THYSANOPTERA SPECIES BIOINDICATORS OF THE ENVIRONMENT POLLUTION WITH HEAVY METALS (INSECTA: THYSANOPTERA)

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Abstract. *The LIFE 02ENV/RO/000461 project had as main purpose the identification and use of bioindicators for air quality monitoring in the urban area, represented by three parks, situated in down town Bucharest, Romania, polluted by intense car traffic. Thysanoptera insects presented an increase of the biodiversity from the limits of the parks to their central parts, which is less exposed to the air pollution. Frankliniella intonsa proved to be very resistant to pollution according to the very high values of the numerical density even at the parks' limits. Only these species presented antennal anomalies. The analysis of heavy metals in Frankliniella intonsa confirmed that this species is a very important bioindicator of urban pollution in the herbaceous layer of the parks.*

Keywords: *Thysanoptera, bioindicator, pollution, heavy metals.*

Rezumat. Specii de Thysanoptere biondicatori ai poluării mediului cu metale grele (Insecta: Thysanoptera). *Proiectul LIFE 02ENV/RO/000461 a avut ca principal scop identificarea şi utilizarea bioindicatorilor pentru monitoringul calităţii aerului în zona urbană, reprezentată de trei parcuri, situate în centrul Bucureştiului, România, poluate de traficul intens de maşini. Insectele thysanoptere au prezentat o creştere a biodiversităţii dinspre marginea parcurilor spre centru, mai puţin expus poluării. Frankliniella intonsa este considerată a fi foarte rezistentă la poluare datorită densităţii numerice foarte mari chiar la marginea parcurilor. Numai această specie a prezentat anomalii ale antenelor. Analiza metalelor grele la Frankliniella intonsa a confirmat că aceasta specie este un important bioindicator al poluării urbane din stratul ierbos al parcurilor.*

Cuvinte cheie: *Thysanoptera, bioindicator, poluare, metale grele.*

INTRODUCTION

The combination of natural stress factors intensified in the city and intensification of pollution causes the decrease of thrips species richness and their density populations. Thysanoptera have been used as indicators to describe changes in agroecosystems (LEWIS, 1973), indicators of the climatic changes (VASILIU-OROMULU, 1995, 2002) and of the air pollution (VASILIU in IONESCU et al. 1973, VASILIU-OROMULU et al., 2008).

The Order Thysanoptera comprises about 5,500 described species and possibly there are three times more. Adults have typically four slender wings, with a long fringe of margin cilia. Thrips are found in all kinds of vegetation: flowers, foliage, under bark of live and dead trees, litter, in stored bulbs and a few forms galls or distort leaves. Almost all of them are phytophagous, only a few being predatory. Some species are serious pests, some are considered beneficial, as they may facilitate pollination and decomposition. Thrips are cosmopolitan, with most species found in tropical regions, many in the temperate zone, but only few in the arctic regions (LEWIS, 1973).

The present study is the first research in the world on the heavy metals accumulation in Thysanoptera insects.

MATERIAL AND METHODS

The pilot area is represented by three public parks, Cişmigiu, Izvor and Unirea, located in downtown Bucharest, an area with intense car traffic accounting for up to 70% of the local air pollution. Also, the elements of local industrial pollution exceed standard levels. The pollutants are a mixture of NOx, SO_2 H+, heavy metals and suspensions. The sites–GPS coordinates were for Cişmigiu Park: 44^0 26' 09" N, 26^0 05' 28" E, 73m altitude; for Izvor Park : 44^0 25' 53" N, 26^0 05' 19" E, 68m altitude and for Unirea Park: 44^0 21' 41" N, 26^0 06' 56" E, 71m altitude.

The investigations were carried out in 2006-2007, from April to September, on a transect from the park limits, more exposed to air pollution, to the centre, less exposed, on both native and ornamental plant species. The thrips fauna was collected from the herbaceous layer, by entomological sweep-net (30 ø cm), 5 samples/site (one sample = 50 sweeps). Also, soil samples were taken simultaneously. In 2006, in Unirea Park, the scant herbaceous layer caused a small number of thrips samples to be collected. Immature thrips were not used in the count.

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

Abbreviations: m^2 **-** sq m.

