; euryök; panphy	Hol.
Eporibatulla rauschenenis Sellnick M., 1928	2.85	40	deciduous forests; panphy	Eur
Tropacarus pulcherimus (Berlese, 1887)	2.22	80	forests; macrophy	C-S-Eur
Oribotritia serrata Feider et Suciu, 1958	2.22	40	forests; high meadow. macrophy	R.
Ramusela insculpta (Paoli G., 1908)	1.90	40	forests; xero. panphy.	Pal.
Suctobelbela baloghi (Forsslund K.-H., 1958)	1.90	60	Forests; microphy.	Pal.
Ceratoppia sexpilosa Willmann, 1938	1.27	60	Forests; panphy	C-SE-Eur
Nothrus biciliatus C.L. Koch, 1841	1.27	60	forests; lowns; moss; euryök; panphy	Hol
Oribatulla tibialis Nicolet H., 1855	1.27	40	forests; lowns; mesohygro.; euryök microphy., panphy.	Pal.; nearct
Protoribates monodactylus (Haller, 1804)	1.27	20	forests; mesohygro.; euryök; microphy.; panphy	Hol
Globozetes tricuspidatus (Willmann, 1953)	0.95	60	forests; panphy	Eur.
Phtriracarus sp.	0.95	60	-	-
Tectocepheus sarekensis Trägårdh I., 1910	0.95	40	lowns;panphy.	Hol.; arkt.;

				trop
Steganacarus magnus (Nicolet H., 1855)	0.95	40	silv.; macrophy	Eur.; kauk.; N.-Am.;
Medioppia obsoleta (Paoli G., 1908)	0.95	20	forests; lowns; euryök.; panphy	Eur.
Oribatella tenuis Csiszar, 1962	0.63	20	forests; lowns; panphy	Eur; sibir.
Ophidiotrichus vindobonensis Piffl E., 1960	0.32	20	lawns; xeroterm.; panphy.	C-Eur
Phthiracarus globosus (C.L. Koch,1841)	0.32	20	forests; macrophy.	Eur.; orient.; As.
Belba pseudocorynopus Märkel, 1960	0.32	20	coniferous forests; panphy	C-S-Eur
Brachychthonius berlesei Willmann, 1928	0.32	20	lawns; xeroterm.; panphy.	C-Eur
Carabodes femoralis (Nicolet H., 1855)	0.32	20	forests; euryök; panphy	Pal.
Ctenobelba pectinigera (Berlese), 1908	0.32	20	deciduous forests; panphy	C-S-Eur.
Damaeollus asperatums Berlese, 1904	0.32	20	forests; panphy	Eur; N-Am
Minunthozetes semirufus C.L. Koch, 1841	0.32	20	coniferous forest; panphy.	Hol
Nanhermannia elegantula Berlese, 1913	0.32	20	meadow; moss; deciduous forests; panphy.	Eur; Am
Nothrus parvus Sitnikova, 1975	0.32	20	meadow; forest panphy	S-Eur; Sibir
Phtiracarus piger (Scopoli, 1973)	0.32	20	forests.; macrophy.	Eur.; kauk.; magreb.; N.-Am.;
Protoribates pannonicus Willmann, 1931	0.32	20	xero.; lowns.; panphy	C-S-Eur
Suctobelbella acutidens (Forsslund K.-H., 1941)	0.32	20	forests; micophy	Eur.; N.-Am
Tropacarus pulcherimus (Berlese, 1887)	0.32	20	forests; macrophy	C-S-Eur
Achypteria sp.	0.32	20	-	-
Melanozetes sp.	0.32	20	-	-
Bellba sp.	0.32	20	-	-
Immatures	11.71	100		

Legend:

* first record of the species;
hygro.= hygrophilous; mesohygro.= mesohygrophylous; xero.= xerophylous; helio.= heliophylous; xeroterm.= xerotermphylous; euryök.= cosmopolitan; makrophy.= makrophytophagous; mikrophy.= mikrophytophagous; panphy.= panphytophagous; pal.= palearctic; hol.= holarctic; arkt.= arctic; nearkt.= nearctic; eurosibir.= euro Siberian; sibir.= Siberian; kauk.= Caucasian; magreb.= magrebien; orient.= oriental; trop.= tropical; neotrop.= neotropical; C-S-E-W-N = European; R = Romania; N.-Am.= North-American; As.= Asian; Austr.= Australian.

In Izvor park, as eudominant-euconstant, we could note the presence of only *Punctoribates punctum* (C.L.Koch, 1839) species, which had the highest number of individuals of all studied ecosystems. Only one species is dominant-constant, in this park: *Galumna obvia* (Berlese A., 1915). From the subdominant category were identified 6 species, as shown in Table 3. Only 4 species: *Tectocepheus sarekensis* Trägårdh I., 1910, *Ramusella insculpta* (Paoli G., 1908), *Medioppia obsoleta* (Paoli G., 1908), *Zygoribatulla terricola* v.der. Hammen, 1952, are more important, being at the same time euconstant. In all ecosystems the unmentioned species are classified as subdominant and accidental, due to the decreased values of the abundance and constancy.

In Baloteşti forest ecosystem the identified oribatid species presented in Table 4, have been classified in certain classes as following: *Medioppia obsoleta* (Paoli G., 1908) as eudominant-euconstant species; *Tectocepheus velatus* (Michael A.D., 1880) as euconstant-accessory. In the dominant species category are identified: *Oribatulla tibialis* Nicolet H., 1855, dominant-euconstant and *Tropacarus pulcherimus* (Berlese, 1887) as dominant-constant. In subdominant, but constant category are included 7 species, from which *Ramusela insculpta* (Paoli G., 1908), *Metabelba pulverulenta* (C.L.Koch, 1840), *Punctoribates punctum* (C.L.Koch, 1839), *Ceratoppia bipilis* (Hermann J.F., 1804), *Tectocepheus sarekensis* Trägårdh I., 1910 are defined by more relevant values of the constancy index.

In Băneasa forest ecosystem, the specific spectrum presents: *Ceratoppia bipilis* (Hermann J.F., 1804) eudominant-constant, *Hypochthonilella pallidula* (C.L.Koch sensu Willmann C., 1931), *Damaeollus ornatissimus* (Berlese, 1904), *Metabellba pulverulenta* (C.L.Koch, 1840), *Oribatulla pannonicus* (Willmann C., 1949) dominant euconstant. From subdominant-constant category as shown in Table 5 were identified 9 species, from which: T*ectocepheus veletus* (Michael A.D., 1880), *Berniniella bicarinata (*Paoli, 1908), *Oribatella berlesei* (Michael A.D., 1898), *Tropacarus pulcherimus* (Berlese, 1887) are most constant. As shown in the same tables the largest category belongs to the recedent-subconstant and accidental species, in all ecosystems.

The structural differences in the parks (Figure 1 and 2) are revealed by the dynamics of the numerical structure of the 83 oribatid mites population recorded. The total numerical density the Oribatida mites consists in 71,000 ind./sq.m. (27,400 ind./sq.m. in Izvor, 26,600 ind./sq.m. in Unirii and 16,800 ind./sq.m. in Cişmigiu). The numerical structure of the population of the 55 oribatid species from the forest ecosystems recorded very small differences in the values of the density compared to the parks. As shownin Figure 2, in Baloteşti forest we recorded 67,800 ind./sq.m., and in Băneasa forest 63,200 ind./sq.m.

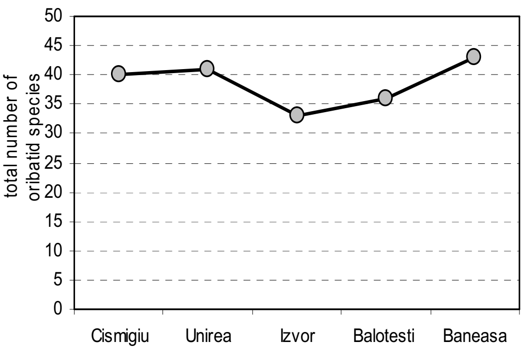

Figure 1: Fluctuations of the number of Oribatid mite species in the soil of central parks and in the forest ecosystems in 2006-2007.

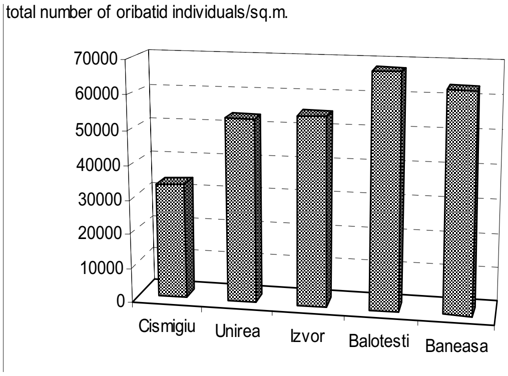

Figure 2: Numerical density (ind./sq.m.) of Oribatid mite species in the soil of central parks and in the forest in 2006-2007.

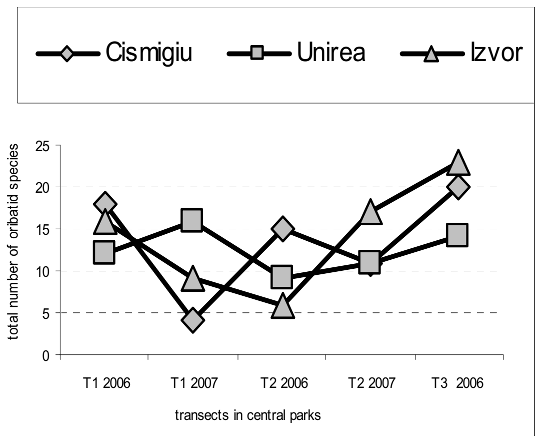

Figure 3: Fluctuations of the number of Oribatid mite species in the soil transects of central in 2006-2007

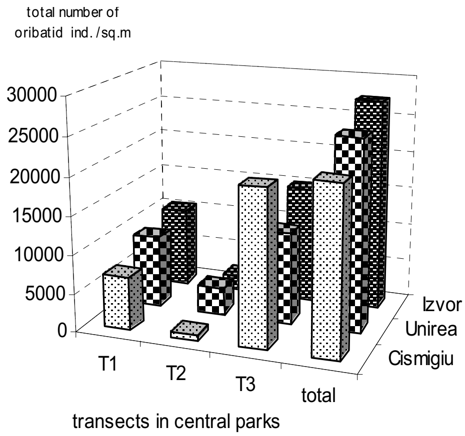

Figure 4: Numerical density (ind. /sq.m.) of Oribatid mite species in the soil transects of central parks in 2006

Studying the structural dynamics on transects in the parks (Figures 3, 4 and 5), we can argue that Oribatida populations had an evolution in concordance with the number of species found in both years. The highest density was registered in first year of the study on Transect 3 (T_3) in all parks; in second year, the highest density was registered on: transect 1 (T_1) in Cişmigiu park, transect 2 (T_2) in Izvor park and in transect 3 (T_3) in Unirii park.

In first year of study, increased density values have been found for: *Trichoribates trimaculatus* (C.L.Koch, 1836) (6200 ind./sq.m) in Cişmigiu park, *Zygoribatulla terricola* V.der. Hammen, 1952 (3400 ind./sq.m) in Unirii park, and *Punctoribates punctum* (C.L.Koch, 1839) (4400 ind/sq.m) in Izvor park. In second year, increased density values have been found for the species: *Zygoribatulla terricola* Hammen, 1952 (2400 ind./sq.m; 2200ind./sq.m) in Cişmigiu and Unirii parks, and *Punctoribates punctum* (C.L.Koch, 1839) (3400 ind./sq.m.) in Izvor park.

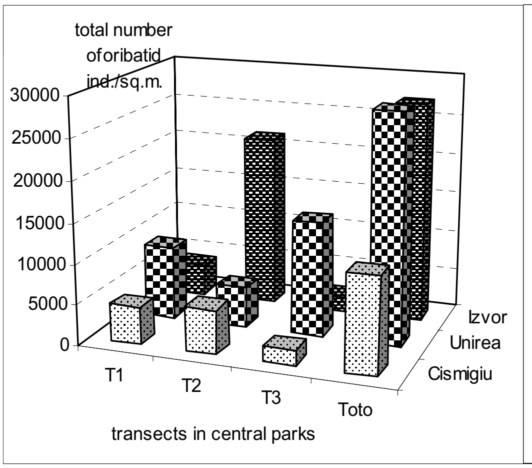

Figure 5: Numerical density (ind./sq.m.) of Oribatid mite species in the soil transects of central parks in 2007.

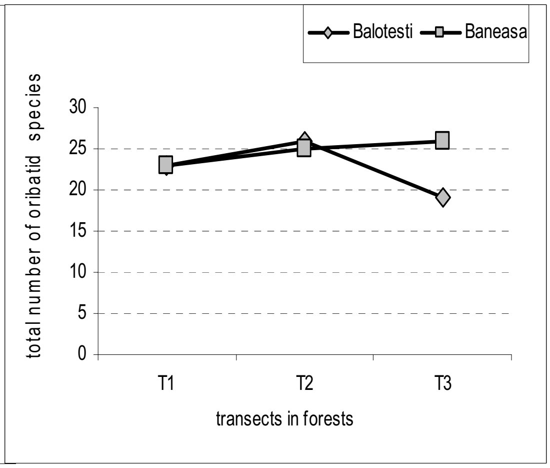

Figure 6: Fluctuations of the number of oribatid mite species in the soil transects of forest ecosystems in 2007.

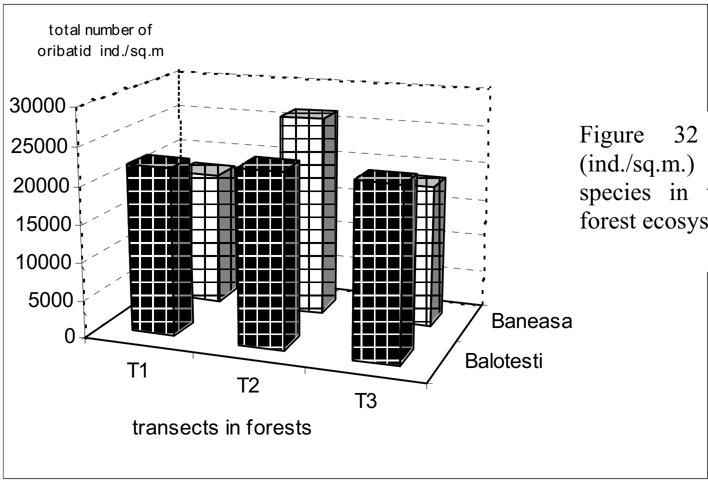

Figure 32 Numerical density (ind./sq.m.) of Oribatid mite species in the soil transects of forest ecosystems in 2007.

In the forests, as shown in Figure 6, the collection of samples on transects and the analysis of the specific and structural differences of the Oribatid populations, showed that the high number of species have been recorded in Baloteşti forest and in T_2 and T_3 in Băneasa forest.

The eudominant-dominant-constant species identified from T_1 and T_2 transects at Baloteşti forest are: *Medioppia obsoleta* (Paoli G., 1908) (4800 ind./sq.m.;1200 ind./sq.m.) and *Tectocepheus velatus* (Michael A. D., 1880) (2400 ind./sq.m.; 5600 ind./sq.m.).

In Băneasa forest the recorded species are: *Metabelba pulverulenta* (C.L.Koch, 1840) (2400 ind/sq.m.) in T_2 and *Damaeollus ornatissimus* (Berlese), 1904 (2800 ind./sq.m) in T_3. The results are different regarding the dynamics of density values from Figure 6, the highest density values being found in T_2 for both forests, contributed by species: *Tectocepheus velatus* (Michael A. D., 1880) *Metabelba pulverulenta* (C.L.Koch, 1840) with the above mentioned densities, with a high number of immature individuals.

The high density values of the recorded species from microsites (transects) level have a great contribution at the density values from macrosite level (entire forest).

The mites fauna from parks is characterized by the presence of the panphytophagous species (24 species in Cişmigiu; 25 species in Unirii and 19 species in Izvor parks). Other trophic categories are less represented by the recorded species from the sites; the higher number of species is represented by mycrophytophages species (11 species in Cişmigiu; 9 species in Unirii and 6 species in Izvor parks). In forests the situation of the representation of this categories is almost the same, with more representation of the panphytophages species as follows: 23 species in Baloteşti forest and 25 species in Băneasa forest.

From the biogeographycal point of view, in parks the mites fauna is mainly characterized by the presence a species with general European distribution, followed by the species with Holarctic and Palaearctic distribution. In the forest ecosystems the oribatid mite species have the same distribution of the European elements, followed by the Palaearctic and Holarctic category.

In all studies areas we recorded a few Siberian, Asian, and N-American species, and very rare (one or two species) with Caucasian, Magrebian, neotropical etc. distribution.

DISCUSSION AND CONCLUSION

In this study the research methods followed the taxonomical and ecological structure and dynamics of the mites groups, in correlation with their importance in the structure and dynamics of the ecosystems as a whole. Taking into account that in the environmental conditions of the forest ecosystems the Ord. Oribatida has the highest number of species and individuals, because of their role as decomposers, in comparison with other micoarthropods, in the structural and dynamical analysis the discussion of the results was done according to the importance of this aspect. As it can be observed in the taxonomical, structural and dynamical researches, the oribatid fauna is dominant in forest ecosystems, and is more representative because of its ecological role as decomposer of the organic matter, aspects also presented in other researches in Romania (Călugăr & Vasiliu 1980; Honciuc 1992, 1993; Honciuc & Stănescu 2000; Honciuc & Stănescu, 2003, 2004, 2005; Stănescu & Honciuc 2005).

The structural (the number of the species and their classification in classes of dominance and constancy) and the dynamic (numerical abundances expressed by the ind./sq.m, between the mites populations from the studied ecosystems) differences are determined by the variations of the environmental conditions in different types of ecosystems, especially between studied parks and forests.

The equal presence of the oribatids, with very closed values of the numerical densities in the studied forests, is due to the similar environmental conditions created by the presence of the same vegetation layer (primary producers), with difference related to Băneasa forest, referring to the abiotic factors (*i.e.* soil, humidity and pH). The increased number of species in the forests (Băneasa and Baloteşti) compared to the parks (Cişmigiu, Izvor and Unirii) as well as the species ratio from the dominance and constancy categories, are due to the specificity of each ecosystem. This specificity is obvious on the transects levels, where obvious differences were observed in the number of species and individuals. In Băneasa forest, toward the centre, on transect 3 (T_3), the increased number of species and numerical density are obvious. Besides the two studied forests which have the same ecological characteristics referring especially to soil, from all identified species, only 7 are common species: *Berniniella bicarinata* Paoli, 1908; *Ramusela insculpta* (Paoli G., 1908); *Oribatella berlesei* (Michael A.D., 1898); *Phthiracarus globosus* (C.L. Koch, 1841); *Belba pseudocorynopus* Märkel, 1960; *Carabodes femoralis* (Nicolet H., 1855); *Ctenobellba pectinigera* (Berlese), 1908. This fact reflects the similarity of the habitats present in these forests. The signalled species in the forests are characteristic to these types of ecosystems from Romania. This group of species is ubiquitous and some eudominant and dominant species were identified in other types of ecosystems as: coniferous forests, meadows, agroecosystems. Most of the of the oribatid species identified in our researches are panphytopages and mycrophytophages, as also reported by other studies (Luxton 1982,1983; Schatz 1983;Vsiliu 1993; Honciuc 2000).

Eudominant and dominant species signalled in these forests such as *Medioppia obsoleta* (Paoli G., 1908); *Ceratoppia bipilis* (Hermann J. F., 1804); *Tectocepheus velatus* (Michael A. D., 1880); *Oribatulla tibialis* Nicolet H., 1855; *Hypochthonilella pallidula* (C.L.Koch sensu Willmann C., 1931); *Damaeollus ornatissimus* (Berlese), 1904, are ubiquitous, being signalled in other studies from other forest ecosystems from Romania (Călugăr & Vasiliu 1980; Honciuc 1992, 1993; Honciuc & Stănescu 2000; Honciuc & Stănescu, 2003, 2004, 2005; Stănescu & Honciuc 2005).

The structural and dynamic differences of the oribatid populations identified in parks are: increased number of species in Cişmigiu and Unirii parks and increased numerical densities in Unirii and Izvor parks. The reason is the specificity of the vegetation and soil structure and of environmental conditions as humidity and pH. Their variations affect the evolution of the populations on the transects level, by increasing or decreasing the species number and the numerical densities.

The more increased abundances of species in the transects from the middle of parks are due to the decreased influence of the impact factors such as the anthropic interventions. In the parks, the eudominant and dominant species, also characterized as euconstant and constant, are ubiquitous.

The identification of species *Zygoribatulla terricola* Hammen, 1952 and *Trichoribates trimaculatus* (C.L. Koch, 1836) as eudominant-euconstant only in Cişmigiu and Unirii can be explained by the diversity and the provenience of the primary producers from these two parks. These species are not ubiquitous, having preferences strictly for organic matter with woody origin (Honciuc, unpublished observations). *Punctoribates punctum* (C.L. Koch, 1839,*Tectocepheus velatus* (Michael A. D., 1880), *Minunthozetes semirufus (*C.L. Koch, 1841) are dominant and ubiquitous. The identification of *Eulohmania cylindrica* (Berlese), 1904 as subdominant-constant species in Izvor park, shows the xerophillous nature of this urban area and the presence of sandy soil, the preferred habitat for this species as is mentioned by other researches from Romania (Paucă-Comănescu M. et al. 1996; Honciuc, unpublished observations). From the structural point of view, regarding the number of species, there is a similarity between Băneasa forest and Unirii and Izvor parks. From the dynamic point of view, the values of the densities are more similar in both forests and Unirii and Izvor parks. The fact that almost a half from the identified species are common to these ecosystems is due to the ubiquitous character of these microarthropods as well as to the soil characteristics and vegetation from the Romanian Plain, where the studied ecosystems are located.

Taking into account our results, we can conclude that the oribatid species, mainly saprophages-decomposer, with an important role in the decomposition process of the detritus and organic matter in soil, are directly correlated with the presence and the availability of the food source, which depends of the environmental factors.

In forest ecosystems the similarity of the soil structure and a few differences of vegetation, determined the different values of the number of species and the close values of the numerical density for all identified mites species.

The presence of an increased number of accessory and accidental species reflects the modification of the trophic source of mites, due to the biotic and abiotic factors.