RESULTS AND DISCUSSIONS

Thrips may represent a useful tool to differentiate between polluted and unpolluted areas; those species growing in polluted areas may be long-term biomonitors. The pollutants are taken up by plants from the soil, and transferred to the next links of the trophic chain (ONETE, 2008).

The influence of the pollutants on the Thysanoptera insects was visible at the following levels: the specific diversity; ecological indicators; morphological changes; chemical analysis.

The specific diversity.

In the two years of research, 38 species were identified. The "basic nucleus" of thrips was represented by 7 species common to the parks: *Aeolothrips intermedius* BAGNALL, 1934, *Anaphothrips obscurus* (MŰLLER, 1776), *Frankliniella intonsa* (TRYBOM, 1895), *Thrips tabaci* LINDEMAN, 1889 (S. Ord Terebrantia), *Haplothrips aculeatus* (FABRICIUS, 1803), *Haplothrips leucanthemi* (SCHRANK, 1781) and *H. niger* (OSBORN, 1883) (S. Ord. Tubulifera) (Figs. 1-3). *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 and *Bagnaliella yuccae* was characteristic for *Yucca filamentosa*.

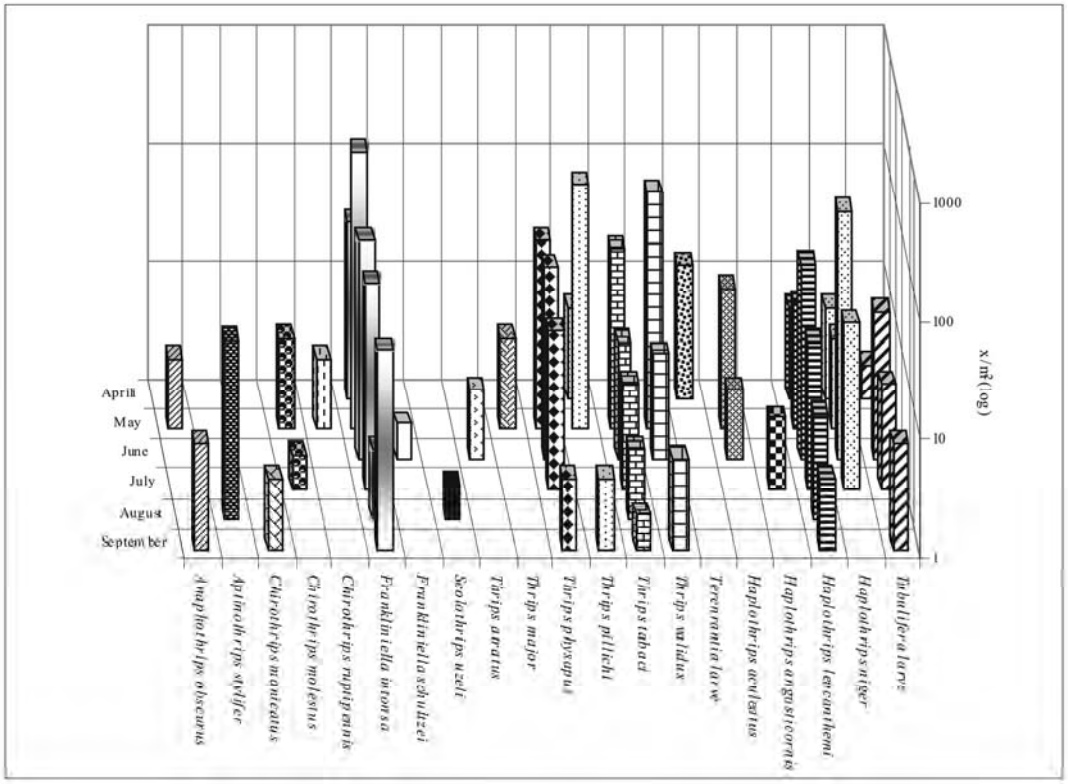

Figure 1. Thysanoptera species in Cişmigiu Park-2007 / Figura 1. Specii de Thysanoptere în Parcul Cişmigiu-2007.