Besides these above mentioned species, classified in dominance and constancy classes, the increased number of accessory and accidental species from all three parks is due to the anthropic interventions. These species could be brought together with the soil from other sites or with modifications of the soil structure.

The decreased number of the common species from the two forests and the three parks showed the different influence of the environmental factors on the structure of the oribatid, as well as the variability of the vegetation and soil structure.

Studying the saprophagous-detritophagous oribatid mites from forest ecosystems and the central parks from Bucharest, we can argue that Cişmigiu park is a particular case regarding the meaningful structural difference (number of species, diversity) but not so important dynamic difference.

Making a comparison between the specific structure and the numerical densities of the oribatid populations from forest ecosystems and parks, we observed the presence of fluctuations of these parameters correlated with the specific bio-edaphic conditions.

In parks (except the Cişmigiu park), similar species diversity and numerical density for oribatid mites populations are determined by environmental conditions (vegetation, humidity and pH of soil, etc.).

The dominance of the some trophic category (panphytophages species) in all studied areas showed that the influence of oribatid mites species in the decomposition process is the same because the ecological conditions for this category are the same in all studies areas in spite of the fact that these areas are polluted or non-polluted.

For the first time in Romania, studies of oribatid mite fauna from the urban area have been performed in comparison with natural forest ecosystems. Further studies on the influence of pollution on the mites species are necessary, combined with monitoring the impact of other abiotic and biotic factors on these invertebrates.

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STRUCTURE AND DYNAMICS OF THE PREDATORY MITES (ACARI: MESOSTIGMATA- GAMASINA)

Minodora Manu

INTRODUCTION

"Ubiquitous" is a much abused adjective that literally means "being everywhere", but in practice it means considerably less. The word is often trotted out by ecologists and systematisers to justify their work on a particular group of animals. However, mites have a fair claim for being truly omnipresent. With the exception of the water column of the open ocean, they are in every sort of aquatic, terrestrial, arboreal and parasitic habitat. The optimal bioedaphic conditions for their development are the reason of a very rich mites' fauna, representing about 80% from the number of individuals from total soil fauna.

In nature, mites play a positive role. Regarding the position and the role of the gamasids populations in the trophic structure of the soil fauna, these studies give us information about the importance of the acarofauna in the energy and matter flows, at different trophic levels. The role of the predatory mites is important to understand their influence in the soil system, especially on the limit between soil and litter.

Mesostigmatids-gamasids influence the dynamics of other invertebrate populations like: nematodes, enchytreids, earthworms, carabides, springtails, aphids, dipterans, others mites. The majority of the functional groups of invertebrates are not included in the decomposers level. This aspect impacts on the decomposing process, by regulating other invertebrates populations. The activity of the gamasids in soil as the second and the third consumers in ecosystem, consist in transformation of the primary and secondary organic matter.

The use of the quantitative statistical parameters, that characterize the structure and functions of the soil mite populations, parameters which are influenced by the abiotic factors (*i.e.* airborne pollution), allows the use of soil mites as bioindicators of air pollution.

MATERIAL AND METHODS

The studies have been performed in three parks from Bucharest (Cişmigiu, Unirii and Izvor) as pilot area and in reference forests (Băneasa and Baloteşti forests) near by the city, in 2006 and 2007. The forests have been chosen as less polluted areas being far from the city and the main pollution source (traffic).

The structure of Baloteşti and Băneasa forests and Cişmigiu, Unirii and Izvor central parks ecosystems and the environmental conditions associated with the forests and parks are described by Onete and Paucă-Comănescu (2008, this volume).

For a correct analysis of the dynamics of the gamasid populations, the studies have been done taking into account the number, size, periodicity and the structure of the soil samples.

The mites fauna was directly collected from layers of 10 cm with a MacFadyen corer. A number of 15 samples was collected from each study area. The soil layers were separated at the moment of sampling in the same time units (day), after macro-morphological criteria. Each sample was divided in L layer (surface litter), S1 - the first layer of soil and S2 - the second layer of soil (variable weight). The samples were taken from three transects (T_1 - near to the main road, T_2 - the lateral side of the studied area and T_3 – in the middle of the studied area) (Figure 1).

Cişmigiu Izvor Unirii

Figure 1: Transects established in the studied parks from Bucharest: Cişmigiu, Izvor and Unirii.

The identification of the mites species from Mesostigmata order was made at genera and species level. Extraction was performed with a modified Berlese-Tullgren extractor, in ethylic alcohol and the extracted mites individuals were clarified in lactic acid.

After taxonomical identification, the numerical abundance was obtained, forming a database to determine the numerical density (no. of ind/m^2), relative abundance (A%) and constancy (C). Taking into account that the studied layers have variable thickness, the numerical densities of the mite populations were reported by surface unit (square meter).

The main abiotic factors: humidity and pH of soil were measured in order to reveal the structural and dynamic differences of the mites populations from the studied areas (Table 1).

Table 1: Averages humidity and pH of soil in studied areas

Abiotic Factors	Forests		Parks		
	Băneasa	Baloteşti	Cişmigiu	Unirii	Izvor
Mean soil humidity %	22	15.27	10.23	12.37	9.89
pH	5.87	5.7	7.15	7.45	6.73

RESULTS AND DISCUSSIONS

In all studied ecosystems, the taxonomical structure shows the presence of 38 species of Gamasina, according to Ghiliarov & Bregetova (1977) and Karg (1993), included in 22 genera and 10 families: Parasitidae, Veigaidae, Ameroseiidae, Phytoseiidae, Rhodacaridae, Pachylaelapidae, Pseudolaelapidae, Laelaptidae, Eviphididae and Zerconidae (Table 2).

In the forest ecosystems gamasids were represented by 24 species (21 species in Băneasa and 16 species in Baloteşti) (Table 3). In parks the taxonomical identification revealed the presence of 23 gamasid species (Table 4).

From the structural point of view, the mites fauna from the studied ecosystems was characterized by the presence of the common species from forests, common species for the parks and of common species for all types of researched areas.

The common gamasids from forest ecosystems were: *Lysigamasus truncus* Schweizer, 1961; *Leptogamasus* sp.; *Pergamasus* sp., *Veigaia nemorensis* C. L. Koch, 1938; *Asca aphidoides* Linne, 1758; *Asca bicornis* Caneastrini and Fanzago, 1887; *Rhodacarellus silesiacus* Willmann, 1936; *Pseudolaelaps doderoi* Berlese, 1916; *Olopachys suecicus* Sellnick, 1950; *Hypoaspis miles* Berlese, 1892; *Zercon hungaricus* Sellnick, 1958; *Prozercon traegardhi* Halbert, 1923; *Prozercon fimbriatus* C.L. Koch, 1839.

Table 2: Mesostigmatid mites species identified in the studied sites.

Gamasina species	Parks	Forests	Habitats	Trophical preferences	Distribution
Lysigamasus neoruncatellus Schweizer 1961	+		In forestry ecosystems.	Predator	Europe and S. America
Lysigamasus cornutus Schweizer 1961		+	In litter and fermentation layer from forest ecosystems, in humus, in moos.	Predator	Central Europe
Lysigamasus truncus Schweizer 1961		+	Coastal meadows, in decaying vegetation, grassland, moss and in stored cereal products.	Predator	Central Europe
Lysigamasus sp.		+			
Leptogamasus sp.	+	+		Predator	
Pergamasus sp.	+	+		Predator	
Pergamasus laetus Ilinca Juvara Bals, 1970		+	Litter of deciduous and coniferous forests.	Predator	Romania
Pergamasus quisquiliarum G. and R. Canestrini, 1882		+	Agroecosystems, birch stands.	Predator	Europe and S. America
Parasitus beta Oudemans and Voigts, 1904	+				
Holoparasitus calcaratus C.L. Koch, 1839		+	In orchards, meadows, moos, soil.	Predator	Europe
Veigaia nemorensis C. L. Koch,1938	+	+	Inland and coastal meadows, forests, agroecosystems, washed ashore material, dunes, bogs, calciferous bog, *Acer spp.*	Predator	Europe, Asia
Veigaia exigua Berlese, 1917	+	+	In decaying vegetation, heathland, sand dunes, lichen.	Poliphagous	Europe
Ameroseius fimentorum Karg, 1971	+		In decaying vegetation	Predator	Central Europe
Amblyseius meridionalis Berlese, 1914	+		In moss, dunes, coastal meadows, *Pinus spp., Juniperus communis.*	Poliphagous	Europe
Amblyseius obtusus C.L.Koch, 1839	+				
Asca bicornis Caneastrini and Fanzago, 1887	+	+	In decaying vegetation, grasslands, under stones in sand	Predator	Europe
Asca aphidoides Linne, 1758		+	Forests, bogs, coastal meadows.	Predator	Europe
Dendrolaelaps sp.	+	+			
Rhodacarellus silesiacus Willmann, 1936	+	+	In decaying vegetation, grassland, bogland, arable fields, farm animal waste.	Poliphagous	Europe, Asia, N. Africa, N. America, Australia
Rhodacarellus perspicuus Halaskova, 1958	+		In soil	Poliphagous	Central Europe
Rhodacarus denticulatus Berlese, 1921	+				
Protogamasellus singularis Karg, 1962		+	In meadows, fields, in soil, humus, sand.		Europe
Pachyseius humeralis Berlese, 1910		+	In decaying vegetation, grassland, arable fields and in a mine.		Europe
Pachylaelaps pectinifer C. and R. Canestrini, 1882		+	In soil, humus of the forest ecosystems.		Europe
Olopachys suecicus Sellnick, 1950		+	In humus and litter, in moos.		Europe

Hypoaspis miles Berlese, 1892		+	Inland meadows.		Europe, Asia
Pachylaelaps furcifer Oudemans, 1903	+		In mixed and deciduous forests, beech forest, inland and coastal meadows, *Acer spp.*	Predator	Europe
Olopachys vysotskajae Koroleva, 1976	+				
Pseudolaelaps doderoi Berlese, 1916	+	+	In decaying vegetation, grassland, under stones, in arable fields.	Predator	Europe
Hypoaspis aculeifer Caneastrini, 1883	+		In decaying vegetation, grassland, heathland, sand dunes, seashore, moss, small mammal and bird nest, cola shale, arable fields, in stored cereal products, farm animal waste.	Poliphagous	Europe, Asia, South America, North America
Hypoaspis praesternalis Willmann, 1949	+		Coastal meadows, dunes, spruce stands, pine forests, dungs, bogs, nests of wild birds.		Europe, Africa
Crassicheles concentricus Oudemans, 1904	+		In soil.		Europe
Alliphis siculus Berlese, 1921	+		Fields, gardens, forests, dung, inland and coastal meadows, washed ashore material.		Europe
Prozercon fimbriatus C.L. Koch, 1839	+	+	In decaying vegetation, moss.	Omnivorous	Europe
Prozercon traegardhi Halbert, 1923		+	In decaying vegetation and grassland.	Omnivorous	Central and North Europe
Prozercon sellnicki Halaskova, 1963		+	Inland and coastal meadows, washed ashore material.	Omnivorous	Central Europe
Zercon hungaricus Sellnick, 1958		+	In soil.	Omnivorous	Europe
Zercon fageticola Halaskova, 1970		+	Dunes, forest ecosystems.	Omnivorous	Central Europe
Immature	+	+			

The following common gamasid species were identified in the parks: *Rhodacarellus silesiacus* Willmann, 1936 and *Hypoaspis aculeifer* Caneastrini, 1883.

The following common 9 gamasid species were identified in all studied ecosystems: *Leptogamasus* sp.; *Pergamasus* sp.; *Veigaia nemorensis* C. L. Koch, 1938; *Veigaia exigua* Berlese, 1917; *Asca bicornis* Caneastrini and Fanzago, 1887; *Rhodacarellus silesiacus* Willmann, 1936; *Pachyseius humeralis* Berlese, 1910; *Pseudolaelaps doderoi* Berlese, 1916; *Prozercon fimbriatus* C.L. Koch, 1839.

Analysing the relative abundance (Ar %) and constancy (C%) of the identified species from the studied ecosystems, according to the statistical analysis (Lehmann & D'Abrera 1998; Honciuc, unpublished observations, 2000; Stănescu, unpublished observations, 2007), the mite populations can be divided in dominance and constancy classes. The mite species from the highest classes of dominance and constancy are the most important as population structure and indirectly in the decomposing process. This is the reason of focusing the researches on these mites.

In the forest ecosystem from Baloteşti, the gamasids species were classified as: eudominant-euconstant: *Prozercon fimbriatus* C.L. Koch, 1839 and *Zercon hungaricus* Sellnick, 1958; eudominant-constant: *Asca aphidoides* Linne, 1758 and *Pseudolaelaps doderoi* Berlese, 1916; dominant-accessories: *Prozercon traegardhi* Halbert, 1923; subdominant-accessory: *Veigaia exigua* Berlese, 1917 and *Olopachys suecicus* Sellnick, 1950 (Table 3).

Table 3. The relative abundance (Ar %) and constancy (C %)
of the Gamasina mite species in the reference sites

Species	Baloteşti		Băneasa	
	Ar	C	Ar	C
Prozercon fimbriatus C.L. Koch, 1839	26.53	80	33.70	100
Zercon hungaricus Sellnick, 1958	18.37	80	2.17	40
Pergamasus laetus Ilinca Juvara Bals, 1970			4.35	80
Asca aphidoides Linne, 1758	8.16	60	1.09	20
Pseudolaelaps doderoi Berlese, 1916	8.16	60	5.43	60
Veigaia nemorensis C. L. Koch,1938	4.08	40	16.30	80
Lysigamasus cornutus Schweizer 1961			4.35	60
Veigaia exigua Berlese, 1917	4.08	40		
Olopachys suecicus Sellnick, 1950	4.08	40	2.17	40
Prozercon traegardhi Halbert, 1923	6.12	40	4.35	60
Lysigamasus truncus Schweizer 1961	2.04	20	2.17	40
Leptogamasus sp.	2.04	20	2.17	40
Pergamasus quisquiliarum G. and R. Canestrini, 1882			2.17	40
Pachyseius humeralis Berlese, 1910			2.17	40
Pachylaelaps pectinifer C. and R. Canestrini, 1882			2.17	40
Prozercon sellnicki Halaskova, 1963			2.17	40
Pergamasus sp.	2.04	20	1.09	20
Asca bicornis Caneastrini and Fanzago, 1887	4.08	20	1.09	20
Rhodacarellus silesiacus Willmann, 1936	2.04	20	1.09	20
Protogamasellus singularis Karg, 1962	2.04	20		
Hypoaspis miles Berlese, 1892	4.08	20	2.17	20
Zercon fageticola Halaskova, 1970	2.04	20		
Lysigamasus sp.			1.09	20
Holoparasitus calcaratus C.L. Koch, 1839			1.09	20
Immature			5.43	40

In Băneasa forest the eudominant–euconstant species are: *Prozercon fimbriatus* C.L. Koch, 1839 and *Veigaia nemorensis* C. L. Koch, 1938, followed by the dominant-euconstant: *Pergamasus laetus* Ilinca Juvara Balş, 1970 and by *Pseudolaelaps doderoi* Berlese, 1916 as dominant-constant. Species *Lysigamasus cornutus* Schweizer, 1961 and *Prozercon traegardhi* Halbert, 1923 were subdominant-constant (Table 3).

The identified gamasid species from all three parks, presented in Table 4, are common species for the temperate forest ecosystems, as reported by many researchers (Karg, 1993; Salmane, 2001; Skorupski, 2001; Gwiazdovicz & Maciej 2004).

The following species have been identified in Cişmigiu park: *Rhodacarellus perspicuus* Halaskova,1958 as eudominant–euconstant; *Rhodacarellus silesiacus* Willmann, 1936 as eudominant–constant; *Hypoaspis aculeifer* Caneastrini, 1883 and *Veigaia nemorensis* C. L. Koch, 1938 as dominant-accessories species; *Pachyseius humeralis* Berlese, 1910 as eudominant-accidental.

In Unirii park the situation is as follows: species *Asca bicornis* Caneastrini and Fanzago, 1887 is eudominant-euconstant; species *Pseudolaelaps doderoi* Berlese, 1916 eudominant–accidental; species *Hypoaspis aculeifer* Caneastrini, 1883 and *Hypoaspis praesternalis* Willmann, 1949 are dominant-accessory.

In Izvor park the identified gamasids are represented by: eudominant–euconstant species *Hypoapsis aculeifer* Caneastrini, 1883; eudominant-constant species *Ameroseius fimentorum* Karg, 1971; eudominant-accidental species *Hypoaspis praesternalis* Willmann, 1949; dominant-accessory species *Amblyseius meridionalis* Berlese, 1914 and *Pseudolaelaps doderoi* Berlese, 1916; and dominant-accidental species: *Rhodacarellus perspicuus* Halaskova, 1958; *Rhodacarellus silesiacus* Willmann, 1936 and *Amblyseius obtusus* C.L.Koch, 1839. In all ecosystems the unmentioned species have been classified as subdominant and accidental, due to the low recorded values of abundance and constancy.

Table 4: The relative abundance (Ar %) and constancy (C %)
of the Gamasina mite species in central parks

Species	Cişmigiu		Unirii		Izvor	
	Ar	C	Ar	C	Ar	C
Asca bicornis Caneastrini and Fanzago, 1887			26.83	100		
Rhodacarellus perspicuus Halaskova, 1958	32.14	80			8.57	40
Rhodacarellus silesiacus Willmann, 1936	14.29	60	2.44	20	5.71	40
Amblyseius obtusus C.L.Koch, 1839			4.88	40	8.57	40
Veigaia nemorensis C. L. Koch,1938	7.14	40			2.86	20
Hypoaspis aculeifer Caneastrini, 1883	7.14	40	7.32	40	17.14	80
Hypoaspis praesternalis Willmann, 1949			7.32	40	11.43	20
Crassicheles concentricus Oudemans, 1904			4.88	40		
Lysigamasus neoruncatellus Schweizer 1961			2.44	20		
Lysigamasus truncus Oudemans, 1901	3.57	20				
Leptogamasus sp.	3.57	20				
Parasitus beta Oudemans and Voigts, 1904	7.14	20			2.86	20
Ameroseius fimentorum Karg, 1971	3.57	20			17.14	60
Macrocheles sp.	3.57	20				
Pachyseius humeralis Berlese, 1910	14.29	20				
Pachylaelaps furcifer Oudemans, 1903	3.57	20			2.86	20
Amblyseius meridionalis Berlese, 1914			2.44	20	5.71	40
Dendrolaelaps sp.			2.44	20		
Rhodacarus denticulatus Berlese, 1921			2.44	20		
Olopachys vysotskajae Koroleva, 1976			2.44	20		
Pseudolaelaps doderoi Berlese, 1916			21.95	20	5.71	40
Alliphis siculus Berlese, 1921			2.44	20		
Pergamasus sp.					2.86	20
Veigaia exigua Berlese, 1917					2.86	20
Prozercon fimbriatus C.L. Koch, 1839					2.86	20
Immature			2.44	20	5.71	40

In the forest ecosystems we identified 24 species of gamasids, with 18,400 ind./sq.m.in Băneasa, and lower number in Baloteşti (9,600 ind./sq.m.).

In parks we have identified 23 species of Mesostigmata (14 species in Unirii, 14 species in Izvor and 11 species in Cişmigiu). In dynamical structure, the total numerical density is 21,000 ind./sq.m. (8,200 ind./sq.m. in Unirii; 7,200 ind./sq.m. in Izvor and 5,600 ind./sq.m. in Cişmigiu) (Figure 2 and 3).

In the forests, at the transects level (Figure 4 and 5), analysing the specific and structural differences of the Mesostigmata populations, the most increased number of the identified species, as well as the numerical density were recorded on transect 3 (T_3) at Baloteşti and on transect 1 (T_1) at Băneasa. The dominant identified species from these transects, at Băneasa is *Prozercon fimbriatus* C.L. Koch, 1839 (1200 ind./sq.m.) and at Baloteşti are *Veigaia nemorensis* C. L. Koch, 1938 (1000 ind./sq.m.) and *Prozercon fimbriatus* C.L. Koch, 1839 (1400 ind./sq.m.). All these species with their highest density values have a contribution to the total density values in these forests.

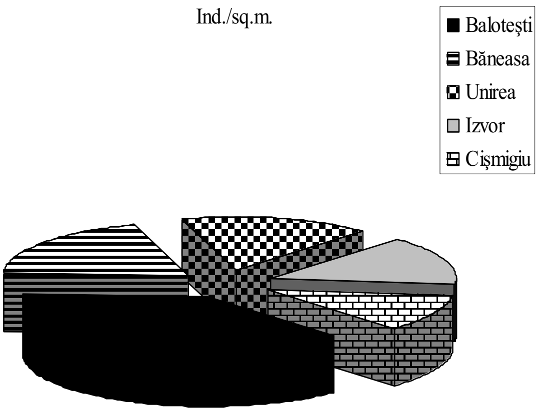

Figure 2: Fluctuations of the number of Gamasina mite species in soil of forest ecosystems and in central parks

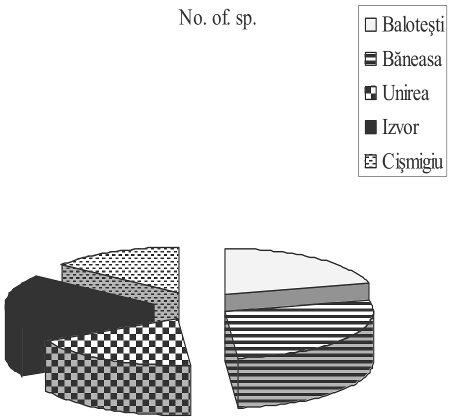

Figure 3: Numerical density (ind. /sq.m.) of Gamasina mite species in soil of forest ecosystems and in central parks

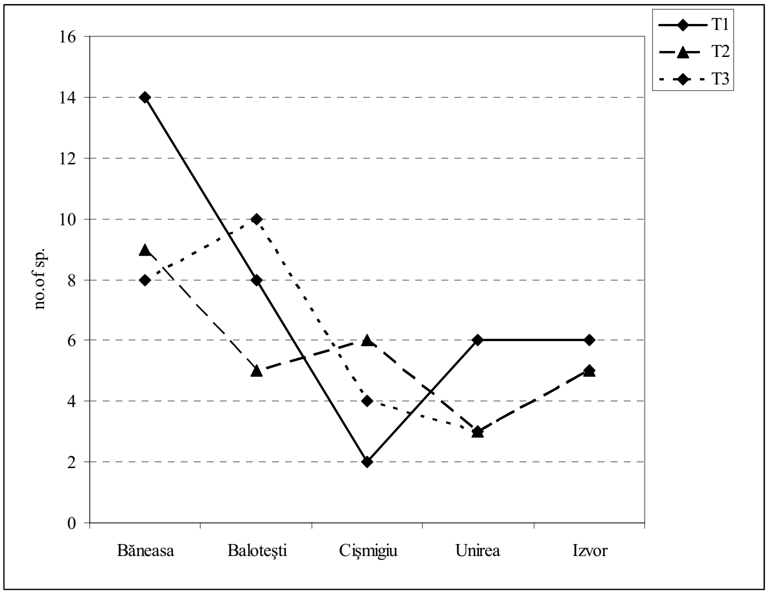

Figure 4: Fluctuations of the number of Gamasina mite species in soil transects from forest ecosystems and parks

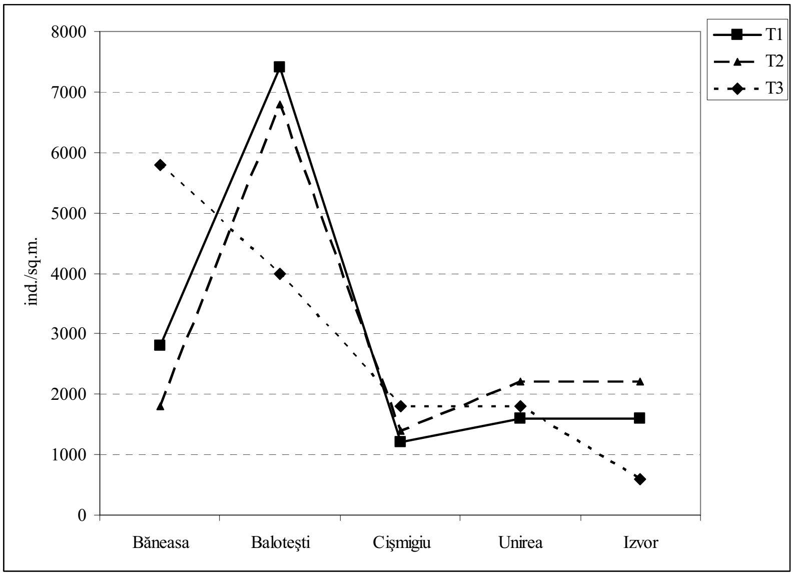

Figure 5: Numerical density (ind./sq.m.) of Gamasina mite species on transects from forest ecosystems and in central parks

Analysing the specific structure, the predator mites recorded the highest values at T_1 in Unirii and Izvor and at T_3 in Cişmigiu in the first year (2006). The highest values of numerical density were recorded in T_2 at Unirii and Izvor and in T_3 at Cişmigiu. These increased values were recorded in 2006, in the mentioned transects for *Pseudolaelaps doderoi* Berlese, 1916 (1800 ind./sq.m.) in Unirii, for *Asca bicornis* Caneastrini and Fanzago, 1887 (1000 ind./sq.m.) in Izvor and for *Rhodacarellus perspicuus* Halaskova, 1958 (1000 ind./sq.m.) in Cişmigiu. In the second year, the specific structure as well as numerical density showed the highest values in T_1 at Izvor, in T_2 at Cişmigiu and in T_3 at Unirii. The dominant species in Izvor were: *Amblyseius meridionalis* Berlese, 1914, *Hypoaspis aculeifer* Caneastrini, 1883 and *Hypoaspis praesternalis* Willmann, 1949 (each recording 400 ind./sq.m.); in Cişmigiu they were *Rhodacarellus perspicuus* Halaskova, 1958 and *Hypoaspis aculeifer* Caneastrini, 1883 (each recording 200 ind./sq.m.) and in Unirii, *Asca bicornis* Caneastrini and Fanzago, 1887 (800 ind./sq.m.) and *Hypoaspis praesternalis* Willmann, 1949 (600 ind./sq.m.).

Our researches had as base the taxonomical position of the mites and their importance in the structure and dynamics of the studied ecosystems.

The structural (species number and their classification in classes of dominance and constancy) and dynamic (numerical abundances expressed by the ind./sq.m) differences of mites populations, appear due to environmental factors variations between the different types of studied ecosystems (forests and parks) and within the same ecosystem (at micro-site level).

Regarding the predator mites, the highest number of species and numerical densities recorded in Băneasa forest were due to the better environmental conditions, compared to Baloteşti forest. These conditions determined the most increased number of the identified species, as well as the numerical density in T1 at Băneasa and in T_3 at Baloteşti.

The eudominant-euconstant species identified in forest ecosystems from Baloteşti and Băneasa were signalled by us (Honciuc & Stănescu, 2000; Stănescu & Juvara-Balş, 2005; Stănescu & Honciuc, 2006) and by other specialists, as common species for deciduous forest ecosystems from temperate area, having as preferred habitats the litter and soil layers. These are omnivorous species, having a wide trophic spectrum, which allowed a better adaptation to the variations of the environmental conditions. Among the eudominant species signalled in these forests, *Veigaia* *nemorensis* C. L. Koch, 1938 is ubiquitous, surface dweller, hemiedaphic species, predator, characteristics mentioned in different papers (Skorupski & Luxton, 1998; Koehler, 1999; Honciuc & Stănescu, 2000; Salmane, 2001; Stănescu & Juvara-Balş, 2005; Stănescu & Honciuc, 2006; Gwiazdowicz, 2007).

The particularities of the species classifications from parks were due to the environmental characteristics of each urban area. In Cişmigiu park, eudominant-euconstant identified species were found on the soil surface, being very mobile species, of small dimensions, which can easily adapt to the unfavourable environmental conditions (species from *Rhodacarellus* genera). The dominant species *Hypoaspis aculeifer* Caneastrini, 1883 and *Veigaia nemorensis* C. L. Koch, 1938 are ubiquitous, predators, common for the terrestrial ecosystems. They prefer different habitats from the deciduous and coniferous forests, to agroecosystems, inland and coastal meadows, washed ashore material, dunes. In Unirii park *Asca bicornis* Caneastrini and Fanzago, 1887 is predator, being identified in similar xerophytic habitats as those from this urban area (Skorupski & Luxton, 1998; Koehler, 1999; Salmane, 1999, 2000, 2001, 2003; Gwiazdowicz, 2007). It was also reported in industrially polluted areas. Other dominant species *Hypoaspis aculeifer* Caneastrini, 1883 and *Hypoaspis praesternalis* Willmann, 1949, identified in this park, are polyphagous, their food source being the other soil invertebrates fact demonstrated by Ruf (1995 a,b; 1997). Having a wide trophic spectrum these could easily adapt to the environmental conditions from the urban areas. These species were recorded in xerophytic habitats as: coastal and inland meadows, dunes, spruce stands, pine forests, dung, bogs, by the Skorupski & Luxton (1998), and Salmane (2001). In Izvor park, the environmental conditions (poor vegetation, dry soil), could determine the appearance of some insects, their larva representing the food source for these predators, in generally, and for the phytoseids species, especially: *Amblyseius meridionalis* Berlese, 1914 and *Amblyseius obtusus* C.L. Koch, 1839.

CONCLUSIONS

Taking in account our results, we can conclude that most gamasid species are predators, with an important role in the regulation of other invertebrates groups in soil. This group is directly correlated with the presence and availability of the food source, which depends on the environmental factors.

In the studied forest ecosystems (Baloteşti and Băneasa) the similarity of the soil structure and vegetation, determined the close values of the number of species and numerical densities for all identified mites.

In urban areas (Cişmigiu, Unirii and Izvor parks), the dryness, the missing or the poorly litter layer are unfavourable conditions for development of gamasid populations. That is why lower values of the gamasid species number and of the numerical densities were recorded (almost half values from the forests).

The presence of an increased number of accessory and accidental species reflects the modifications on the trophic source of mites, due to the biotic and abiotic factors.

Besides these above mentioned species, classified in dominance and constancy classes, the increased number of accessory and accidental species from all three parks is due to the anthropic interventions. These species could be brought in with the plantation of ornamental plants or with modifications of soil structure.

The decreased number of the common species between the two forests and the three parks showed the different influence of the environmental factors on the structure of the gamasid populations, as well as the variability of the soil structure.

Concerning the predator mite populations, differences were obvious at the structural and dynamics levels, especially between forest ecosystems and parks areas. These differences were due to the environmental conditions, which affect indirectly the trophic spectrum of the gamasid mites.

The environmental conditions (vegetation, humidity and pH of soil) determined in parks a decreasing diversity of species and of the numerical density for mesostigmatid populations. The researches regarding the air pollution impact on the mites population are very new for Romania. Mesostigmatid predatory mites are well suited as bioindicators, because they are very sensitive to the human impact. They are abundant species rich in a variety of biotopes and play a key role in the energy flow and in the nutrition web of soil ecosystems.

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CENTIPEDES FROM URBAN ENVIRONMENT

Mihaela Ion

INTRODUCTION

Humans react very different when they make contact with the arthropods living in the urban ecosystems. Most of the times they are scared or at least they repel the creepers that are invading the homes, endangering the family health and comfort. Besides individual insecticides use in housing, community level disinfection programs are employed. But, once used, these chemicals or biochemicals are affecting the living organisms that enchant and relax us every time we get out in an urban park. Those could be the singing birds, squirrels or arthropods like butterflies, ladybirds or the dragonflies flying over a small lake. Other arthropods, unseen and unknown by most of the people, species living under the layer of leaf, in soil or under the logs, can be affected too. In spite of their obscurity, these species have a role in the simplified ecosystem of urban parks and gardens. Among these there are the species belonging to the Class Chilopoda, invertebrates characterized by more than 4 pairs of legs, predators living on soil, prey for many species of birds.

Centipedes, like other residents of urban spaces, can be affected both by the temperature (the urban heat island) and by other human activities (atmospheric pollution, car traffic etc.).

A serious problem in understanding urban ecosystems and the impact of pollution on them is the lack of information regarding the ecology of soil organisms living in the green spaces. Miriapoda fauna was the subject of some recent scientific studies in European cities. Andersson (1983) studied the centipede communities from Göteborg, Zapparoli (1992) worked in Rome, Wytwer (1995) in Warshaw and Stoev (2004) in Sofia. In many other European cities the structure of the centipede populations remains unknown.

Only a few mentions about centipede species found in gardens from Bucharest or in periurban forests, were found in literature but special studies for the urban fauna are missing.

For the first time a scheme for collecting, describing and monitoring the centipede fauna in Bucharest was developed within the framework of Life-Air Aware project.

METHODS

In the parks situated in the studied area (Izvor, Cişmigiu and Unirii) during two years, four collecting campaign (three days each), were put in practice (2006 in August and 2007 in May, July and September).

The biological material was manually captured with tweezers from 0.0625 sqm sample units consisting of soil layer up to 10cm depth and leaf litter, if present.

Totally, we collected from the parks forty-seven sample units in each campaign, as is follows:

- In the largest park, Izvor, 25 points - 5 points/side of the park and 5 points in the centre.
- In Unirii park we have established 12 points - 10 points/side on the east and west side (the latter with more trees and shrubs) and 2 points in the middle.
- In Cişmigiu park the main alley is running from S-E to N-W with large old trees on the west side, and less human intervention through plantation of decorative species. On the main alley we established 5 collecting points, the rest up to 10 points being set on the opposite side of the park, close to the artificial lake.

The centipedes were stored in glass vials with 70% ethylic alcohol, and determined in the laboratory at species level. Chemical analysis have been performed.

Izvor Unirii Cişmigiu

Figure 1: Location of the set sampling points in the three parks from the central zone of Bucharest

RESULTS AND DISSCUTIONS

A total of 103 individuals, belonging to orders Lithobiomorpha and Geophilomorpha, were collected during the four sampling campaigns. Scolopendromorpha order is represented only by an individual belonging to *Cryptops hortensi* species. The July sampling campaign was fruitless, with no centipede found.

In Izvor park we determined the highest mean density with 18.77 ind/sqm, and also the richest specific diversity (with 9 of a total of 10 species). Cişmigiu park was poorer, with only 4 species and numerical density of 5.3 ind/sqm, while Unirii park had only 1.78 ind/sqm (Figure 2).

In May 2007, in Izvor, a numerical density of 40.3 ind/sqm was determined, the highest obtained in the monitoring period. In Cişmigiu, September 2007 the density reached 11.2 ind/sqm, while in Unirii it remained low.

The most frequent centipede species were *Lithobius muticus* (C.L. Koch, 1847) and *Lithobius lucifugus* (L. Koch, 1862), with central European geographic distribution, belonging to Lithobiomorpha order (Figure 3 and Table 1). Order Geophilomorpha was represented mainly by *Clinopodes flavidus* (C. L. Koch, 1847) and *Henia illyrica* (Meinert, 1870), the latter, a thermophilic species, present in the deciduous woodlands around Bucharest (Cernica and Comana forest)(Matic, 1972).

Strigamia acuminata (Leach, 1815) was found only in Unirii, but it is worth mentioning that many geophilomopha juveniles from Izvor and Cişmigiu were not identified to species level and they might be *Strigamia.*

In Unirii and Cişmigiu parks, the percentage (from total centipedes) represented by individuals from Geophilomorpha order is 75% and 90%, respectively. In Izvor, Lithobiomorpha predominate with 69%, showing a more resembling structure to the one found in natural ecosystems less influenced by humans. In such of ecosystems the Lithobiomorpha is 45%-68% of the capture made following the same methods (Figure 4). This could be explained by the fact that Izvor park has the largest area, the human intervention is lower and most of the leaf litter is not removed, at least in some parts of the park. The favoured hiding place for Lithobiomorpha is the litter, while geophilomorphs hide in soil layers.

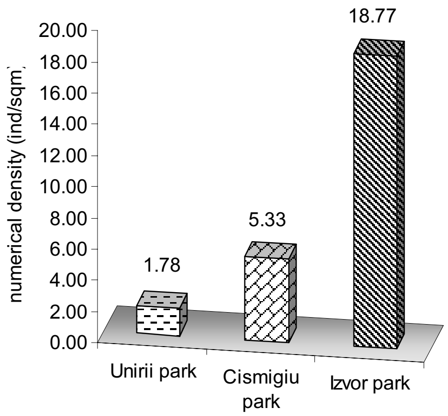

Figure 2: Numerical average density (over the monitoring period) of Chilopoda populations in Bucharest

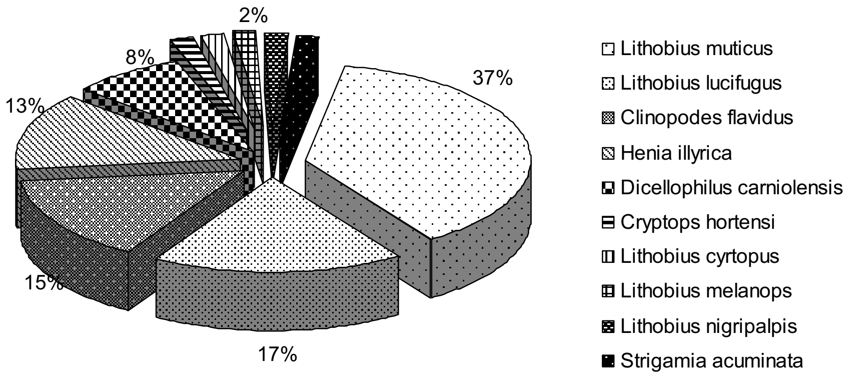

Figure 3: Dominance structure of Chilopoda communities in central parks in Bucharest

Table 1: Species determined in Bucharest urban environment

SPECIES	CIŞMIGIU	IZVOR	UNIRII	Distribution
Lithobius muticus C.L. Koch, 1847	−	+	−	C-EUR
Lithobius lucifugus L. Koch, 1862	−	+	−	C-EUR
Lithobius cyrtopus Latzel, 1880	−	+	−	C-SE EUR
Lithobius melanops Newport, 1845	−	+	−	CARPATIC
Lithobius nigripalpis L. Koch, 1867	+	+	−	E-MEDIT
Clinopodes flavidus C. L. Koch, 1847	+	+	−	BALKAN
Henia illyrica Meinert, 1870	+	+	−	S-EUR
Dicellophilus carniolensis Koch, 1847	+	+	−	C-EUR
Strigamia acuminata Leach, 1815	−	−	+	EUR
Cryptops hortensi Donovan, 1810	−	+	−	EUR-MEDIT

Legend:
C-EUR - Central European; C-SE EUR – Central Southern-Eastern European;
E-MEDIT – East Meditarean; S-EUR – Southern European; EUR – European; EUR-MEDIT – European-Mediteranean

The chemical analysis at *Lithobius muticus* (C.L. Koch, 1847) and *Lithobius lucifugus* (L. Koch, 1862) revealed the presence of copper in their tissue. The quantities of copper, in ppm, are high and close to the values obtained by Hopkin in *Lithobius variegatus* Leach, 1813 from polluted deciduous woodlands in England, found in the vicinity of smelting works (Hopkin 1983). Lead and cadmium is undetectable, zinc quantities are lower that in the mentioned study (Table 2).

Table 2: Copper and zinc concentration (mg/kg) in *Lithobius muticus* and *Lithobius lucifugus* from Izvor Park in comparison with the same metals content in *Lithobius variegatus* from four deciduous woodlands in England (Hopkin 1983)

Species	**Cu**	**Zn**
Lithobius muticus	31.94	16.47
Lithobius lucifugus	40.07	21.68
Lithobius variegatus		
Midger (uncontaminated)	16.4	367
Wetmoor (uncontaminated)	25.7	233
Haw (contaminated)	31.7	470
Hallen (contaminated)	60.9	581

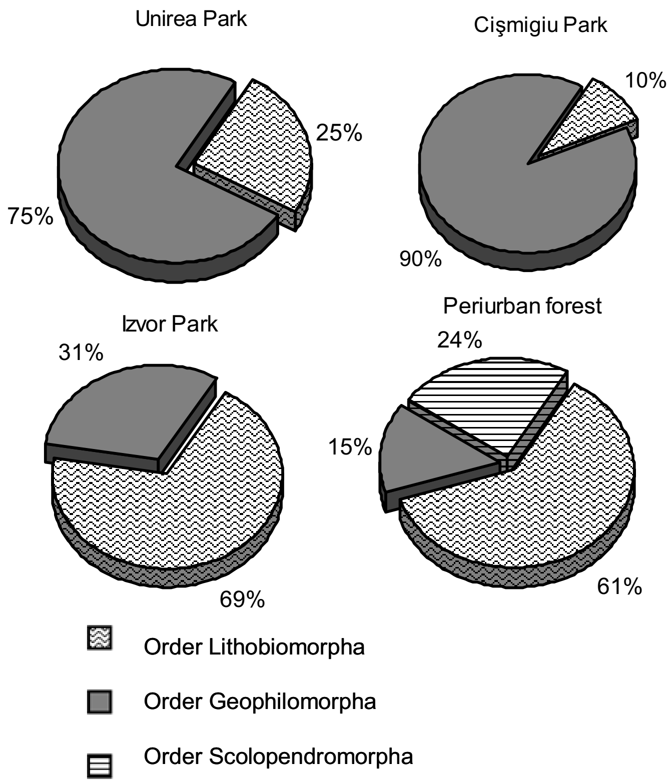

Figure 4: Percentage of centipedes from order Lithobiomorpha, Scolopendromorpha and Geophilomorpha in the composition of populations found in Bucharest parks and in a periurban forest

CONCLUSIONS

The centipedes fauna from the central urban zone is characterized by a low numerical density and specific diversity. Among the three studied parks, Izvor has the most similar structure of the centipede community with natural ecosystems, while in the other two parks the structure is disturbed. The degree of human intervention, park surface, type of management, atmospheric pollution might be the causes of the disturbance. Cişmigiu Park is a suitable habitat for various invertebrates. It shows a high heterogeneity, trees and shrubs well developed that reduce the heat in the summer and the atmospheric pollution. Yet, the soil in Cişmigiu is as dry as in Izvor and even more, the leaf litter is almost totally missing, thus lacking the two important characteristics for being a proper habitat for Lithobiomorpha order.

During the summer months, the drought is amplified in the urban centre and causes pronounced dryness of soil and herbaceous layer, leading to a drastic reduction of the number of centipedes.

In Cişmigiu, in autumn 2007 compared to 2006, the higher chilopoda density may be explained by the presence of wood debris and logs (results of a storm), that where not removed by the workers. These can offer a moist, suitable place for centipedes.

Species identified in Bucharest are common for Romania and most of them are also present in other European cities. At least three species *Lithobius melanops, Clinopodes flavidus* şi *Henia illyrica* are considered thermophilic (Matic, 1966, 1972).

The low numerical density hinders a detailed analysis of the temporal dynamics of the centipede populations in the framework of a long-term monitoring program. In order to obtain sufficient data, the frequency of sampling should be increased but that might prove destructive to the community of centipedes. A feasible solution for monitoring in Bucharest might be the expansion to other parks and urban forest as well.

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ROLE OF COLLEMBOLA IN SOIL HEALTH AND THEIR USE AS INDICATORS

Cristina Fiera

INTRODUCTION

Microarthropods, notably Collembola, are representative of soil biodiversity with numerous species and individuals occupying a wide range of ecological niches. Collembola (springtails) are not a well-known group because of their small size and cryptic habits. Collembola are, together with the mite group Oribatida, the dominant arthropods in soils (Petersen & Luxton, 1982) and are the most diversified on a local scale (<10m^2). They are, however, extremely abundant and widespread, being the most numerous and diverse arthropods in soils and leaf litter after mites and, in some situations, outnumbering them.

Taxonomically, the Collembola belongs to a class of arthropods that are morphologically similar to insects in gross body structure, but different in the lack of a hard exoskeleton and wings, in the presence of internal mouthparts and in possessing, primitively, only a few simple eyes on each side of the head and a jumping organ located ventrally. These differences make their collection and treatment taxonomically often quite different from invertebrates (Greenslade, 2007). Springtails are a rather underrepresented group in the research of Hexapoda, even though there are about 7889 species described in the world (Bellinger et al., 1996-2008). The number of all existing Collembola species in Romania is estimated to be at least 390 species (Fiera, 2007, 2008a).