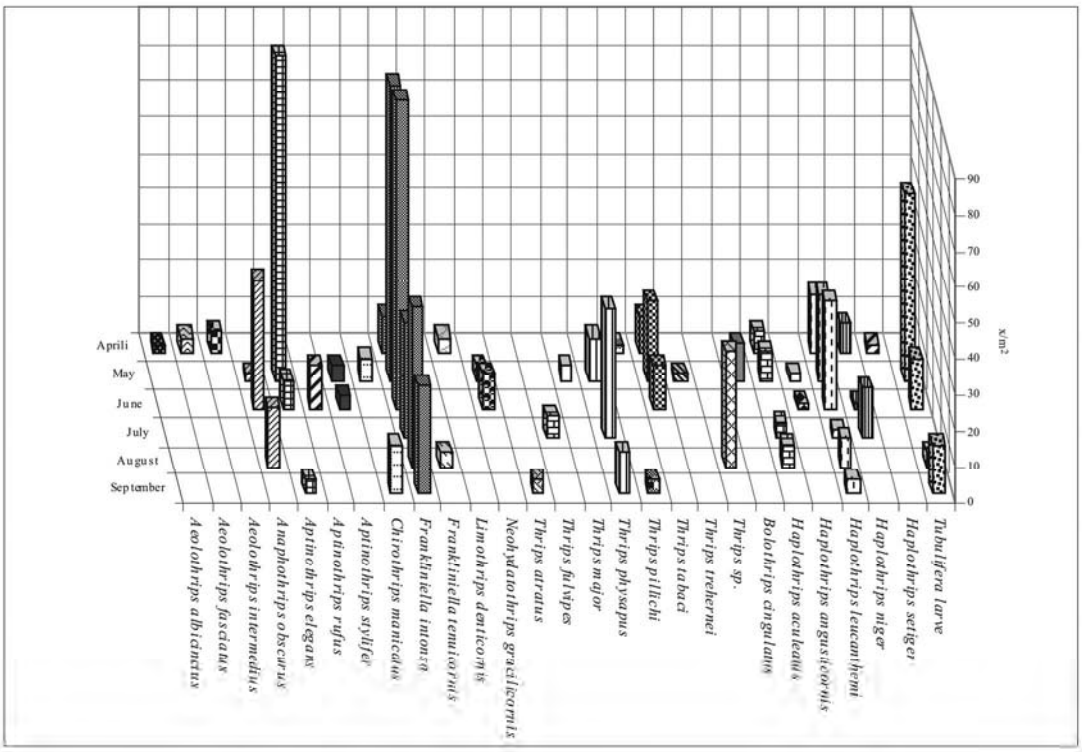

Figure 2. Thysanoptera species in Izvor Park-2007 / Figura 2. Specii de Thysanoptere în Parcul Izvor-2007.

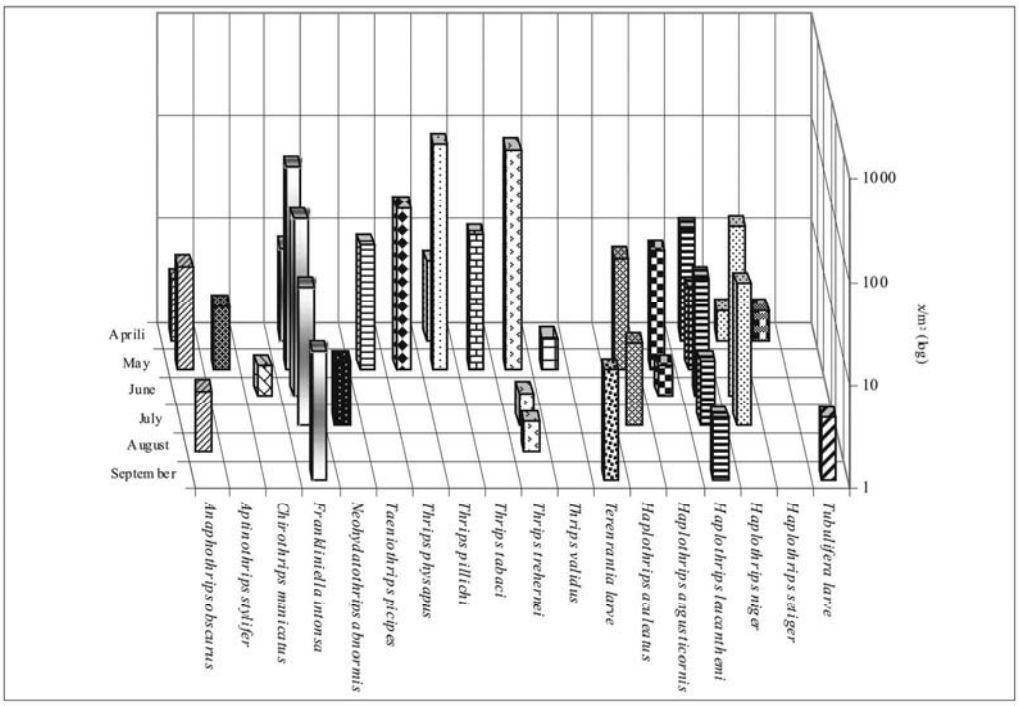

Figure 3. Thysanoptera species in Unirea Park-2007.
Figura 3. Specii de Thysanoptere în Parcul Unirea-2007.

Ecological indicators

A large number of individuals, namely 5,920 individuals/sq m 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 coenosis (Figs. 1-3).

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

The temporal dynamics shows lower values of the numerical density in 2007 compared with the values obtained in 2006 because the summer 2007 was characterised by extremely high temperatures which together with the pollutants affected the normal development of the thrips. 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. This species had a maximal frequency of 100% in Cişmigiu and Izvor Parks and 40% in Unirea Park.

In Cişmigiu Park the pick of numerical density of *Frankliniella intonsa* had values of 970 ind/sq m in July 2006, while in May 2007 it reached as maximum only 228 ind/sq m due to the unusually hot summer (Figs. 4-5).

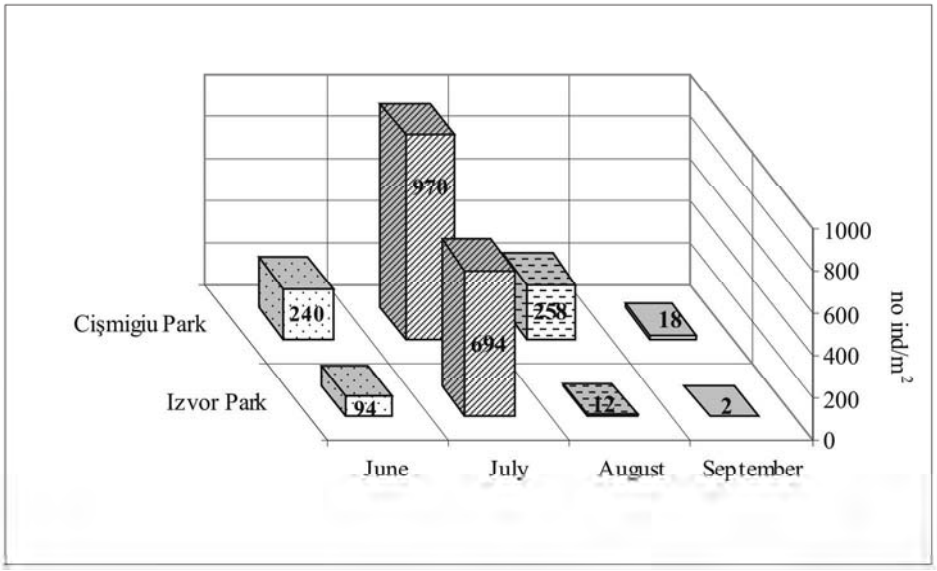

Figure 4. Numerical density/sq m of *Frankliniella intonsa* populations, 2006.
Figura 4. Densitatea numerică/m^2 a populaţiilor de *F. intonsa,* 2006.