Collembola provide an efficient tool for biodiversity assessment in soil habitats (Deharveng, 1996). Moreover, these microarthropods are important members of the detrital system. They participate in the microfragmentation of plant detritus and stimulate the activity of bacterial and fungal colonies. Often, they act as bioindicators of soil condition.

Biotic indicators of soil ecological health or condition can be used to assess the current status of the vital ecological processes in soil and changes over time in the processes. Any indicator should reflect the structure and (or) function of ecological processes and respond to changes in soil condition that result from land-management practices. Furthermore, there must be sufficient taxonomic knowledge to identify the organisms accurately and efficiently. For regional or national monitoring programs, additional criteria constrain the choices of possible indicator taxa. For example, they must be applicable to all geographic locations, soil types and vegetation types. For practical purposes, it is also desirable that the costs for collecting samples by nonscientists be controlled, samples tolerate shipping to a central laboratory from remote locations, and frequent sampling not is required during the year (Neher et al, 1995).

According to Markert et al. (2003), a bioindicator is an organism, a part of an organism or a community of organisms which contains information on the quality of the environment. Hence, any indicator used for a temporal change in the environmental quality—as has to be expected after the application of soil melioration measures—must not show any random fluctuations which bear no relevance to the factor to be indicated (Van Straalen, 1997). This simply means that the composition of a collembolan community, if chosen as a bioindicator, should remain stable as long as environmental conditions do not change and should show directed change as soon as environmental conditions begin to change, e.g. as a consequence of liming. Van Straalen (1997) presented data showing that soil arthropods actually remain quite stable over time. In addition, the usefulness of a bioindicator depends on the strength of the relationship between the causative environmental factor and the ecological endpoint (e.g. species composition; Van Straalen, 1997).

In this paper, we first highlight the role of springtails in soil health; second, analyze the possibility to use them as indicators taking into account the published studies and our recent one, from urban area under the LIFE AIR AWARE Project.

Our study investigated the abundance and diversity of springtails, having as objectives: a) to describe and analyze changes in species richness and numerical densities of the Collembola in selected parks from Bucharest and b) to establish the most sensitive species to air pollution.

Role of Collembola in Soil Health

As detritivores, Collembola play an important role in the decomposition of the dead plant material and in nutrient cycling. They are generally considered to be beneficial organisms as few species feed on live plants (Hopkin, 1997). Some Collembola can feed directly on roots (Edwards, 1962). However the relationship between the plant, the microorganisms of the rhizosphere and the invertebrates associated with it is complex (Finlay, 1985). This association may vary with different densities of plants, animals and other factors such as soil moisture, organic matter content and pH (Wiggins et al., 1979). At low densities grazing Collembola may increase plant yield and nutrient uptake although this effect is not necessarily observed at high densities (Finlay, 1985). Under some conditions Collembola can be beneficial by feeding on pathogenic nematodes (Heijbroek et al., 1980) or pathogenic fungi (Curl, 1979) or be detrimental by transporting pathogenic organisms to new host roots (Curl, 1982).

The main effect of Collembola on decomposition and "soil respiration" is through feeding on fungal hyphae. At certain densities of Collembola, grazing of mycorrhizae on roots can stimulate growth of the symbiont and improve plant growth (Gange, 2000). In other situations, Collembola may reduce diseases by consuming pest fungi (Sabatini et al., 2001). Selective grazing by springtails may be an important factor limiting the distribution of certain species of basidiomycete fungi in the field. However, many of these effects are density-dependent and too little information is available to quantify accurately the specific contribution of Collembola to the "indirect" or "catalytic" decomposition.

Nevertheless, the influence of springtails on decomposition and nutrient availability must be significant in many ecosystems. Due to their very low biomass, the direct contribution of microarthropods to C and N turnover is very small (Petersen & Luxton, 1982), however, they become increasingly important for nutrient mobilization with increasing C/N ratio and decreasing water availability. Numerous studies with manipulated animal densities have proven that collembolan activities considerably affect carbon and nitrogen turnover in bulk soil, respiration and plant growth, are influenced by environmental conditions and often exert a buffering effect (Filser, 2002). To better understand these effects it is necessary to carefully look at the specific processes involved, i.e. the interactions of Collembola with other soil organisms.

Use of Collembola as indicators

Collembola can be considered good candidates to be included as biodiversity indicators among soil fauna in an ''indicator shopping basket'' (Stork, 1995). Not only are they well represented in the soil system in terms of diversity, but they also respond to a variety of environmental and ecological factors, like changes in soil chemistry, microhabitat configuration, and forestry and agricultural practices (Hopkin, 1997).

To be useful in measuring the environmental change, an indicator must provide measurable and repeatable information in response to whatever question is being posed about the environment more rapidly than would be obtained by a superficial visual inspection (Greenslade, 2007). Over the last 25 years or so, authors of several papers have listed the general characteristics of an ecological indicator (Majer, 1983; Greenslade & Greenslade, 1984). All authors have stressed that the main traits required in an indicator taxon are sensitivity, responsiveness, ubiquity, being functionally important in ecosystems and representative, that is being able to act as a surrogate for other taxa, as well being easy to sample, identify and analyze.

Collembola could act as bioindicator of air pollution because they fulfil all the requirements (Hopkin, 1997):

1. they play an important role in functioning of the soil ecosystem;
2. they are widely distributed, common and easy to sample;

3. they are robust and resistant to low levels of pollutants;
4. they have reproducible responses: they produce similar responses to the same levels of pollutant exposure in different sites.

Collembola have several biological features that reinforce their use as indicators. Springtails have a permeable cuticle, which allows them to respond with a range of reactions to pollutants and correspond with the restorative capacity of soil ecosystems. Cu and Pb impair the growth (Bengtsson & Rungren, 1983), even though they have an intriguing method of ridding their bodies of these metals. Collembola store heavy metals in the gut epithelium in the form of sphaerocrystals (Humbert, 1977). When the animals moult, they expel the old gut epithelium as a pellet containing the stored metals before the new epithelium develops. By this mechanism, Collembola are able to excrete about 43% of absorbed Pb (van Straalen et al., 1985). Also, Collembola have short life cycles and so, at least populations on, above or near the ground surface, are likely to respond rapidly to environmental changes. In many studies, the abundance and community composition of Collembola have been used as indicators to describe changes in forest soils after liming or fertilization (Hågvar, 1984; Hågvar & Abrahamsen, 1984; Vilkamaa & Huhta, 1986; Van Straalen et al., 1988; Chagnon et al., 2001). Collembola are considered to be good bioindicators of forests condition and change of these due to the role of them in two key stages of ecosystem functioning, i.e. soil organic matter dynamics and nutrient mineralization (Cassagne et al., 2004); also, springtails could be bioindicators of land use intensification (Ponge et al., 2003).

Collembolan indicators of soil pH have already been identified (Hågvar, 1984; Rusek & Marshall, 2000; Chagnon et al., 2001). Also, it was found that species sensitive to the effects of metals were possible indicators of the pollution status of a site (Fountain & Hopkin, 2004). These studies demonstrated that species diversity indices and the total abundance of Collembola were uninformative as to the extent of contamination of a site. However, species indicative of high or low metal levels can give information on the effect that toxins are having on the Collembola community. Euedaphic (soil dwelling) and epedaphic (surface dwelling) species are affected in different ways by soil contamination (Bengtsson & Rungren, 1984; Kuznetsova & Potapov, 1997). This may be because epedaphic species are usually more mobile and have less contact with the soil pore water than euedaphics (Hopkin, 1997). Edwards & Lofty (1974) found that euedaphic populations of Collembola were reduced more than epedaphics in soil treated with nitrogen. However, farming practices such as tillage only reduce numbers of epedaphic species (Moore et al., 1984).

Other studies have used Collembola as a surrogate group to assess impact of fire on biodiversity, but only a few have identified Collembola to species level; most use only changes in total numbers (York, 1999). In Germany, Heisler (1995) showed that Collembola could be a good bioindicator for soil compaction.

It makes ecological sense to use springtails as bioindicators of soil condition. Collembola represent a central position in the soil food web and correlate with ecological processes such as C and N cycling and plant growth. Priority research areas for implementation of Collembola as indicators of soil condition across large geographic scales include verification of life-history characteristics, feeding preferences, identification of key taxa, correlation of key taxa to disturbance, and calibration of diversity indices relative to ecosystem, climate, and soil type.

MATERIALS AND METHODS

Soil cores were taken to a depth of 10 cm in accordance with Bengtsson & Rungren (1988) and Kaczmarek (1993). 25 samples of soil and litter from each site were collected in July, September and November 2006. The investigations were carried out on a transect starting from the park edge (more exposed to air pollution being close to the roads) toward the centre, farther to the emission source (intense traffic). The cores (including surface vegetation) were placed into plastic bags for transport to the lab in the same day and were put into individual Tullgren funnels. These were maintained until invertebrates had ceased emerging from the cores (approximately 7 days).

The extracted fauna was stored in 70% alcohol. After extraction, the collected individuals were preserved in ethanol 96% and then were labelled. The animals were sorted under Binocular Lupe. Some specimens required clearing with 10% potassium hydroxide to see their identifying structures (such as pseudocelli, ocelli or setae). After clearing, they were laid on slides in Schwann medium (Rusek, 1975) for identification at species level. The taxonomic system of the species list and the nomenclature were arranged according to *The checklist of the Collembola of the World,* by Bellinger et all (1996- 2008). Collembola were identified to species level using the most recent keys: Zimdars & Dunger (1994), Pomorski (1998), Bretfeld (1999), Potapov (2001), Thibaud et al. (2004), Fjellberg (2007).

RESULT AND DISCUSSION

The investigations of soil Collembola showed that they are abundant and diversified in urban soils; 2475 individuals were collected and identified into 28 species (Table 1), reaching the highest value of numerical density on September, in Cişmigiu park (Figure 1). Our results were confirmed by those from the literature concerning the springtails fauna of urban soils (Shrubovych, 2002; Krestyaninova & Kuznetsova, 1996; Sterzynska & Kuznetsova, 1997; Christian, 1991, 1993; Fiera, 2008b).

The influence of the pollutants on the springtails fauna was visible in the following cases: A. Species richness diversity; B. The influence of the proximity of pollution source.

A. Species richness diversity

The "basic nucleus" of springtails was represented by 4 species common to the investigated parks (*Entomobrya puncteola, Hemisotoma thermophyla, Protaphorura armata, Parisotoma notabilis*). *Hemisotoma thermophyla* and *Parisotoma notabilis* were dominant species. The analysis of the springtails species collected showed that even if several species were common to all parks, their qualitative and quantitative representation was different, generating distinct coenosis.

Hemisotoma thermophyla is one of four common species to the parks. We consider this species to be a sensitive species to air pollution in these urban areas, which makes it a very good bioindicator of the pollutants.

B. I*nfluence of the proximity of pollution source*

In Cişmigiu Park, *Protaphorura armata* was found at the edges park, the most polluted areas of the studied transect, but it was abundant in the central section of the park, which is less polluted. We consider this species as a "metal–tolerant species". This species could be used as a possible bioindicator for the long-term effects of a pollutant by demonstrating the possible changes which may occur in the species future reproduction capacities.

Folsomia fimetaria was found only at the edges of Cişmigiu park, so this species could be considered as species resistant to air pollution. We have also found this species in Copşa Mică, one of the most polluted industrial cities of Romania (Fiera, 2008b).

Species richness was highest in Izvor park (19 species). The distance of the main sources of pollution played a very important role in the distribution of the Collembola fauna. Collembola abundance as an estimate of toxicity has been investigated with studies using atmospheric pollution (Rusek & Marshall, 2000) and metal aerial deposition or metal ''spiked'' soils (Strojan, 1978; Haimi & Siirapietikainen, 1996; Bruus Pedersen & Van Gestel, 2001).

However, total Collembola abundance does not seem to be affected in long-term (decades) metal contaminated sites (Bengtsson & Rundgren, 1988; Bruce et al., 1997, 1999; Murray et al., 2000, Fountain & Hopkin, 2004). Abundance may not change because Collembola are relatively resistant to metals due to their ability to excrete contaminants stored in the gut lining when they moult (Humbert, 1974). Applications of metal contaminated sewage sludge to soil may increase the number of Collembola, but it also alters the proportions of individual species (Lübben, 1989). Species that are prevalent in uncontaminated soils may be better competitors, but less able to tolerate metals.

Table 1: Species richness of springtails fauna from parks

Species	Unirea	Cişmigiu	Izvor
Cryptopygus ponticus (Stach, 1947)			x
Cyphoderus albinus (Nicolet, 1842)			x
Cyphoderus bidenticulatus (Parona, 1888)	x		x
Desoria nivalis (Stach, 1947)		x	
Entomobrya dorsalis Uzel, 1891	x	x	x
Folsomia fimetaria (Burmeister, 1835)	x		
Folsomia sp.	x		
Folsomides parvulus Stach, 1922	x		x
Hemisotoma thermophyla Axelson, 1900	x	x	x
Heteromurus major (Moniez, 1889)			x
Heterosminthurus sp.			x
Hymenaphorura nova Pomorski, 1990	x		
Isotoma anglicana Lubbock, 1862	x		x
Isotomiella minor (Schäffer, 1896)	x	x	
Metaphorura affinis (Börner, 1902)	x		x
Orchesella sp.			x
Parisotoma notabilis (Schäffer, 1896)	x	x	x
Proisotoma minuta (Tullberg, 1871)		x	
Protaphorura armata (Tullberg, 1869)	x	x	x
Protaphorura pannonica (Haybach, 1960)			x
Protaphorura sakatoi (Yosii, 1966)	x		x
Pseudachorutes subcrassus Tullberg, 1871	x		x
Schoettella ununguiculata (Tullberg, 1869)	x	x	
Seira domestica (Nicolet, 1842)			x
Sminthurinus sp.	x		x
Stenaphorurella denisi (Bagnall, 1935)			x
Thaumanura carolii (Stach, 1920)	x		
Tomocerus sp. juv.		x	

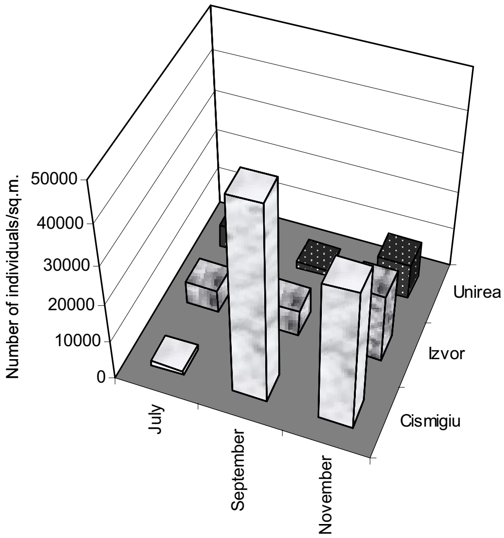

Figure 1: Numerical density (number of individuals/m^2) of Collembola populations

Disturbances caused by pollutants in the soil results in both qualitative and quantitative changes in fauna, which affect soil functioning.

CONCLUSION

This paper reviewed the main data available on the role of Collembola in soil health and on the possibilities to use them as indicator organism.

In the near future, the various existing toxicological tests and those soon-to-be standardized should provide a means of evaluating the environmental quality of different soils. More bioaccumulation studies should be done, especially on *Folsomia fimetaria*, *Protaphorura armata* and *Hemisotoma thermophyla*, to generate a complementary test pool. Microcosm and mesocosm experiments should be continued and expanded to species living in different soil layers to design field study methods.

Single species tests are a step towards environmental risk evaluation, but progressively more complicated systems should be designed to analyze the interaction between the environment and the creatures which live there.

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THRIPS SPECIES RESISTANT TO URBAN POLLUTION (INSECTA: THYSANOPTERA)

Liliana Vasiliu-Oromulu, Daniela Bărbuceanu

INTRODUCTION

Car traffic air pollution is a mixture of several gases and particles, which interact with one another and undergo complex chemical changes. While it is possible, experimentally, to study the biological effects of a single pollutant, the combined effect of a mixture of pollutants is far more difficult to research. Consequently, very few studies so far have focused on the biodiversity and ecology of the Thysanoptera insects under conditions of air pollution.

Thysanoptera species *Frankliniella intonsa* and *Thrips tabaci* have been considered to be resistant to air pollution in Copşa Mică, for decades one of the most polluted industrial cities in Romania, until its decay in the early 1990s (Vasiliu, 1973; Lewis, 1997).

Vasiliu-Oromulu et al. (2008) underlined the role of Thysanoptera in the study of the biological effects of air pollution in inner cities.

Zawirska (oral presentation) carried out a study of the biodiversity of thrips species in an industrial area of Poland, with non specific conclusions.

The present paper shows the results of systematic and ecological researches carried out in the central parks of Bucharest, Romania, during 2006 and 2007. The study is the first complex research worldwide on the effects of air pollution on the biodiversity and ecology of Thysanoptera, and answers numerous calls in the field literature for such an endeavour.

MATERIAL AND METHODS

The investigations (sample collection) were carried out in 2006 and 2007, April-September, (except in the Unirii park in 2006, where the grass was being kept very short) on both native and ornamental plant species as trophic substrate for Thysanoptera..

The thrips fauna was collected from the herbaceous layer, by entomological sweep-net (30 cm diameter), 5 samples/site (one sample = 50 sweeps).

RESULTS AND DISCUSSIONS

Biodiversity

In 2006, the specific structure in the three parks was low, namely 14 species (19.23% from the total of characteristic praticolous species) and in 2007, 35 species (Table 1). The "basic nucleus" of thrips was represented by 7 species common to the parks: *Aeolothrips intermedius* Bagnall*, Anaphothrips obscurus* (Müller), *Frankliniella intonsa* (Trybom), *Thrips tabaci* Lindeman (S.Ord Terebrantia), *Haplothrips aculeatus* (Fabricius), *H. leucanthemi* (Schrank) and *H. niger* (Osborn) (S. Ord. Tubulifera).

Cişmigiu Park had the most balanced thrips community. This can be explained by the presence of phytophagous and zoophagous species (*Aeolothrips intermedius, Ae. fasciatus*) in the intensely landscaped Cişmigiu Park.

Frankliniella intonsa was the most representative species in all three parks, during the two years of study. *Haplothrips niger* was very numerous on *Trifolium pratense* especially in 2006, *Bagnaliella yuccae* was characteristic for *Yucca filamentosa*. According to our results, these three species appear to be a very good bioindicators of pollutants from a biodiversity point of view.

Table 1: Comparative list of thrips species

No.	2006	2007
1.	*Aeolothrips fasciatus*	*Aeolothrips albicinctus*
2.	*Aeolothrips intermedius*	*Aeolothrips fasciatus*
3.	*Anaphothrips atroapterus*	*Aeolothrips intermedius*
4.	*Chirothrips manicatus*	*Anaphothrips obscurus*
5.	*Frankliniella intonsa*	*Aptinothrips elegans*
6.	*Hemianaphothrips articulosus*	*Aptinothrips rufus*
7.	*Limothrips denticornis*	*Aptinothrips stylifer*
8.	*Thrips atratus*	*Chirothrips manicatus*
9.	*Thrips physapus*	*Chirothrips molestus*
10.	*Thrips tabaci*	*Chirothrips ruptipennis*
11.	*Haplothrips aculeatus*	*Frankliniella intonsa*
12.	*Haplothrips angusticornis*	*Frankliniella schultzei*
13.	*Haplothrips leucanthemi*	*Frankliniella tenuicornis*
14.	*Haplothrips niger*	*Iridothrips mariae*
15.		*Limothrips denticornis*
16.		*Neohydatothrips abnormis*
17.		*Neohydatothrips gracilicornis*
18.		*Odontothrips loti*
19.		*Scolothrips uzeli*
20.		*Taeniothrips picipes*
21.		*Thrips atratus*
22.		*Thrips fulvipes*
23.		*Thrips major*
24.		*Thrips physapus*
25.		*Thrips pillichi*
26.		*Thrips tabaci*
27.		*Thrips trehernei*
28.		*Thrips validus*
29.		*Bolothrips cingulatus*
30.		*Haplothrips aculeatus*
31.		*Haplothrips angusticornis*
32.		*Haplothrips leucanthemi*
33.		*Haplothrips niger*
34.		*Haplothrips setiger*
35.		*Haplothrips subtilissimus*

Sex ratio in all sites shows a female dominance, typical for many Thysanoptera species. For example, in 2007 *Frankliniella intonsa* females in Cişmigiu Park represented 93.95%, of the population, with the sex ratio value of 0.94 (Tables 2 and 3).

Ecological indices

The issue of estimating population sizes has a special theoretical and practical significance, as it is the basis for calculating the values of both dimension and graduation of the coenosis.

A large number of individuals, namely 5920 individuals/m^2 belonging to 38 species, were collected from the three sites during the two consecutive years. However, their quantitative and qualitative representation was different, generating distinct coenoses (Figure 1).

Tables 4, 5 and 6 show the characteristic aspects of the spatial and temporal dynamics of the species and their individual numbers in each park.

The highest values of the numerical density were obtained in Cişmigiu Park where the environmental conditions are more favourable to the thrips populations.