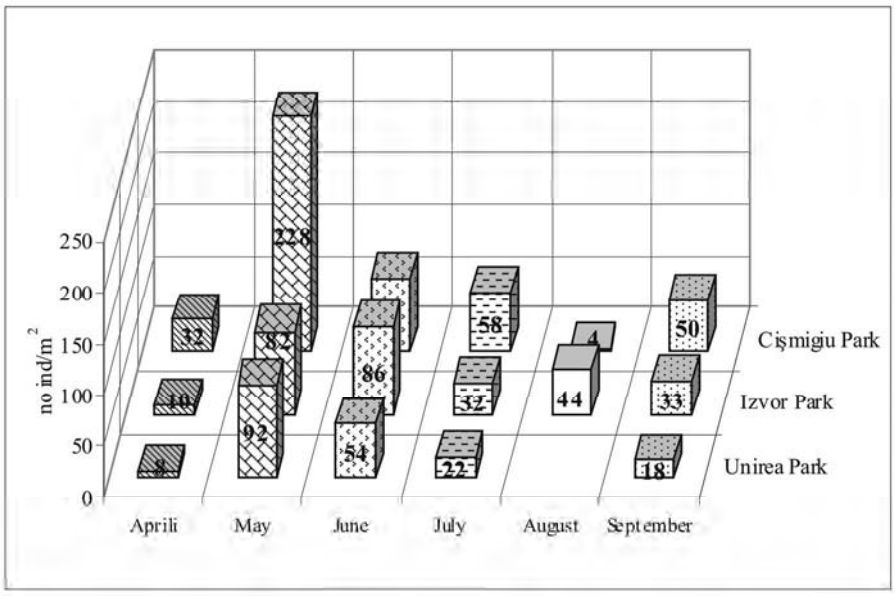

Figure 5. Numerical density / sq m of *Frankliniella intonsa* populations, 2007.
Figura 5. Densitatea numerică / m^2 a populațiilor de *F. intonsa,* 2007.

The thrips community in Cişmigiu Park is more equilibrate, 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.

Morphological changes

The following biological effects of pollutants were found on *Frankliniella intonsa*: discoloration of various body parts; large variations in body size (Fig. 6a-f); individuals (10%) with anomalies of the antennae (a smaller number of antenna articles, and modifications of the latter as compared to the typical antenna) (Fig. 7) 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.

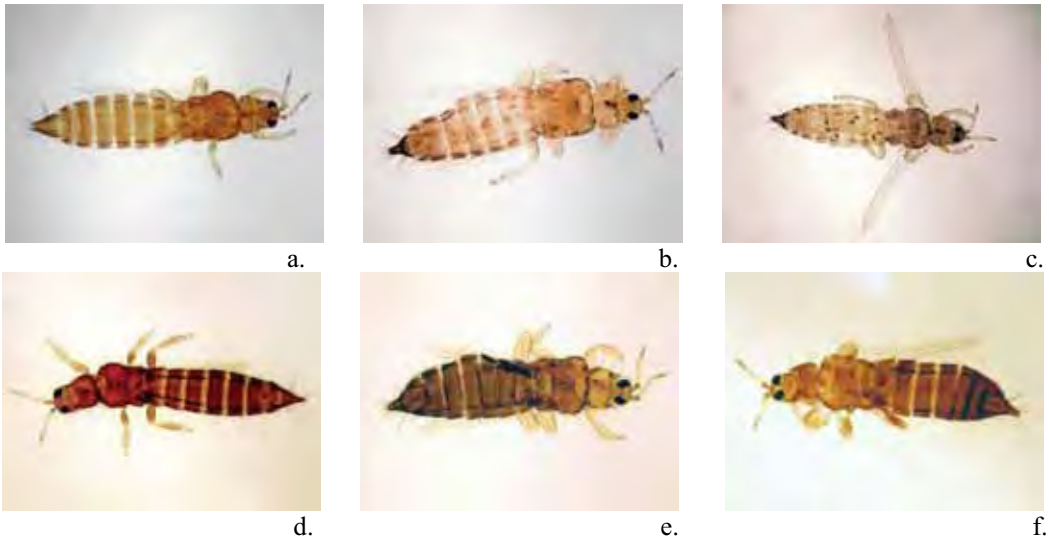

Figure 6. *Frankliniella intonsa*: a - typical species; b - f - females with different colours and sizes of the body type.
Figura 6. *Frankliniella intonsa*: a - specia-tip; b - f - femele cu diferite culori şi mărimi ale corpului.

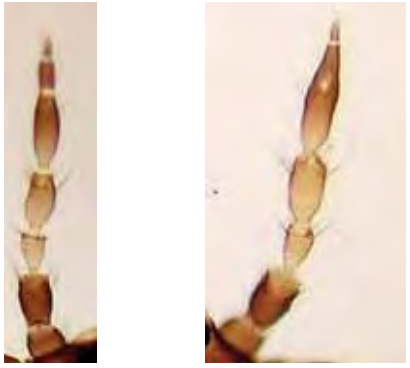

Figure 7. *Frankliniella intonsa* - antennal anomalies.
Figura 7. *Frankliniella intonsa* - anomalii antenale.

The chemical analysis

Air pollution data provided by Bucharest Environmental Protection Agency emphasises the mean annual Pb concentration (μg/m^3) in the air decreasing along 2004-2008 in different sites from Bucharest and rural area. According to the Council Directive 1999/30/EC and Romanian Government Order 592 from June 25 2002 regarding the air quality, the annual limit value of Pb released in the atmosphere is 0.5 μg/m^3 in order to insure the protection of human health. The values of heavy metal content in the soil of the three central parks (Table 1) reveals that the Pb and Cu concentrations in Cişmigiu Park are four times higher than MAC (maximum acceptable concentrations) and in Izvor and Unirii Parks are almost twice as high as MAC. Zn concentration is two times MAC in Cişmigiu Park (Table 1).

Table 1. Mean value and range of heavy metals (mg/kg = ppm dw) in the soil of central Bucharest parks (ONETE, 2008).
Tabel 1. Valoarea medie şi variaţia metalelor grele (mg/kg = ppm s.u.) în solul parcurilor centrale din Bucureşti.

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

Calculating the soil accumulation factor (SAF) in plants, based on the heavy metal analysis of plants and soil from every park, could show that the metal uptake from soil is different with different plants species. For Pb, in the Cişmigiu Park, the highest SAF values are for *Geum urbanum* LINNAEUS (0.101 mg/kg) and all of these species localized in sites close to the major traffic roads. The highest Cu accumulation is in the herbaceous species in the Cişmigiu Park : *Lamium amplexicaule* LINNAEUS (0.940) and *Geum urbanum* L. (0.303). Zn accumulation is higher in the following species: *Ailanthus altissima* (MILLER) SWINGLE (0.108); *Achillea millefolium* LINNAEUS (0.179); *Medicago sativa* LINNAEUS (0.102); *Phragmites australis* (CAV.) STEUEL. (0.112); *Polygonum aviculare* LINNAEUS (0.154). All the species have the highest Cd accumulation in the three parks. *Populus nigra* LINNAEUS, *Quercus robur* LINNAEUS are heavy metal resistant and bio-accumulator species, showing the particular conditions of pollution in Bucharest's central parks (ONETE, 2008).

Plant species are the trophic niche for Thysanoptera. These insects accumulate higher values of heavy metals than the host species, due to the transfer by food and by respiration.

Table 2. The content of the heavy metals on ***Frankliniella intonsa*** (mg/kg = ppm dw).
Tabel 2. Conţinutul în metale grele la ***F. intonsa***.

S/Ord, Terebrantia *Frankliniella intonsa*	Pb (ppm)	Cu (ppm)	Zn (ppm)
Date	**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
Unirea 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

The chemical analysis of heavy metals content in the body of the bioindicators shows that *Frankliniella intonsa*, which can be found at the limit of the street with maximum pollution level, have the highest value of Pb and Cu in Cişmigiu Park during June 2006, and of Zn in June 2007 (Table 2).

In Unirea 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, Pb, Cu and Zn in this species is the highest in Cişmigiu Park.

Cd is under the detection limit in the body of this thrips.

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, Unirea Parks) in downtown Bucharest, Romania, a city area heavily polluted by intense car traffic.

The specific diversity is lower than in non-polluted grasslands. The number of 35 species in 2007 revealed an increase of xero-termophylous thrips and a replacement of the mesophylous ones, probably due to the very hot and long summer as well as to the interaction with pollutants.

The analysis of the spatial dynamics of the thrips populations emphasises the richest communities in the Cişmigiu Park, in both years of study.

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 on *Frankliniella intonsa*.

Frankliniella intonsa is the species most resistant to air pollution; its sensitivity manifested in morphological changes makes it probably the most accurate bioindicator among the invertebrate fauna from the herbaceous layer.

The chemical analysis of heavy metals content in the body of the bioindicators shows that *Frankliniella intonsa* which can be found at the limit of the street with maximum pollution level, have the highest value of Pb and Cu in Cişmigiu Park during June 2006, as well as the highest value of Zn in June 2007.

The chemical analysis of the heavy metals concentrated in the thrips body certifies that *Frankliniella intonsa* is a good bioindicator of the air and soil heavy metals pollution.

The study is the first complex research in the world 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.

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