Table 2: Sex ratio of the thrips species – 2006

No.	Species	Izvor	Cişmigiu
1.	*Aeolothrips fasciatus*	0	1 ♀
2.	*Aeolothrips intermedius*	11 ♀; 13♂	6 ♀
3.	*Anaphothrips atroapterus*	0	7 ♀
4.	*Chirothrips manicatus*	3♀	0
5.	*Frankliniella intonsa*	321 ♀; 13 ♂	508 ♀; 64 ♂
6.	*Hemianaphothrips articulosus*	0	48 ♀
7.	*Limothrips denticornis*	0	2♀
8.	*Thrips atratus*	11 ♀	0
9.	*Thrips physapus*	0	5 ♀
10.	*Thrips tabaci*	6 ♀	61 ♀; 3 ♂
11.	*Haplothrips aculeatus*	7♀	4 ♀
12.	*Haplothrips angusticornis*	0	2♀
13.	*Haplothrips leucanthemi*	5 ♀; 1 ♂	11 ♀
14.	*Haplothrips niger*	23 ♀; 2 ♂	123 ♀; 8 ♂

Table 3: Sex ratio of the thrips species - 2007

No.	Species	Izvor	Cişmigiu	Unirii
1.	*Aeolothrips albicinctus*	1 ♀	0	0
2.	*Aeolothrips fasciatus*	2 ♀	0	0
3.	*Aeolothrips intermedius*	3 ♀	0	0
4.	*Anaphothrips obscurus*	24 ♀; 2♂	2 ♀	6 ♀
5.	*Aptinothrips elegans*	49 ♀	0	0
6.	*Aptinothrips rufus*	6 ♀	0	0
7.	*Aptinothrips stylifer*	4 ♀	17♀	5 ♀
8.	*Chirothrips manicatus*	3 ♀	0	1 ♀
9.	*Chirothrips molestus*	0	4 ♀	1 ♀
10.	*Chirothrips ruptipennis*	0	2 ♀	0
11.	*Frankliniella intonsa*	120 ♀; 5 ♂	215 ♀; 18 ♂	84 ♀; 4♂
12.	*Frankliniella schultzei*	0	1 ♀	0
13.	*Frankliniella tenuicornis*	2 ♀	0	0
14.	*Iridothrips mariae*	X	0	0
15.	*Limothrips denticornis*	2 ♀	0	0
16.	*Neohydatothrips abnormis*	0	0	2 ♀
17.	*Neohydatothrips gracilicornis*	5 ♀	0	0
18.	*Odontothrips loti*	0	0	0
19.	*Scolothrips uzeli*	0	1 ♀	0
20.	*Taeniothrips picipes*	0	0	5 ♀; 3 ♂
21.	*Thrips atratus*	0	2 ♀	0
22.	*Thrips fulvipes*	3 ♀	0	0
23.	*Thrips major*	2 ♀	3 ♀	0
24.	*Thrips physapus*	24 ♀	45 ♀; 5 ♂	18 ♀
25.	*Thrips pillichi*	0	61 ♀; 3 ♂	66 ♀;12 ♂
26.	*Thrips tabaci*	49 ♀	30 ♀	12 ♀
27.	*Thrips trehernei*	1 ♀	51 ♀; 1 ♂	15 ♀; 1 ♂
28.	*Thrips validus*	0	4 ♀	1 ♀
29.	*Bolothrips cingulatus*	5 ♀	0	0
30.	*Haplothrips aculeatus*	10 ♀	8 ♀	9 ♀
31.	*Haplothrips angusticornis*	1 ♀	2 ♀	7 ♀
32.	*Haplothrips leucanthemi*	20♀; 1♂	41♀; 3 ♂	17 ♀; 1 ♂
33.	*Haplothrips niger*	12 ♀	82 ♀; 1 ♂	35 ♀
34.	*Haplothrips setiger*	1 ♀	0	1 ♀
35.	*Haplothrips subtilissimus*	0	0	0

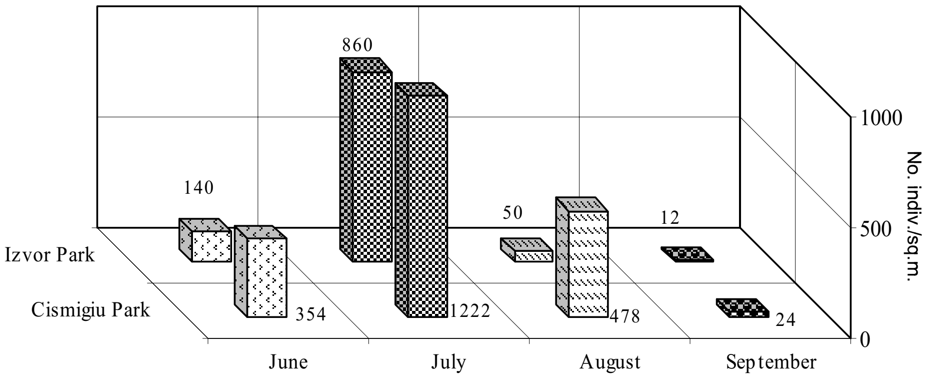

Figure 1: Numerical density (number of individuals/m^2) of Thysanoptera populations – 2006

Table 4: The structural and functional indices of the thrips populations – Cişmigiu Park

2006									
June	$\bar{x}/m^2$	STDEV	d.w.mg/ m^2	energ.metab. ml O_2/m^2	A%	C%	$p_i \log p_i$		
Aeolothrips intermedius	2	0.4	0.20	0.04	1	20	-0.013		
Frankliniella intonsa	240	25.8	24.00	4.80	68	100	-0.114		
Hemianaphothrips articulosus	100	6.6	10.00	2.00	28	100	-0.155		
Limothrips denticornis	4	0.5	0.40	0.08	1	40	-0.022		
Thrips physapus	4	0.9	0.40	0.08	1	20	-0.022		
Haplothrips angusticornis	4	0.9	0.40	0.08	1	20	-0.022	**H(S)**	**1.16**
Haplothrips niger	2	0.45	0.2	0.04	1	20	-0.013	**Hmax**	**2.81**
Σ	**354**	32.7	**35.40**	**7.08**	100		-0.348	**E%**	**41.20**
July									
Aeolothrips fasciatus	2	0.4	0.20	0.04	0	20	-0.005		
Aeolothrips intermedius	4	0.5	0.40	0.08	0	60	-0.008		
Chirothrips molestus	2	0.4	0.20	0.04	0	40	-0.005		
Frankliniella intonsa	970	85.0	97.00	19.40	79	100	-0.080		
Thrips tabaci	10	1.4	1.00	0.20	1	40	-0.017		
Haplothrips aculeatus	14	1.5	1.40	0.28	1	60	-0.022		
Haplothrips leucanthemi	36	5.9	3.60	0.72	3	60	-0.045	**H(S)**	**1.01**
Haplothrips niger	184	16.0	18.40	3.68	15	100	-0.124	**Hmax**	**3.00**
Σ	**1222**	105.9	**122.2**	**24.44**	100		-0.305	**E%**	**33.78**
August									
Aeolothrips intermedius	10	1.7	1.00	0.20	2	40	-0.035		
Anaphothrips atroapterus	14	3.1	1.40	0.28	3	20	-0.045		
Frankliniella intonsa	258	18.4	25.80	5.16	54	100	-0.145		
Hemianaphothrips articulosus	4	0.9	0.40	0.08	1	20	-0.017		
Haplothrips aculeatus	4	0.9	0.40	0.08	1	20	-0.017		
Haplothrips leucanthemi	14	2.2	1.40	0.28	3	20	-0.045	**H(S)**	**1.42**
Haplothrips niger	184	13.6	18.4	3.68	38	100	-0.160	**Hmax**	**2.81**
Σ	**478**	28.9	**47.80**	**9.56**	100		-0.429	**E%**	**50.73**
September									
Frankliniella intonsa	18	3.0	1.80	0.36	75	40	-0.094		
Thrips tabaci	4	0.5	0.40	0.08	17	40	-0.130	**H(S)**	**1.04**
Haplothrips niger	2	0.4	0.20	0.04	8	20	-0.090	**Hmax**	**1.58**
Σ	**24**	3.4	**2.40**	**0.48**	100		-0.313	**E%**	**65.67**

				2007					
April									
Frankliniella intonsa	32	5.5	3.20	0.64	64.0	40	-0.124		
Thrips pillichi	6	1.3	0.60	0.12	12.0	20	-0.110		
Haplothrips leucanthemi	6	0.9	0.60	0.12	12.0	40	-0.110	**H(S)**	**1.51**
Haplothrips niger	6	1.3	0.60	0.12	12.0	20	-0.110	**Hmax**	**2.00**
Σ	**50**	6.3	**5.00**	**1.00**	100		-0.456	**E%**	**75.66**
May									
Anaphothrips obscurus	4	0.9	0.40	0.08	0.7	20	-0.015		
Chirothrips molestus	6	1.3	0.60	0.12	1.0	20	-0.020		
Chirothrips ruptipennis	4	0.9	0.40	0.08	0.7	20	-0.015		
Frankliniella intonsa	228	22.0	22.80	4.56	39.2	100	-0.159		
Thrips major	6	1.3	0.60	0.12	1.0	20	-0.020		
Thrips physapus	40	8.9	4.00	0.80	6.9	20	-0.080		
Thrips pillichi	122	27.3	12.20	2.44	21.0	20	-0.142		
Thrips tabaci	34	3.1	3.40	0.68	5.8	80	-0.072		
Thrips trehernei	104	23.3	10.40	2.08	17.9	20	-0.134		
Haplothrips aculeatus	16	2.2	1.60	0.32	2.7	40	-0.043		
Haplothrips leucanthemi	12	1.1	1.20	0.24	2.1	40	-0.035	**H(S)**	**2.51**
Haplothrips niger	6	1.3	0.60	0.12	1.0	20	-0.020	**Hmax**	**3.58**
Σ	**582**	81.7	**58.2**	**11.64**	100		-0.756	**E%**	**70.07**
June									
Frankliniella intonsa	72	5.4	7.20	1.44	22.6	100	-0.146		
Frankliniella schultzei	2	0.4	0.20	0.04	0.6	20	-0.014		
Thrips atratus	4	0.9	0.40	0.08	1.3	20	-0.024		
Thrips physapus	44	4.6	4.40	0.88	13.8	40	-0.119		
Thrips tabaci	10	2.2	1.00	0.20	3.1	20	-0.047		
Thrips validus	8	1.8	0.80	0.16	2.5	20	-0.040		
Haplothrips aculeatus	4	0.9	0.40	0.08	1.3	20	-0.024		
Haplothrips leucanthemi	46	9.2	4.60	0.92	14.5	40	-0.121	**H(S)**	**2.31**
Haplothrips niger	128	8.2	12.80	2.56	40.3	100	-0.159	**Hmax**	**3.17**
Σ	**318**	21.9	**31.80**	**6.36**	100		-0.695	**E%**	**72.79**
July									
Chirothrips molestus	2	0.4	0.20	0.04	1.4	20	-0.027		
Frankliniella intonsa	58	5.9	5.80	1.16	42.0	60	-0.158		
Thrips physapus	22	3.5	2.20	0.44	15.9	40	-0.127		
Thrips tabaci	8	1.8	0.80	0.16	5.8	20	-0.072		
Haplothrips angusticornis	4	0.9	0.40	0.08	2.9	20	-0.045		
Haplothrips leucanthemi	18	4.0	1.80	0.36	13.0	20	-0.115	**H(S)**	**2.26**
Haplothrips niger	26	4.3	2.60	0.52	18.8	40	-0.137	**Hmax**	**2.81**
Σ	**138**	14.3	**13.80**	**2.76**	100		-0.68	**E%**	**80.49**
August									
Aptinothrips stylifer	34	4.4	3.40	0.68	65.4	60	-0.121		
Frankliniella intonsa	4	0.5	0.40	0.08	7.7	40	-0.086		
Scolothrips uzeli	2	0.4	0.20	0.04	3.8	20	-0.054		
Thrips tabaci	4	0.5	0.40	0.08	7.7	40	-0.086	**H(S)**	**1.57**
Haplothrips leucanthemi	8	1.1	0.80	0.16	15.4	40	-0.125	**Hmax**	**2.32**
Σ	**52**	3.7	**5.20**	**1.04**	100		-0.472	**E%**	**67.46**
September									
Anaphothrips obscurus	8	1.8	0.80	0.16	9.8	20	-0.099		
Chirothrips manicatus	4	0.9	0.40	0.08	4.9	20	-0.064		
Frankliniella intonsa	50	2.2	5.00	1.00	61.0	100	-0.131		
Thrips physapus	4	0.9	0.40	0.08	4.9	20	-0.064		
Thrips pillichi	4	0.9	0.40	0.08	4.9	20	-0.064		
Thrips tabaci	2	0.4	0.20	0.04	2.4	20	-0.039		
Thrips validus	6	0.9	0.60	0.12	7.3	20	-0.083	**H(S)**	**2.02**
Haplothrips leucanthemi	4	0.9	0.40	0.08	4.9	20	-0.064	**Hmax**	**3.00**
Σ	**82**	2.7	**8.20**	**1.64**	100		-0.608	**E%**	**67.3**

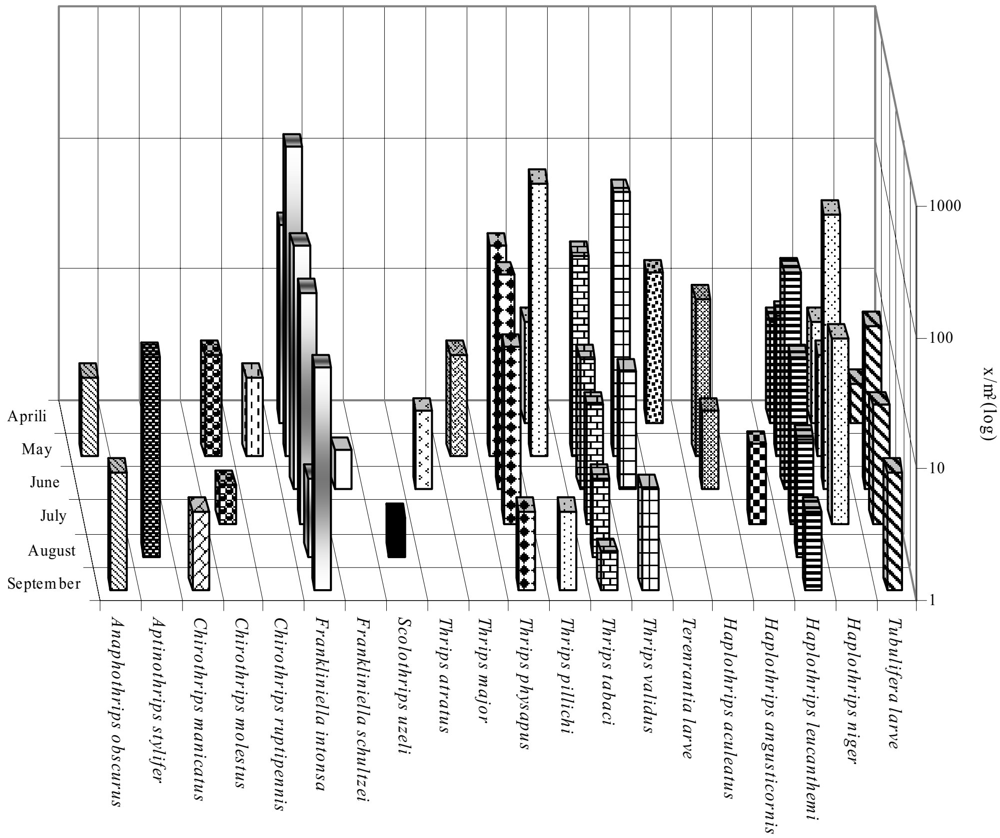

Figure 2: Thysanoptera species in Cişmigiu Park – 2007

Table 5: The structural and functional indices of the thrips populations – Izvor Park

2006									
June	- x/m^2	STDEV	d.w.mg/ m^2	energ. metab. ml O_2/m^2	A%	C%	$p_i \log p_i$		
Aeolothrips intermedius	14	3.1	1.40	0.28	10	20	-0.100		
Frankliniella intonsa	94	12.9	9.40	1.88	67	40	-0.116		
Thrips atratus	22	4.4	2.20	0.44	16	40	-0.126		
Thrips tabaci	8	1.3	0.80	0.16	6	40	-0.071	**H(S)**	**1.46**
Haplothrips aculeatus	2	0.4	0.20	0.04	1	20	-0.026	**Hmax**	**2.32**
Σ	**140**	20.0	**14.00**	**2.80**	100		-0.440	**E%**	**62.93**
July									
Aeolothrips intermedius	32	5.1	3.20	0.64	4	40	-0.053		
Frankliniella intonsa	694	27.0	69.40	13.88	81	100	-0.075		
Thrips tabaci	8	1.1	0.80	0.16	1	40	-0.019		
Haplothrips aculeatus	4	0.5	0.40	0.08	0	40	-0.011		
Haplothrips leucanthemi	18	1.8	1.80	0.36	2	60	-0.035	**H(S)**	**1.01**
Haplothrips niger	104	15.6	10.40	2.08	12	80	-0.111	**Hmax**	**2.58**
Σ	**860**	33.5	**86.00**	**17.20**	100		-0.304	**E%**	**39.09**
August									
Aeolothrips intermedius	2	0.4	0.20	0.04	4	20	-0.056		

Chirothrips manicatus	10	1.4	1.00	0.20	20	40	-0.140		
Frankliniella intonsa	12	1.8	1.20	0.24	24	40	-0.149		
Thrips sp.	2	0.4	0.20	0.04	4	40	-0.056		
Haplothrips aculeatus	2	0.4	0.20	0.04	4	20	-0.056	**H(S)**	**2.04**
Haplothrips niger	22	2.2	2.20	0.44	44	60	-0.157	**Hmax**	**2.58**
Σ	**50**	3.1	**5.00**	**1.00**	100		-0.613	**E%**	**78.80**
September									
Frankliniella intonsa	2	0.4	0.20	0.04	17	20	-0.130		
Haplothrips aculeatus	8	0.8	0.80	0.16	67	60	-0.117	**H(S)**	**1.25**
Haplothrips niger	2	0.4	0.20	0.04	17	20	-0.130	**Hmax**	**1.58**
Σ	**12**	0.8	**1.20**	**0.24**	100		-0.377	**E%**	**78.97**
2007									
April									
Aeolothrips albicinctus	2	0.4	0.20	0.04	2.9	20	-0.044		
Aeolothrips fasciatus	4	0.5	0.40	0.08	5.7	40	-0.071		
Aeolothrips intermedius	6	1.3	0.60	0.12	8.6	20	-0.091		
Frankliniella intonsa	10	2.2	1.00	0.20	14.3	20	-0.121		
Limothrips denticornis	4	0.9	0.40	0.08	5.7	20	-0.071		
Thrips pillichi	2	0.4	0.20	0.04	2.9	20	-0.044		
Thrips tabaci	10	1.7	1.00	0.20	14.3	40	-0.121		
Haplothrips aculeatus	6	1.3	0.60	0.12	8.6	20	-0.091		
Haplothrips leucanthemi	16	1.8	1.60	0.32	22.9	60	-0.147		
Haplothrips niger	8	1.3	0.80	0.16	11.4	40	-0.108	**H(S)**	**3.17**
Haplothrips setiger	2	0.4	0.20	0.04	2.9	20	-0.044	**Hmax**	**3.46**
Σ	**70**	3.9	**7.00**	**1.40**	100		-0.953	**E%**	**91.51**
May									
Anaphothrips obscurus	2	0.4	0.20	0.04	0.7	20	-0.016		
Aptinothrips elegans	90	20.1	9.00	1.80	33.1	20	-0.159		
Aptinothrips stylifer	4	0.9	0.40	0.08	1.5	20	-0.027		
Chirothrips manicatus	6	0.9	0.60	0.12	2.2	40	-0.037		
Frankliniella intonsa	82	11.3	8.20	1.64	30.1	80	-0.157		
Neohydatothrips gracilicornis	4	0.9	0.40	0.08	1.5	40	-0.027		
Thrips major	4	0.9	0.40	0.08	1.5	20	-0.027		
Thrips physapus	12	2.7	1.20	0.24	4.4	20	-0.060		
Thrips tabaci	22	2.7	2.20	0.44	8.1	40	-0.088		
Thrips trehernei	2	0.4	0.20	0.04	0.7	20	-0.016		
Bolothrips cingulatus	10	1.4	1.00	0.20	3.7	100	-0.053		
Haplothrips aculeatus	8	1.1	0.80	0.16	2.9	40	-0.045		
Haplothrips angusticornis	2	0.4	0.20	0.04	0.7	20	-0.016	**H(S)**	**2.72**
Haplothrips leucanthemi	24	3.4	2.40	0.48	8.8	40	-0.093	**Hmax**	**3.81**
Σ	**272**	32.7	**27.20**	**5.44**	100		-0.819	**E%**	**71.49**
June									
Anaphothrips obscurus	36	8.0	3.60	0.72	17.8	20	-0.133		
Aptinothrips elegans	8	1.1	0.80	0.16	4.0	40	-0.056		
Aptinothrips rufus	12	2.7	1.20	0.24	5.9	20	-0.073		
Aptinothrips stylifer	4	1.0	0.40	0.08	2.0	20	-0.034		
Frankliniella intonsa	86	4.6	8.60	1.72	42.6	100	-0.158		
Neohydatothrips gracilicornis	10	1.4	1.00	0.20	5.0	40	-0.065		
Thrips tabaci	12	1.8	1.20	0.24	5.9	40	-0.073		
Haplothrips angusticornis	2	0.4	0.20	0.04	1.0	20	-0.020		
Haplothrips leucanthemi	30	6.7	3.00	0.60	14.9	20	-0.123	**H(S)**	**2.50**
Haplothrips niger	2	0.4	0.20	0.04	1.0	20	-0.020	**Hmax**	**3.32**
Σ	**202**	19.9	**20.20**	**4.04**	100		-0.754	**E%**	**75.36**
July									
Frankliniella intonsa	32	2.9	3.20	0.64	34.0	80	-0.159		
Thrips fulvipes	6	1.3	0.60	0.12	6.4	20	-0.076		
Thrips physapus	36	4.2	3.60	0.72	38.3	60	-0.160		
Haplothrips aculeatus	4	0.9	0.40	0.08	4.3	20	-0.058		
Haplothrips leucanthemi	2	0.4	0.20	0.04	2.1	20	-0.036	**H(S)**	**2.03**
Haplothrips niger	14	2.1	1.40	0.28	14.9	60	-0.123	**Hmax**	**2.58**

Σ	**94**	4.3	**9.40**	**1.88**	100		-0.612	**E%**	**78.69**
August									
Anaphothrips obscurus	16	3.6	1.60	0.32	14.5	20	-0.122		
Frankliniella intonsa	44	5.8	4.40	0.88	40.0	100	-0.159		
Frankliniella tenuicornis	4	0.9	0.40	0.08	3.6	100	-0.052		
Thrips sp.	32	4.4	3.20	0.64	29.1	40	-0.156		
Haplothrips aculeatus	6	1.3	0.60	0.12	5.5	20	-0.069	**H(S)**	**2.13**
Haplothrips leucanthemi	8	1.8	0.80	0.16	7.3	20	-0.083	**Hmax**	**2.58**
Σ	**110**	10.0	**11.00**	**2.20**	100		-0.641	**E%**	**82.37**
September									
Aptinothrips elegans	4	0.9	0.40	0.08	5.6	20	-0.070		
Chirothrips manicatus	14	1.9	1.40	0.28	19.4	40	-0.138		
Frankliniella intonsa	30	4.2	3.00	0.60	41.7	60	-0.158		
Thrips atratus	4	0.9	0.40	0.08	5.6	20	-0.070		
Thrips physapus	12	2.7	1.20	0.24	16.7	20	-0.130		
Thrips pillichi	4	0.9	0.40	0.08	5.6	20	-0.070	**H(S)**	**2.34**
Haplothrips leucanthemi	4	0.9	0.40	0.08	5.6	20	-0.070	**Hmax**	**2.81**
Σ	**72**	5.4	**7.20**	**1.44**	100		-0.705	**E%**	**83.46**

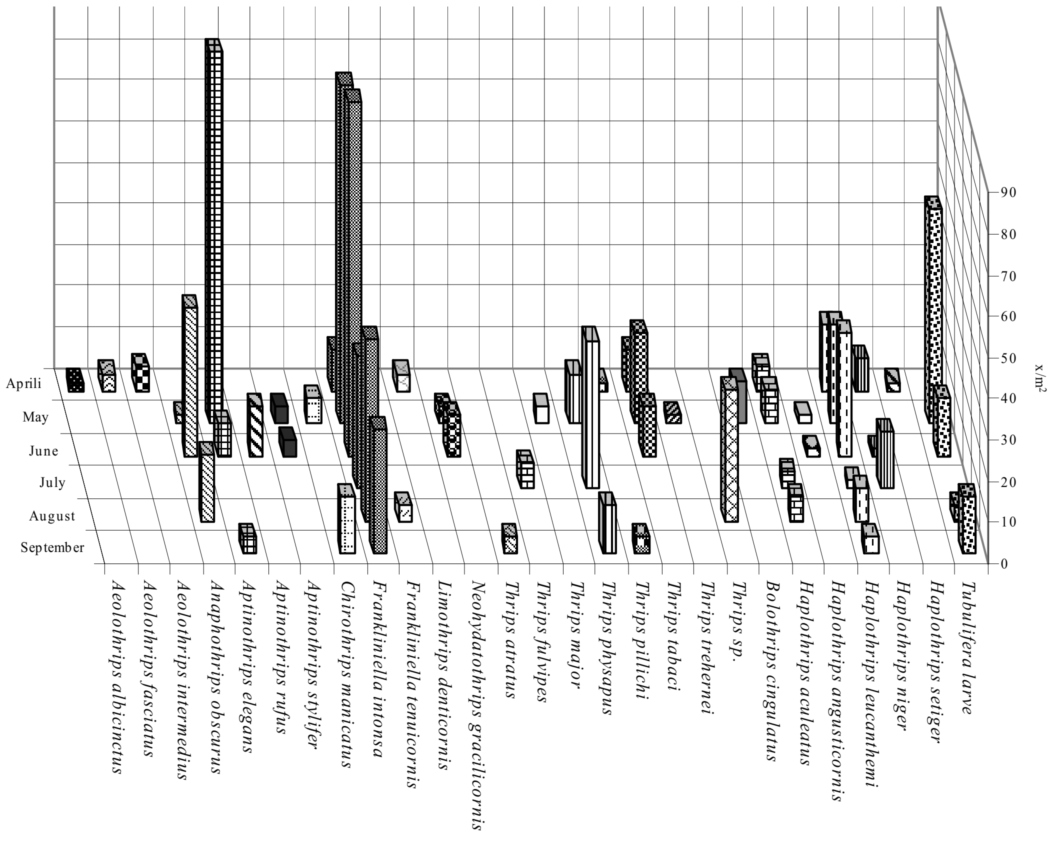

Figure 3: Thysanoptera species in Izvor Park – 2007

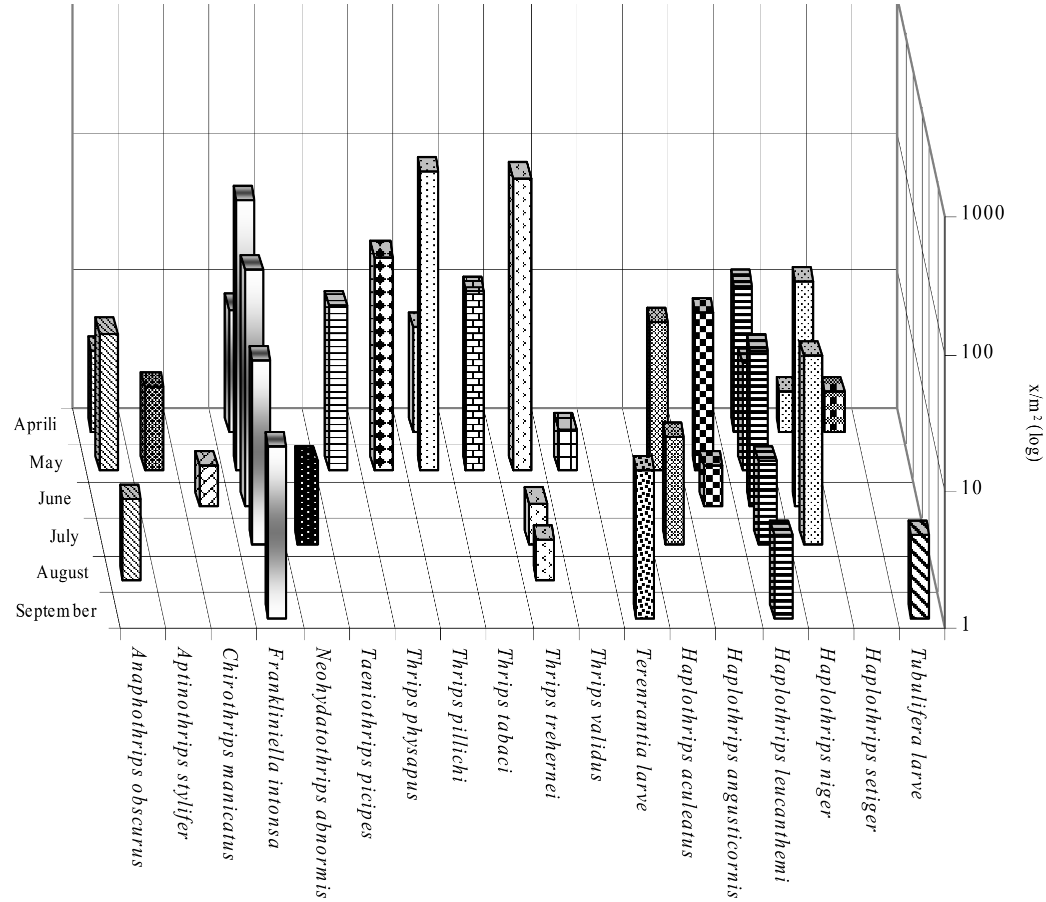

Figure 4: Thysanoptera species in Unirii Park – 2007

The temporal dynamics shows lower values of the numerical density in 2007 compared to the values obtained in 2006 because the summer of 2007 was characterised by extreme high temperatures which together with the pollutants affected the normal development of the thrips (Figures 2, 3 and 4).

Maximal values of the monthly numerical density in the studied parks were observed for 2006 during the month of June, and for 2007 during May, before the hot summer.

Frankliniella intonsa was a dominant species, presenting the highest values of the relative abundance, 24-81%, for the two years (Tables 4, 5 and 6). This species had a maximal frequency of 100% in Cişmigiu and Izvor Park and 40% in Unirii Park. This species appears to be resistant and sensitive to air pollution in these urban areas.

In Cişmigiu Park the peak of numerical density of *Frankliniella intonsa* had values of 970 ind/m^2 in July 2006, while in May 2007 it reached as maximum only 228 ind/m^2 due to the unusually hot summer (Figures 5 and 6). The biomass density values followed the same curve pattern as the numerical density, with minimal values in September in all sites (Tables 4, 5 and 6).

Table 6: The structural and functional indices of the thrips populations – Unirii Park

2007									
April	- x/m^2	STDEV	d.w.mg/ m^2	energ.metab. ml O_2/m^2	A%	C%	$p_i \log p_i$		
Anaphothrips obscurus	4	0.9	0.40	0.08	11.8	20	-0.109		
Frankliniella intonsa	8	1.8	0.80	0.16	23.5	20	-0.148		
Thrips pillichi	6	1.3	0.60	0.12	17.6	20	-0.133		
Haplothrips leucanthemi	12	1.8	1.20	0.24	35.3	40	-0.160		
Haplothrips niger	2	0.4	0.20	0.04	5.9	20	-0.072	**H(S)**	**2.31**
Haplothrips setiger	2	0.4	0.20	0.04	5.9	20	-0.072	**Hmax**	**2.58**
Σ	**34**	3.5	**3.40**	**0.68**	100.0		-0.695	**E%**	**89.25**
May									
Anaphothrips obscurus	10	2.2	1.00	0.20	2.0	20	-0.034		
Aptinothrips stylifer	4	0.9	0.40	0.08	0.8	20	-0.017		
Frankliniella intonsa	92	16.5	9.20	1.84	18.5	40	-0.135		
Taeniothrips picipes	16	1.8	1.60	0.32	3.2	60	-0.048		
Thrips physapus	36	8.0	3.60	0.72	7.2	20	-0.082		
Thrips pillichi	150	28.7	15.00	3.00	30.1	60	-0.157		
Thrips tabaci	20	3.5	2.00	0.40	4.0	20	-0.056		
Thrips trehernei	136	30.4	13.60	2.72	27.3	20	-0.154		
Thrips validus	2	0.4	0.20	0.04	0.4	20	-0.010		
Haplothrips aculeatus	12	2.7	1.20	0.24	2.4	20	-0.039		
Haplothrips angusticornis	14	3.1	1.40	0.28	2.8	20	-0.044	**H(S)**	**2.65**
Haplothrips leucanthemi	6	0.9	0.60	0.12	1.2	40	-0.023	**Hmax**	**3.58**
Σ	**498**	85.9	**49.8**	**9.96**	100.0		-0.799	**E%**	**74.05**
June									
Chirothrips manicatus	2	0.4	0.20	0.04	1.7	20	-0.030		
Frankliniella intonsa	54	8.4	5.40	1.08	46.6	40	-0.155		
Haplothrips angusticornis	2	0.4	0.20	0.04	1.7	20	-0.030		
Haplothrips leucanthemi	14	2.2	1.40	0.28	12.1	40	-0.111	**H(S)**	**1.61**
Haplothrips niger	44	4.8	4.40	0.88	37.9	60	-0.160	**Hmax**	**2.32**
Σ	**116**	11.0	**11.60**	**2.32**	100.0		-0.486	**E%**	**69.52**
July									
Frankliniella intonsa	22	3.5	2.20	0.44	35.5	40	-0.160		
Neohydatothrips abnormis	4	0.9	0.40	0.08	6.5	20	-0.077		
Thrips tabaci	2	0.4	0.20	0.04	3.2	20	-0.048		
Haplothrips aculeatus	6	1.3	0.60	0.12	9.7	20	-0.098		
Haplothrips leucanthemi	4	0.9	0.40	0.08	6.5	20	-0.077	**H(S)**	**2.06**
Haplothrips niger	24	3.9	2.40	0.48	38.7	40	-0.160	**Hmax**	**2.58**
Σ	**62**	8.6	**6.20**	**1.24**	100.0		-0.619	**E%**	**79.56**
August									
Anaphothrips obscurus	4	0.9	0.40	0.08	66.7	20	-0.117	**H(S)**	**0.92**
Thrips tabaci	2	0.4	0.20	0.04	33.3	20	-0.159	**Hmax**	**1.00**
Σ	**6**	1.3	**0.60**	**0.12**	100.0		-0.276	**E%**	**91.83**
September									
Frankliniella intonsa	18	2.5	1.80	0.36	52.9	40	-0.146		
Terenrantia larva	12	2.7	1.20	0.24	35.3	20	-0.160	**H(S)**	**1.38**
Haplothrips leucanthemi	4	0.9	0.40	0.08	11.8	20	-0.109	**Hmax**	**1.58**
Σ	**34**	4.2	**3.40**	**0.68**	100.0		-0.415	**E%**	**87.02**

The diversity Shannon-Weaver index showed values varying between 1.01 - 2.51 in Cişmigiu Park, between 1.01 - 3.17 in Izvor Park, and between 0.68 - 2.65 in Unirii Park, the highest values being registered during the second year of study (Tables 4-6). The value of 3.17 in the Cişmigiu Park is close to that reported for the natural meadows (Vasiliu-Oromulu 1995).

The thrips community in Cişmigiu Park is more balanced, due to the presence of two trophodynamics modules, with both primary consumers (93.33%) and secondary ones (6.67%).

Thysanoptera insects showed a very fast reaction to pollutants, which can be explained by their intense metabolic activity.

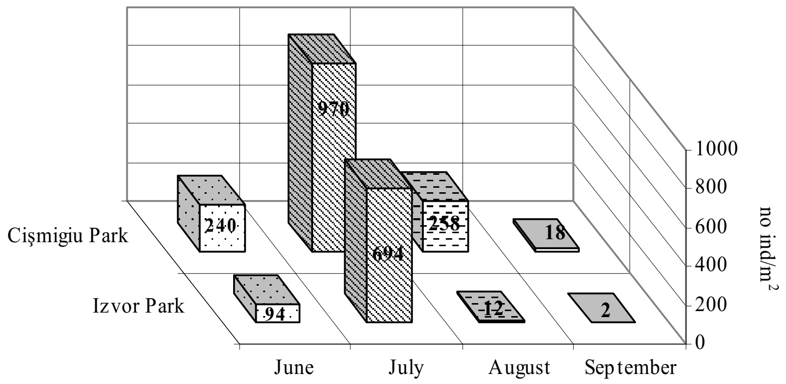

Figure 5: Numerical density (number of individuals/m^2) of *Frankliniella intonsa* populations, 2006

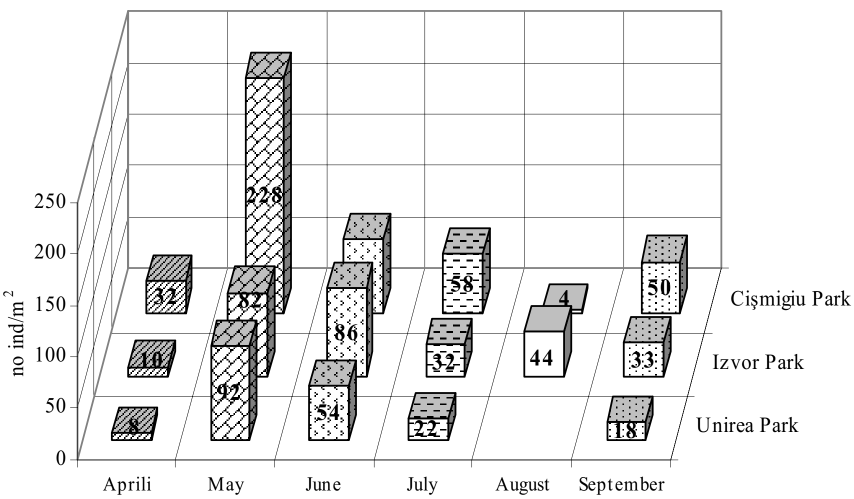

Figure 6: Numerical density (number of individuals/m^2) of *Frankliniella intonsa* populations, 2007

Morphological changes

The following biological effects of pollutants were found on *Frankliniella intonsa*: discoloration of various body parts; large variations in body size (Figure 7); individuals (10 %) with abnormality of the antennae (Figure 8) phenomenon which had not been encountered in our earlier studies on mountainous, non-polluted grasslands (Vasiliu-Oromulu 2002) The other species, collected on the same sites displayed no antennal abnormalities.

This particular case points out to the sensitivity of *Frankliniella intonsa* to environmental pollution.

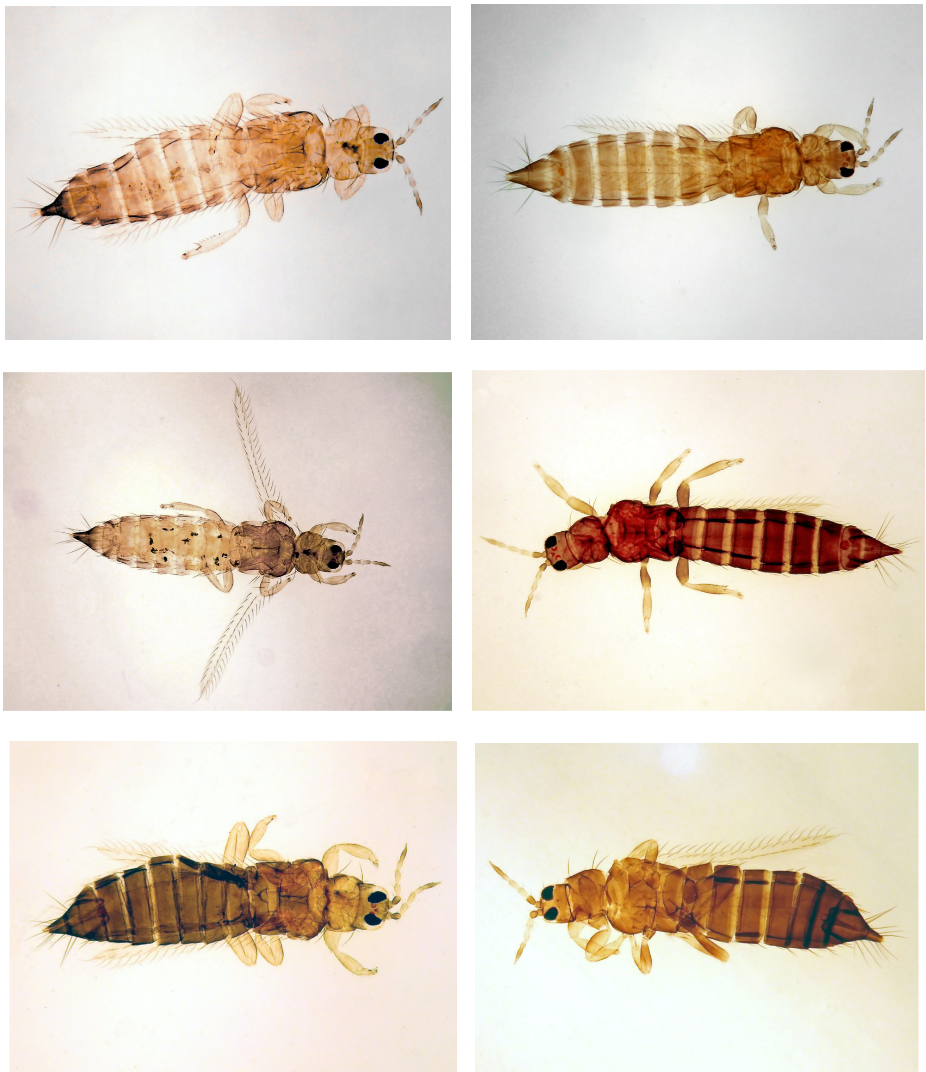

Figure 7: *Frankliniella intonsa* - different colours of the body type

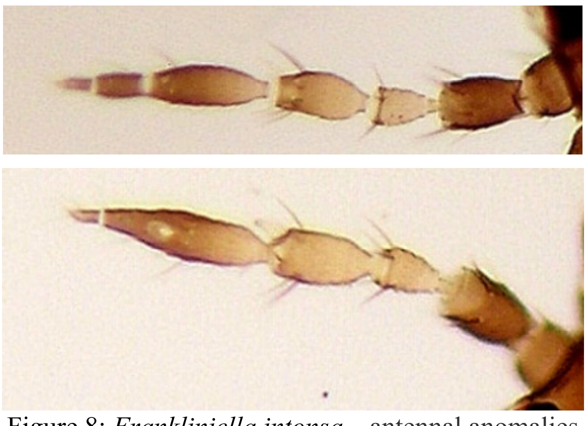

Figure 8: *Frankliniella intonsa* – antennal anomalies

Chemical analysis

The chemical analysis of the heavy metals content in the body of the bioindicators shows that *Frankliniella intonsa* which can be found at the edge of the street with maximum pollution level, has the highest value of Pb and Cu in Cişmigiu Park durig June 2006, and of Zn in June 2007 (Table 7). In Unirii Park the maximal values are in June 2007 for Pb, and Zn, and for Cu in July 2006. The same results are in Izvor Park for Pb in July 2006 and Cu and Zn in June 2007. The content of the three heavy metals is the highest in Cişmigiu Park.

Haplothrips niger – in Izvor Park concentrated the highest level of heavy metals from all the Parks: Pb and Zn in July 2007 and Cu in October 2006 (Table 7).

Bagnaliella yuccae – from all three bioindicators, which was not found at the edge of Cişmigiu Park, concentrated a good quantity of pollutants. In Unirii Park *Bagnaliella yuccae* has accumulated the highest concentrations of Pb, Cu, Zn in May 2007.

In the leaves of *Yucca filamentosa*, the concentrations of the Pb, Cu, Zn in Cişmigiu Park were in June 2007: 0.24, 0.88, 5.72 ppm and respectively in Unirii Park, in the same time: 0.28, 1.32, 7.07 ppm, that means very low values in comparison with those obtained in the thrips.

Table 7: Content of the heavy metals

S/Ord. Terebrantia *Frankliniella intonsa*			
Data	Pb (ppm)	Cu (ppm)	Zn (ppm)
Cişmigiu Park			
06.2006	8.40	42.68	1.39
07.2006	0.60	7.53	2.98
08.2006	2.01	42.49	1.45
06.2007	2.31	37.41	6.26
Unirii Park			
07.2006	1.22	22.52	1.28
06.2007	1.77	19.22	1.83
Izvor Park			
07.2006	3.08	23.33	1.83
06.2007	2.35	39.90	3.44
S/Ord. Tubulifera *Haplothrips niger*			
Data	Pb (ppm)	Cu (ppm)	Zn (ppm)
Cişmigiu Park			
07.2006	1.73	16.91	4.52
08.2006	2.09	24.78	3.65
Unirii Park			
07.2006	0.80	24.74	2.11
06.2007	3.51	30.11	5.38
Izvor Park			
07.2006	1.48	31.34	2.45
08.2006	1.79	31.88	4.37
10.2006	2.71	60.64	6.50
05.2007	2.78	39.89	4.53
06.2007	4.06	27.19	5.57
07.2007	6.17	37.76	15.71
S/Ord. Tubulifera *Bagnaliella yuccae*			
Data	Pb (ppm)	Cu (ppm)	Zn (ppm)
Cişmigiu Park			
08.2006	7.19	37.56	2.03
09.2007	9.20	32.23	9.60
Unirii Park			
10.2006	6.94	34.74	1.88
05.2007	15.53	44.08	16.62

CONCLUSIONS

● ● The study of the influence of the air pollution on Thysanoptera communities was conducted during the years 2006 and 2007 in three public parks (Cişmigiu, Izvor, and Unirii Parks) in downtown Bucharest, Romania, a city area heavily polluted by intense car traffic.

● In each park the investigations were done on transects from the edge (more exposed to air pollution) toward the park centre. In the herbaceous layer, Thysanoptera presents changes in biodiversity on the lengthways of the transects.

● The spatial and temporal dynamics of the thrips populations present the richest communities in Cişmigiu Park, in both years of researches.

● The specific diversity is lower as in non-polluted grasslands. The number of 35 species in 2007 (in 2006 only 14 species) revealed an increase of xero-termophylous thrips and a replace of the mesophylous ones, probably due to the very hot and long summer interaction with pollutants.

● The values of energetic metabolism show a very high activity of the Thysanoptera; their answer to the pollutants is very quickly, due to their intense metabolism activity.

● The impact of environmental changes is reflected by the taxonomical diversity, the values of structural and functional indices, as well as by the incidence of abnormal morphological aspects.

● *Frankliniella intonsa* is the species the most resistant to air pollution; its sensitivity turns it into potentially the most accurate bioindicator among the invertebrate fauna from the herbaceous layer; other bioindicators are on native plants *Haplothrips niger* and *Bagnalliella yuccae* on the ornamental plants.

● The chemical analysis of the heavy metals concentrated in the body of thrips shows maximal values of Cu at *Haplothrips niger* and of Pb and of Zn at *Bagnalliella yuccae*.

●The study is the first complex research worldwide on the effects of air pollution on the biodiversity and ecology of Thysanoptera, and answers numerous calls in the field literature for such an endeavour.

The assessment of heavy metals content in thrips is the first one worldwide.

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THE DIVERSITY OF URBAN COLEOPTERANS

Sanda Maican, Cristina Munteanu

INTRODUCTION

The Coleoptera Order is the largest group of the insects, including nearly a quarter of all the animal species described up to now in the world.

Data on the presence of coleopterans in Bucharest and neighbouring areas were published by numerous specialists, beginning with the end of the 19th century: Montandon (1880, 1906, 1908), Hurmuzachi (1904), Panin (1941, 1944), Panin & Săvulescu (1961), Serafim (2005, 2006), Gruev et al. (1993), Maican (2006 a, b), etc. The majority of the recordings are very old and refer mainly to Bucharest (Cotroceni quarter, Filaret) and to Comana and Băneasa forests.

Serafim & Maican (2008) made a synthesis on the distribution of the cerambycids and chrysomelids species in Bucharest and adjacent areas using the data resulted from the study of the material preserved in the collections of the Institute of Biology Bucharest and “Grigore Antipa” National Museum of Natural History and the bibliographical reports.

The environment degradation changes the plants coenosis structure. The phytophagous insects and especially the monophagous ones, when they became dominant, they reflect the best these perturbations. According to Pfeffer (1963), the relation between plants and insects is so close that in the polluted areas species of *Apion* and *Protapion* (Coleoptera: Apionidae) are considered bioindicators of quantitative changes for leguminous plants, *Phyllotreta* (Coleoptera: Chrysomelidae) and *Ceutorrhynchu*s (Coleoptera: Curculionidae) for boraginaceous plants and *Chaetocnema* (Coleoptera: Chrysomelidae) for gramineous.

MATERIAL AND METHODS

The insects have been collected using the sweeping method with an entomological net, from the herbaceous layer and from wild and ornamental plants. In a few cases the insects were collected directly from plants or the soil surface, by hand.

In the case of curculionids, from each of the three parks we took 5 samples (50 sweepings and 50 branch beatings per sample) – four from the edge and one from the middle of the park. The frequency of sampling was seasonal.

The insects were transferred in 85% ethanol. The specimens were subsequently screened and processed in the laboratory, using stereomicroscopes and specific techniques: e.g., the chrysomelid and curculionid specimens were determined on the basis on external morphology and genitalia - aedeagus for males and spermateca for females, using Warchalowski (1991, 2003) and Freude et al. (1983) papers.

RESULTS

In the studied sites (Izvor, Unirii and Cişmigiu Parks, Băneasa and Baloteşti forests), the Coleoptera Order is represented by 38 species from 28 genera, belonging to the following families: Carabidae, Staphylinidae, Silphidae, Lucanidae, Melyridae, Coccinellidae, Cerambycidae, Lagriidae, Chrysomelidae, Apionidae and Curculionidae (Table 1). Most of the species are exclusive phytophagous (Chrysomelidae, Curculionidae, Apionidae).

The best represented families are Chrysomelidae, with 19 species, followed by Curculionidae (7 species).

Izvor Park is the urban site with the highest number (21) of species; among these, 10 species belong to the Chrysomelidae family and 6 species to the Curculionidae family.

Table 1: Taxonomical structure and number of individuals of Coleoptera fauna from the studied sites (2006-2007)

	Cişmigiu Park	Izvor Park	Unirii Park	Baloteşti forest	Băneasa forest
Carabidae family					
Calosoma sycophanta (Linnaeus, 1758)	1				
Staphylinidae family					
Paederus fuscipes Curtis, 1826		1			
Chrysomelidae family					
Lema cyanella (Linnaeus, 1758)				1 ♂	
Oulema melanopus (Linnaeus, 1758)		2		1	1
Labidostomis longimana (Linnaeus, 1761)		3 ♂♂			
Cryptocephalus hypochoeridis (Linnaeus, 1758)				2 ♂♂	
Cryptocephalus octacosmus Bedel, 1891		5		1	
Cryptocephalus moraei (Linnaeus, 1758)				4 ♂♂, 1♀	
Cryptocephalus sericeus (Linnaeus, 1758)		1			
Chrysolina fastuosa (Scopoli, 1763)				2	2
Chrysolina herbacea (Duft., 1825)				3 ♂♂	
Chrysolina varians (Schaller, 1783)				1♀, 1♂	
Colaphus sophiae (Schaller, 1783)		1			
Gastrophysa polygoni (Linnaeus, 1758)		5	20 ♂♂ 15 ♀♀		
Gonioctena fornicata (Brüggemann, 1873)		3			
Chaetocnema chlorophana (Duftschmidt, 1825)					1 ♂
Neocrepidodera ferruginea (Scopoli, 1763)		1	1		
Phyllotreta nemorum (Linnaeus, 1758)			4		
Phyllotreta undulata (Kutschera, 1860)		1	1		
Hispa atra (Linnaeus, 1767)	1	1			
Cassida vibex Linnaeus, 1767				1	
Coccinellidae family					
Coccinella septempunctata Linnaeus, 1758			3	2	2
Adalia bipunctata (Linnaeus, 1758)			1		
Propylaea quatuordecimpunctata (Linnaeus, 1758)		1	1		
Lucanidae family					
Lucanus cervus Linnaeus, 1758					1 ♂
Lagriidae family					
Lagria hirta Linnaeus, 1758					1
Silphidae family					
Silpha carinata Herbst, 1783					1
Cerambycidae family					
Plagionotus floralis Pallas, 1773		2			
Melyridae family					
Malachius bipustulatus (Linnaeus, 1758)		2	1		
Apionidae family					
Protapion fulvipes (Geoffroy, 1785)	72	33	60		
Protapion apricans (Herbst, 1797)	1	8			
Curculionidae family					
Tychius cuprifer (Panzer, 1799)	4	9	39		
Tychius medicaginis (C. Brisout, 1862)		1			
Coeliodinus rubicundus (Herbst, 1795			2		
Sitona crinitus (Herbst, 1795)		2			
Sitona lepidus Gyllenhal, 1834		2	2		
Sitona hispidulus (Fabricius, 1776)		1	2		
Ceuthorhynchus erysimi (Fabricius, 1787)	2	5			

From the three urban studied sites, Cişmigiu is the less set up area, the herbaceous layer being formed mainly by wild plants species from Fabaceae, Polygonaceae, Poaceae, Ranunculaceae families. Ornamental plant species are mixed with native (mainly ruderal). For phytophagous insects (represented in Izvor Park especially by chrysomelids and curculionids), the vegetation is the main factor conditioning their development. Regular maintenance works as mowing or pesticides administration are performed in all these parks. Mowing the herbaceous layer (which is made by the park administration at different time intervals) is one of the main anthropic factors with a negative impact on the phytophagous beetles fauna (and not only). In the case of Izvor Park (comparatively with Cişmigiu and Unirii Parks) the maintenance works are less frequently, allowing, in good conditions, the continuation of the life-cycle of the insects. Also, Izvor Park has the larger open grassy area which favours the development of the phytophagous insects.

From the Chrysomelidae Family, the identified species belong to the subfamilies of Criocerinae, Clytrinae, Cryptocephalinae and Alticinae, these families having many mesoxerophilous or xerophilous species.

Among Chrysomelidae Family, *Gastrophysa polygoni* was the most abundant species.

The host plants and the general distribution for each recorded chrysomelid species are presented in the Table 2.

Table 2: Chrysomelid species, their distribution and host plants

Chrysomelidae species	**General distribution**	**Host plants**
Lema cyanella (Linnaeus, 1758)	Palaearctic	*Cirsium arvense*, *Cirsium oleraceum*
Oulema melanopus (Linnaeus, 1758)	Euro-Siberian	*Agropyron* sp., *Lolium* sp., *Dactylis* sp., *Avena* sp., *Hordeum* sp.
Labidostomis longimana (Linnaeus, 1761)	West-Palaearctic	Poaceae and Fagaceae (*Trifolium montanum*, *Lotus* sp.)
Cryptocephalus hypochoeridis (Linnaeus, 1758)	Europe, Asia Minor, southern Siberia	Ranunculaceae (*Ranunculus* sp.)
Cryptocephalus octacosmus Bedel, 1891	Europe, Central Asia, western Siberia	Oleaceae (*Fraxinus* sp.), Betulaceae (*Alnus* sp.), Asteraceae (*Cirsium* sp.)
Cryptocephalus moraei (Linnaeus, 1758)	Europe (excepting northern Scandinavia), Asia Minor	Hypericaceae (*Hypericum* sp.), Rubiaceae (*Galium* sp.), Fabaceae (*Spartium* sp.)
Cryptocephalus sericeus (Linnaeus, 1758)	Europe, Asia Minor, Kazachstan, Siberia, North-western China	Asteraceae
Chrysolina fastuosa (Scopoli, 1763)	Europe, Caucasus, Asia Minor, Central and western Siberia	Urticaceae (*Urtica* sp.), Lamiaceae (*Galeopsis* sp., *Lamium* sp.)
Chrysolina herbacea (Duft., 1825)	Europe, Caucasus, Asia Minor, Iran, Afghanistan, Altai Mts	Lamiaceae (*Mentha* sp.)
Chrysolina varians (Schaller, 1783)	Europe, western Siberia; introduced also in North America	Hypericaceae (*Hypericum* sp.)
Colaphus sophiae (Schaller, 1783)	Europe	Brassicaceae (*Brassica napus*, *Sisymbrium* sp., *Lepidium ruderale*)
Gastrophysa polygoni (Linnaeus, 1758)	Holarctic	Polygonaceae (*Rumex*, *Polygonum aviculare*, *Fagopyrum sagittatum*)

Gonioctena fornicata (Brüggemann, 1873)	Danube River basin, Balkan Peninsula, Ukraine, southern Russia, Caucasus, Asia Minor	*Medicago sativa*
Chaetocnema chlorophana (Duftschmidt, 1825)	Europe, Caucasus, Turkey, Iraq, Israel, Syria, North-western Africa	Cyperaceae, Poaceae, Juncaceae
Neocrepidodera ferruginea (Scopoli, 1763)	Europe, Caucasus, Turkey, Iran	
Phyllotreta nemorum (Linnaeus, 1758)	Europe, Palaearctic Asia	Brassicaceae
Phyllotreta undulata (Kutschera, 1860)	Europe, Caucasus, Asia Minor, Central Asia, Siberia, Mongolia, Kazakhstan	Brassicaceae
Hispa atra (Linnaeus, 1767)	Palaearctic	Poaceae (*Poa compressa*, *Agropyron repens*)
Cassida vibex Linnaeus, 1767	Europe, Palaearctic Asia	Asteraceae (*Achillea millefolium, Cirsium oleraceum, Cirsium palustre, Centaurea scabiosa*)

Some of the mentioned species are common and widely distributed in the Romanian fauna, such as: *Coccinella septempunctata*, *Oulema melanopus*, *Labidostomis longimana*, *Cryptocephalus sericeus*, *Gastrophysa polygon, Malachius bipustulatus*, *Plagionotus floralis*.

Labidostomis longimana (Chrysomelidae: Clytrinae); the adults of Clytrinae are polyphagous and especially occur on the plants of the families Fagaceae and Betulaceae. In larvar stage, the Clytrinae species feed on vegetal detritus and ant eggs.

Cryptocephalus sericeus (Chrysomelidae) is a mesophilous species, polyphagous but clearly oriented to oligophagy, feeds on Asteraceae and Ranunculaceae and *Knautia*.

Malachius bipustulatus (Melyridae) is a predator species, frequently found both in plain and mountainous regions, adults are predators and feed with small insects found on flowers; their larvae feed with the nymphaes of some xilophagous insects.

Larva of the species *Plagionotus floralis* (Cerambycidae) develops in the roots of *Medicago sativa*, which is present only in Izvor Park.

We noticed the occurrence of some species interesting from a protective point of view:

Calosoma sycophanta (Carabidae) – one specimen collected in 2006, from the Cişmigiu Park. Critically Endangered species – CR. Its habitat is represented mainly by deciduous forests. Both imago and larva are polyphagous predators, preferring hairy caterpillars from oaks, spruce fir and pine trees. This species is protected in England, Czech Republic, Germany, Poland, Russia and Ukraine. In the "*Carpathian List of Endangered Species*" (Pawłowski, 2003), *Calosoma sycophanta* is considered a Vulnerable Species (VU).

Lucanus cervus (Lucanidae), one specimen ♂, collected in 2007, from Băneasa Forest. IUCN – status: species with Lower Risk (LR). The habitat of this species is represented by deciduous forests, mainly in the *Quercus* forests; however, it can also be found in the sylvosteppe and steppe areas. Imagoes are frequently flying in gardens and parks. The larva is growing in decayed wood (oak, birch and ash), which is also used as food. The species is distributed in Europe, Central Asia, Crimea, Caucasus and Northern Africa. It is protected, being included in the Habitats Directive (1992) and in the Bern Convention addenda (1982) – as a rare and endangered species. Also, *Lucanus cervus* is included in the "*Carpathian List of Endangered Species*" (Pawłowski, 2003).

Apionidae family is represented by two species: *Protapion fulvipes* and *P. apricans*. The first species was present in all the parks from Bucharest, in almost all the samples and the number of specimens was sometime considerable (Table 3).

Protapion fulvipes is a Palaearctic, oligophagous beetle on *Trifolium* species. Larvas develop only on the blooms of *Trifolium repens*, *T. hybridum* and *T. spadiceum*. It is active from March to November which explains its permanent presence in the samples.

Protapion apricans is a Palaearctic species, probably monophagous on *Trifolium pratense*, eating its seeds. Larvae develop in the blooms of the plant. It is active from April to November.

Comparing with the Apionidae family, the diversity of Curculionidae family is greater. The number of identified species is higher, but they are not so constant in the samples excepting *Tychius cuprifer* which is present in all three locations, but not in autumn. *Tychius cuprifer* is a monophagous species, on *Trifolium arvense*, and it is active from April to August which explains its absence from the autumn samples.

Table 3: Apionidae and Curculionidae species from central parks

	Unirii			**Cişmigiu**			**Izvor**		
	spring	summer	autumn	spring	summer	autumn	spring	summer	autumn
Apionidae Family									
Protapion apricans						1	7	1	
Protapion fulvipes	36	24		30	30	4	23	7	3
Curculionidae Family									
Tychius cuprifer	29	10		2	2		5	4	
Tychius medicaginis							1		
Coeliodinus rubicundus		2							
Sitona crinitus									2
Sitona hispidulus			2				1		
Sitona lepidus			2				2		
Ceuthorhynchus erysimi						2			5

The Apionidae and Curculionidae species diversity is not influenced by the surface of the working plots but mostly by the management applied to each park, Cişmigiu Park being the most exposed to the maintenance works (Figure 1).

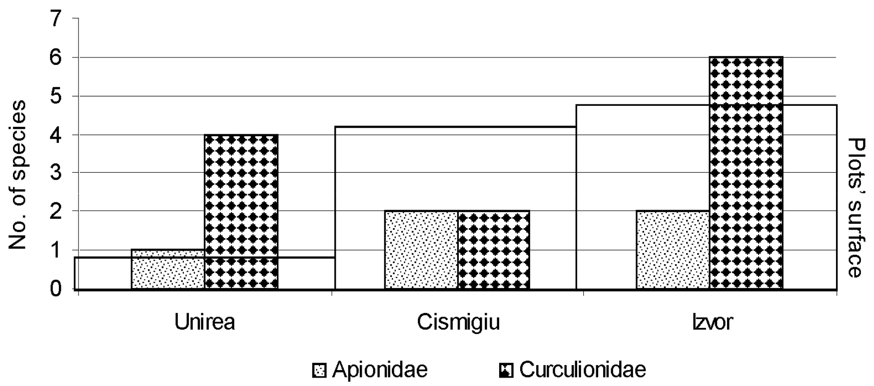

Figure 1: Parks surface and Apionidae and Curculionidae species diversity

CONCLUSIONS

The Coleoptera Order is represented in the studied sites (the Izvor, Unirii and Cişmigiu Parks, Băneasa and Baloteşti forests) by 38 species from 28 genera, belonging to the following families: Carabidae, Staphylinidae, Silphidae, Lucanidae, Melyridae, Coccinellidae, Cerambycidae, Lagriidae, Chrysomelidae, Apionidae and Curculionidae.

The Chrysomelidae family was the best represented, with 19 species, followed by Curculionidae, with 7 species. These species are exclusively phytophagous.

The urban site with the highest number of species – 21 (among these, 9 species belong to the Chrysomelidae family and 6 species to the Curculionidae family) was Izvor Park, because it has large open grassy areas, it is less set up and the maintenance works are less frequent.

Mowing the herbaceous layer is one of the main anthropic factors with negative impact on the phytophagous species populations.

Regarding the specific diversity of Apionidae and Curculionidae Families, no edge-center gradient has been identified.

From apionids, *Protapion fulvipes* is the most abundant and constant. It is present in 70% of the samples and in all seasons (it is missing in Unirii Park in autumn, maybe because of the recent grass cut) due to its long active period (from March to November) and because of the presence of *Trifolium* species as host plants for the beetle.

In the case of curculionids, the most abundant and present in 40% of the samples is *Tychius cuprifer.*

The Apionidae and Curculionidae species identified in studied area are the consequence of the structure of herbaceous layer which is dominated by cultivated or wild ruderal species as *Trifolium arvense*, *T. pratense*, *Capsella bursa-pastoris*, *Medicago sativa* etc.

The dominance of the oligophagous and monophagous species, among Apionidae and Curculionidae Families, may indicate a certain degree of pollution probably caused by the level of car traffic near the parks.

In the studied area there are some rare and endangered species, important from the conservation point of view: *Calosoma sycophanta* (Carabidae) and *Lucanus cervus* (Lucanidae).

From coleopterological point of view, the urban sites: Cişmigiu, Unirii and Izvor Parks were investigated for the first time.

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THE GROUND BEETLES MONITORING IN URBAN AREAS

Dorina-Marieta Purice

INTRODUCTION

In all terrestrial habitats, natural or degraded, there are ground beetles. From the systematics point of view, the ground beetles are insects belonging to Order Coleoptera, Family Carabidae, this family comprising the highest number of beetles species.

In selection of their habitat, the species preferences/limits vary from one species to another. The forest species prefer the litter layer, the hidden places under the logs, stones etc. Most of the species are active during the night, while during the daytime they stay in dark places.

The life cycle of the ground beetle species is usually one-year long, from the juvenile stage until the stage of post-reproductive adult.

Based on food spectra, the ground beetle species could be divided in a few trophic groups: the predators more or less specialized, the phytophagous (in this category are also included the species feeding on plant seeds and fruits) and omnivorous. Thus, the food spectrum the ground beetles generally use is very diverse and comprises snails, slugs, earthworms, springtails, isopods, caterpillars, larva of various invertebrates, vegetal fragments (plant leaves, stalks, seeds, fruits) and, in small proportion – decomposing organic matter (a few ground beetle species were found on and in dead carcasses). Because of these, the connexions of the ground beetle species with so many other groups of organisms made them valuable elements in the ecological studies which, as already well-known, involve a complex approach and many scientific connections.

The ground beetle fauna present in the terrestrial habitats is influenced as quality and quantitatity by several factors: the ecological characteristics of the habitat and the food quality. In the urban areas, the habitats populated by the ground beetles are severe anthropically modified.

According to the classifications of the biological and ecological indicators, the ground beetle species follow the eligibility criteria as bioindication elements: their taxonomy, morphology, phenology and ecology are well-known; low cost of collecting and identifying them; having one-year life cycle, are very useful in studies on the ecosystem state and/or ecosystem succesion.

The species inventory and their ecological and trophic characteristics – offer information on the abiotic characteristics of the habitat (how much of the natural habitats characteristics occur in the urban habitats to be considered by the ground beetle species suitable for living). The presence mainly of the euritopic species (species with wide limits of tolerance on the habitat characteristics) is a elementary clue that the habitat is not complex and constant (in ecological terms) to support the persistence in time of more demanding ground beetle species. The evaluation of the ground beetle populations composition according to the species trophic characteristics shows the food richness and more, the complexity of the habitat structure. The presence mainly of the species with wide trophic preferences (non-specialized) is the clue that the food categories (and hence the trophic structure) are not constant in time and the habitat stability is not strong enough under these terms.

The species numerical dominance and constancy classes – represent one of the first steps in quantifying the proportions between species (numerical and/or biomass) and their proportions in populations. The habitat is simple and not very stable when species with wide limits of ecological and trophic needs are dominant.

The analysis of the pollutant compounds in the individuals tissues, reported to their body weight is a more accurate indicator of the traffic and polluting industrial activities impact on the environment. Taking into account the existing data on the matter flow in nature and on the trophic structure of the ground beetle species we might evaluate the accumulation rates of the heavy metals mainly in the trophic module; these results, correlated with the dynamics of the ground beetle populations, offer a database consistent enough for long-term predictions of the green urban areas trend, starting from the limiting factors: habitats ecological characteristics and anthropic pressure (pollution – what kind, the rates etc.).

MATERIAL AND METHODS

The ground beetles (Coleoptera: Carabidae) were monitored during two years in three central parks in Bucharest, taking into account both their important position in the trophic webs and their potential as bioindicators. To estimate the ground beetle populations status into these green urban areas, we investigated their qualitative (species richness, species ecological characteristics, index of diversity) and quantitative characteristics (numerical abundance, relative abundance, dominance, constancy, heavy metals concentrations into the body tissues).

In each park we collected monthly the ground beetle fauna using pitfall traps filled with water and detergent. In 2006 the survey started in June and the collection ended in October. In the next year, the sampling started in May and ended in September. Each month, ten pitfall traps were emptied and refilled with a mixture of water and detergent to collect the ground beetles.

In this study the ground beetle fauna was used to quantify the urban pollution at the epigeic invertebrate fauna level.

The two years study of ground beetles had been followed by a comparison between the annual datasets. Thus the stability of the ground beetle populations in the green urban areas could be identified: how many species from the first year of study occur in the following year. Without other more detailed investigations (e.g. egg production of the ground beetle females) species viability could be estimate both as species presence in consecutive years and as population dimension (numerical abundances), depending on the values of the environmental limiting factors.

The results are confirmed by the supplementary information offered by the comparison of the species constancy classes.

Initially, according to the work protocol, we have chosen 18 ground beetle species to be monitored and studied in detail as bioindicator species of the pollution in the urban areas. Because of the second year results, we decided that only four of them remain as target bioindicator species: *Abax parallelipipedus*, *Amara plebeja*, *Carabus nemoralis* and *Harpalus rufipes*. We have chosen these species because each of them was found in at least two of the three investigated areas and are representative species for studied habitats. According to the species connections with other organisms (from the trophic point of view), the four ground beetle species are involved in a high number of interspecific relationships: *Abax parallelipipedus* and *Carabus nemoralis* are generalist predators while *Amara plebeja* and *Harpalus rufipes* are phytophagous species, the last one being quite well studied ecotoxicologically (as bioaccumulation of heavy metals from the atmospheric pollution sources in urban areas).

RESULTS

In Unirii park, the ground beetle fauna was represented by five species in 2006 and respectively four in 2007. The numerical densities was low for all species, in comparison with the species from non-urban areas.

According to the relative numerical abundances, *Amara familiaris* was best represented in both years (42.86% in 2006 and respectively 58.33% in 2007). Following the presence of this species in time, in 2006 the status was of eudominant species while in 2007 it was only accessory species.(frequency - 50%). The other species were having a status of accidental species in the ground beetle populations in both years.

The value of Shannon-Wiener index of diversity decreased from 1.356 in 2006 to 0.958 in 2007. The difference is due to the absence of one species (*Harpalus cupreus*, present in 2006) and also to an obvious decrease of the numerical abundances of the ground beetle populations (from 35 individuals captured in 2006 to only 12 in 2007).

The ecological characteristics of the ground beetle species present in Unirii park show that most of them are euritopic species, mainly of open habitats. Their presence is influenced by the park particularities (a lot of sun exposure, alleys and open green areas) determine the microclimate (more arid, higher temperatures). Thus, the ground beetle species are well adapted to this microclimate, most of them being meso-xerophilous.

The structure of the ground beetle population in Unirii park revealed that in both years, no species could be considered constant (low annual values of the species frequency); in 2007 the proportion of accessory species increased, the proportion of the accidental species decreased and *Amara familiaris* was the dominant species (as numerical abundance).

In Izvor park we identified 6 ground beetle species in 2006 and respectively 9 species in 2007. The numerical abundances of the ground beetle fauna in both years was quite equal. The species with the highest numerical densities were *Amara lunicollis* and *Abax parallelipipedus* in both years.

Taking into account that the sampling effort in 2007 was higher because the pitfall traps were installed on three sides of the park, we could say that the numerical densities of the ground beetle species was lower in 2007.

According to the species relative abundances, we notice that no ground beetle species was more than accidental and in 2007, only *Amara lunicollis* (relative abundance 30%) was accessory species. Also, *A. lunicollis* is the only constant species in both years in this park.

The value of Shannon-Wiener index of diversity decreased from 2.72 in 2006 to 1.71 in 2007, due to the lower densities of the species.

The composition of the ground beetle population in Izvor park according to species ecological characteristics (Thiele et al., 1977; Desender, 1989) is dominated by euritopic species, meso-hygro-termophilous.

As in the previous case, no constant species was found in the two years period in this park. Most of the species are accidental and even if the species number increased slightly in 2007, the proportion of the accessory species in this population decreased (Figure 1).

In Cişmigiu park we identified 8 ground beetle species in 2006 and respectively 5 species in 2007. The numerical abundances decreased from 49 individuals in 2006 to only 29 individuals in 2007. The highest relative abundances was recorded by *Amara ovata* in 2006 (18.37%) and *Abax parallelipipedus* in 2007 (31.03%). Even so, no constant ground beetle species in this habitat shows the lack of proper condition for them (lack of food, improper microclimate etc.).

The value of Shannon-Wiener index of diversity, decreased from 1.846 in 2006 to 1.495, (Figure 1); the difference is not significant statistically but in the trophic structure, the predaceous species *Carabus violaceus* and *Notiophilus biguttatus* show a deterioration of the local conditions (unfavourable microclimate and the status of the lower trophic levels under the species needs).

As classes of constancy, in 2006 only *Amara ovata* and *Abax parallelipipedus* were constant species while in 2007 only *Pterostichus oblongopunctatus* was constant in Cişmigiu park. Also, the trend from one year to another for the Cişmigiu ground beetle population was the decreasing proportions of the accidental and sporadic species (Figure 1).

Trying to establish more or less the differences between the ground beetles populations structure from the green urban areas and those from natural habitats near by the city, we analyzed a few aspects of the ground beetle populations structure in the two categories of habitats (urban vs. periurban; polluted vs. less polluted). We investigated species composition and the value of the Shannon-Wiener index of diversity in four forests near by Bucharest: Baloteşti, Băneasa, Cernica and Mogoşoaia (Table 1).

The number of species and the value of the diversity index were higher in the natural forest habitats than those of the urban green areas. More than that, the ground beetle population structure in forests show a more complex trophic structure (e.g. the presence of a high proportion of predaceous species) and more stable environmental conditions (e.g. the presence of the stenotopic forest species) (Table 2).

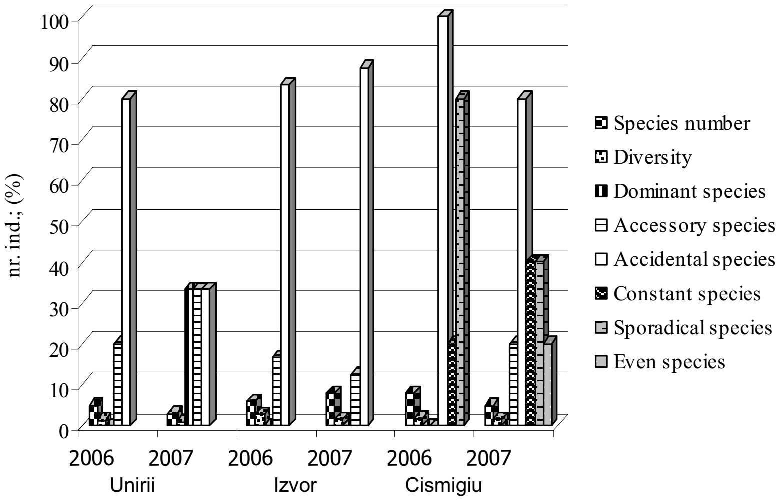

Figure 1: The main structural characteristics of the ground beetle populations in Unirii, Izvor and Cişmigiu parks; even, sporadical, accidental, accessory, dominant and constant species are represented as proportions (%) from the entire population

Taking into account the specific composition of the ground beetle populations, the degree of similarity (Sørensen index of similarity) varies very much between the seven sites we investigated. Thus, no similarity between the ground beetle populations from Unirii park and those from Cişmigiu park was found, while a very high degree of similarity (0.857) exists between Unirii and Izvor ground beetle populations (Table 3).

In comparison with the natural habitats, Cişmigiu is the only urban area whose ground beetle population has a degree of similarity higher than 0.3 (Table 3).

Even if most of the forest habitats we investigated differ a lot as species composition (e.g. 0.11 – the degree of similarity between the ground beetle populations from Cernica and Baloteşti), the most important is that the two categories of habitats differ in complexity and environmental conditions.

Nowadays, the results of many studies on the structure of the ground beetle populations in an urban-rural gradient show that in the urban and very perturbed areas occur mainly small size ground beetle species, capable of flight, while in natural (rural) areas, a more heterogeneity is noticed in the species body-size, the large species being better represented here (Weller & Ganzhorn 2003).

The heavy metals accumulation into the ground beetle tissues was noticed in all studied species (Figures 2 and 3).

We analyzed the mean proportions of heavy metals (Pb, Cd, Cu, Zn) reported to the mean individual biomass for the individuals we captured.

We could observe that the highest concentrations of heavy metals in the body tissues were found to the individuals from Izvor park; the concentrations decreased in Unirii and respectively Cişmigiu ground beetle individuals.

In comparison with the mean individual biomass (MIB), the heavy metals concentrations seem to be higher in fitophagous species.

In both ground beetle species found in Cişmigiu park we determined lower concentrations of heavy metals in comparison with ones from Izvor park.

Table 1: Presence of the ground beetle species in studied areas

Species	UNIRII	IZVOR	CIŞMIGIU	BALOTEŞTI	BĂNEASA	CERNICA	MOGOŞOAIA
Abax carinatus				+	+		
Abax parallelipipedus		+	+			+	+
Abax parallelus						+	
Agonum dorsale				+	+		
Amara apricaria					+		
Amara communis				+			
Amara familiaris	+						
Amara lunicollis,		+					
Amara ovata			+				
Amara plebeja	+	+					
Asaphidion flavipes						+	+
Badister lacertosus						+	+
Bradycellus harpalinus						+	+
Calosoma sycophantam				+			
Carabus auronitens						+	+
Carabus cancellatus					+	+	
Carabus convexus				+			
Carabus coriaceus						+	+
Carabus nemoralis		+	+				
Carabus violaceus			+				
Cychrus caraboides						+	
Harpalus affinis				+		+	+
Harpalus dimidatus						+	
Harpalus distinguendus				+			
Harpalus griseus						+	+
Harpalus latus					+		
Harpalus modestus						+	+
Harpalus oblitus						+	+
Harpalus rufipes	+	+			+		
Lebia chlorocephala				+			
Nebria brevicollis			+	+	+		
Notiophilus biguttatus			+	+	+	+	+
Ophonus rufibarbis						+	+
Patrobus atrorufus						+	
Pterostichus aethiops						+	
Pterostichus cristatus						+	
Pterostichus cupreus	+	+			+	+	+
Pterostichus melanarius					+	+	+
Pterostichus madidus						+	+
Pterostichus melas		+					
Pterostichus oblongopunctatus			+			+	
Pterostichus strenuus						+	+
Pterostichus vernalis					+		
Trechus obtusus,		+					
Stomis pumicatus						+	
Trechus quadristriatus	+			+			
Trechus secalis			+		+	+	+
Zabrus tenebrioides		+					
Total species number	5	5	8	11	12	26	17

Table 2: Composition (%) of the ground beetle populations in urban parks and surrounding forests of Bucharest according to their habitat affinity and trophic preferences

Species' habitat preferences	UNIRII	IZVOR	CIŞMIGIU	BALOTEŞTI	BĂNEASA	CERNICA	MOGOŞOAIA
Euritopic	-	-	-	-	-	43.48	35.3
Euritopic of open habitats	80	50	12.5	23.07	25	19.23	32.35
Euritopic forest	20	50	87.5	69.24	75	30.77	32.35
Stenotopic forest	-	-	-	7.69	-	7.69	-
Ubiquistic	-	-	-	-	-	1.17	-
Fitophagous	80	50	12.5	23.07	25	19.23	23.53
Predator	20	50	87.5	76.93	75	80.77	76.47

Table 3: Degree of similarity (%) between the ground beetle populations from urban parks and the forests at the edge of Bucharest

	UNIRII	IZVOR	CIŞMIGIU	BALOTEŞTI	BĂNEASA	CERNICA	MOGOŞOAIA
IZVOR	0.857	-	0.36	0.285	0.266	0.138	0.2
CIŞMIGIU	0	0.36	-	0.235	0.35	0.266	0.15
BALOTEŞTI	0.133	0.285	0.235	-	0.42	0.11	0.154
BĂNEASA	0.266	0.266	0.35	0.42	-	0.3	0.32
CERNICA	0.066	0.138	0.266	0.11	0.3	-	1
MOGOŞOAIA	0.095	0.2	0.15	0.154	0.32	1	-

The heavy metals with the highest concentrations were Cu and Zn into the ground beetle species from Unirii and Izvor and Zn in those from Cişmigiu park (Figure 2a-d).

Only Zn and only in Cişmigiu was determined in high in concentrations in the ground beetles from all three parks.

In each park we monitored, we measured the heavy metal concentrations for two ground beetle species: in Unirii park – for *Amara plebeja* and *Harpalus rufipes*, both fitophagous species, in Izvor park – for *Abax parallelipipedus* and *Carabus nemoralis*, the last two species are predators and respectively Cişmigiu park – *Amara plebeja* and *Carabus nemoralis*.

We noticed that in Unirii park, from the four elements we measured, both species accumulated mainly Pb. In Izvor park, Zn was accumulated mostly by the predator species – *Abax parallelipipedus* and *Carabus nemoralis*, while the phytophagous species *Amara plebeja* and *Harpalus rufipes* accumulated mostly Pb (Figure 2).

In Cişmigiu park there is a different situation: the predator species accumulated differently the heavy metals: *Abax parallelipipedus* accumulated more Cu and *Carabus nemoralis* more Zn (Figure 2).

Similar to Stone et al. (2002) studies, the analysis of the heavy metal concentrations in the ground beetle tissues form the three parks shows a noticeable Zn accumulation in three of the four investigated species. Also, studying the four ground beetle species in Bucharest park, we noticed that Cu accumulation varies from species to species and from site to site with no evident pattern. The hypothetical explanation for this fact is the reduced Cu uptake or species efficiency in Cu regulation.

Harpalus rufipes, phytophagous species, shows insignificant differences in the mean individual biomass (0.3 g for the individuals found in Unirii park and respectively 0.29 g for those from Izvor park) and also, small differences in the total amount of heavy metals concentrations (33.5 ppm in Unirii and respectively 37.5 ppm in Izvor) (Figure 3).

A different situation has been identified in *Amara plebeja* from Unirii and Izvor parks; while the differences in *A. plebeja* mean individual biomass are low (0.025 g for the individuals from Unirii and respectively 0.03 g for those from Izvor), situation similar for *Harpalus rufipes,* in both species, the concentrations of heavy metals are higher in the individuals collected from Izvor park (47.7 ppm) in comparison with individuals from Unirii park (28.2 ppm)(Figure 3).

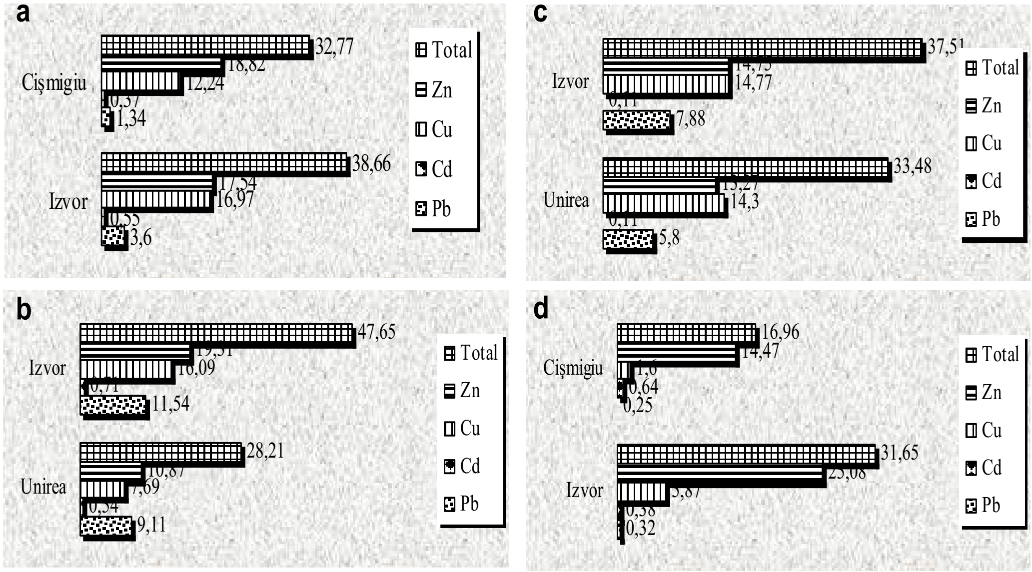

Figure 2: Heavy metal concentrations (ppm) in *Abax parallelipipedus* (2a), *Harpalus rufipes* (2b), *Amara plebeja* (2c) and *Carabus nemoralis* (2d) tissues collected in Unirii, Izvor and Cişmigiu parks

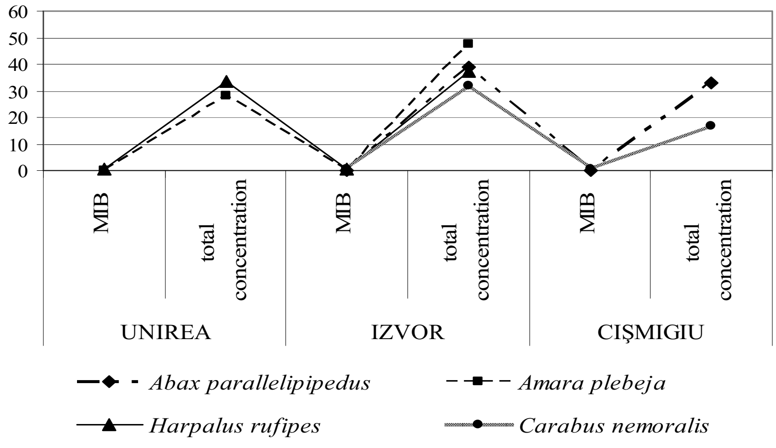

Figure 3: Heavy metals concentrations (ppm) in comparison with the mean individual biomass (MIB, g) of the ground beetle species from Unirii, Izvor and Cişmigiu parks

For the two predaceous species present in Izvor and Cişmigiu parks, *Abax parallelipipedus* and *Carabus nemoralis*, the situation is quite similar with respect to the small differences in the mean individual biomass for each species in the two parks. *Abax parallelipipedus* shows no difference of the MIB for the individuals from the two parks (0.05 g) and small and higher quantities of heavy metals in the body tissues of the individuals from Izvor park (32.7 ppm for individuals from Cişmigiu and respectively 38.7 ppm for individuals from Izvor park).

The previous studies on the heavy metals accumulation in predaceous invertebrates (Hendrickx et al., 2004, about heavy metal accumulation in spiders), show that it is possible to note no consistency in the pattern of metal accumulation in the different species.

The concentrations of heavy metals in the two predaceous ground beetle species are lower in both species collected in Cişmigiu, differences in concentrations (much lower in Cişmigiu) are noticed to *Carabus nemoralis*. The individuals of this species have small differences in MIB (0.32 g in Izvor and 0.4 g in Cişmigiu) but more significant and higher concentrations of heavy metals in the individuals from Izvor park (31.7 ppm in comparison with 16.96 ppm for the individuals from Cişmigiu).

Stone et al. (2001) emphasize that metals are highly persistent and exert a strong selection pressure over multiple generations on organisms with low-dispersal abilities. In their investigations they noticed that the beetles inhabiting the most polluted sites were able to maintain a body mass comparable to beetles collected from less polluted sites. During their study they noticed that beetles had a decreased median survival rate as the season progressed and also, the existence of a negative correlation between the exposure to chronic pollutants and the ability to survive.

As Szyszko et al. (2000) stated that, at least for the ground beetles, MIB is the evidence of the environment state (successional stage, food resources richness etc.). Taking these into account, it is not possible to say that the variations of heavy metal concentrations in the ground beetle species found in different parks are proportional to the food they ingested, because of the small differences in MIB of the individuals of each species from site to site. Thus, a more reasonable explanation is the differences in air pollution degree, reflected in the concentrations of heavy metals in the food of the ground beetle species.

The differences in the way the ground beetle species accumulate the heavy metals could be explained by the nature of food they ingest.

In *H. rufipes* case, a phytophagous species, the individuals ingest vegetal segments covered with depositions from air, containing heavy metals. The ingestion in this way determine almost 100% retention of the pollutants.

In the case of the predaceous species, the individuals ingest invertebrates containing various concentrations of heavy metals in their tissues, usually, the heavy metal concentrations in the invertebrates prey are lower than what is deposited on and inside the vegetal tissues.

CONCLUSIONS

The structure of the ground beetle communities and also their dynamics and tendency are the result of a few synergic factors: the integrating trophic structure stability and complexity; structure of the vegetation; microclimatic characteristics; and least but not last, the stress factors: air pollution and deterioration of the green areas by human behaviour.

All the parameters we analyzed in these years reveal the trend of decreasing number of species and numerical densities, because of the deteriorating environmental quality (microclimatic and trophic factors) and because the heavy metal accumulations determine physiological malfunctions at the individual level (respiratory, digestive and very important – in the reproductive capacity). All these determine from year to year the presence of smaller and poorer ground beetle populations.

Without them in the local trophic food webs, the presence of other coenotic elements connected to the ground beetles (predators of the ground beetles) are disturbed and determine a cascade of effects in the structure and functioning of the local green habitats.

The results are reflected in a polluted and hostile environment for humans neglecting the nature.

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