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THYSANOPTERA CAPABILITY FOR BIOMONITORING OF URBAN POLLUTED GREEN SPACES (INSECTA: THYSANOPTERA)

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Abstract

The research, part of the LIFE 02ENV/RO/000461 project, aimed to identify flora and fauna species which can be used as indicators in the monitoring of air quality in urban areas, and was carried out for two years in three public parks of downtown Bucharest, Romania, all polluted by intense car traffic and industrial pollutants. The analysis of heavy metals in individuals of Thysanoptera *Frankliniella intonsa* (Trybom, 1895) (S/Ord. Terebrantia), *Bagnaliella yuccae* Hinds, 1902 and *Haplothrips niger* (Osborn, 1883) (S/Ord. Tubulifera) from the herbaceous layer of the parks confirmed these thrips as important biomarkers for urban pollution, in the transfer of pollutants from soil-plants-invertebrate to vertebrate. This study is the first in the world on the accumulation of heavy metals in Thysanoptera insects.

KEY WORDS: Thysanoptera, urban pollution, parks, heavy metals

Introduction

The combination of natural stress factors in the city and the intensification of pollution cause a decrease in the richness of thrips species and in their population density. Thysanoptera have been used as indicators of changes in agroecosytems (LEWIS, 1973), and as indicators of climatic changes (VASILIU-OROMULU, 1995, 2002) and air pollution (VASILIU, 1973, VASILIU-OROMULU *et al*., 2008).

Thysanoptera are perhaps the smallest winged insects measuring between 1.0 to 3 millimeters in temperate climate areas; the largest species living in the tropics is 15 mm.

There are over 5,500 described species. Thrips are an economically important species, they reduce plant productivity, reduce the number of flowers and fruits or skelatonize plant leaves, and 0.2% of them can transmit plant viruses. At the same time, a few species prey on pest mites and scale insects, and a number of them may aid in the pollination of flowers and, indirectly, in the formation of leaf mould (MOUND, 2002).

Thysanoptera species *Frankliniella intonsa* (Trybom, 1895) and *Thrips tabaci* Lindemann, 1889 have been considered resistant to air pollution in Copşa Mică, for decades one of the most polluted industrial cities in Romania, until its economic decay in the early 1990s (LEWIS, 1997).

VASILIU-OROMULU *et al.* (2008) underline the role of Thysanoptera in the study of the biological effects of air pollution in inner cities.

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

Materials and Methods

Field studies were carried out in Cişmigiu, Izvor and Piața Unirii Parks, in Bucharest, Romania, all located in areas with heavy vehicular traffic and increased urbanization, and thus with high air pollution. Cişmigiu Park has the following GPS coordinates: 44°26'09" N, 26°05'28" E (73 m a.s.l.); Izvor Park : 44°25'53" N, 26°05'19" E (68 m a.s.l.); Unirea Park: 44°21'41" N, 26° 06' 56" E (71 m a.s.l.).

The investigations were carried out from April to September, 2006-2007, on both native and ornamental plant species.
The thrips fauna was collected from the herbaceous layer by an entomological sweep-net (ø 30 cm), 5 samples/site (one sample = 50 sweeps).

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

The capability of Thysanoptera for assessing the impacts of heavy metals and the concentration effects of pollutants compounds are taken into account in biomonitoring.

Bagnalliella yuccae Hinds, 1902 is a specific host to *Yucca filamentosa*, a common ornamental plant native to the USA, on the coastal plains stretching from southern New Jersey to the state of Georgia. *Haplothrips yuccae*, described in the Caucasus by SAVENKO (1944) and redescribed by DERBENEVA (1959) in Crimea, is undoubtedly the same as *Bagnalliella yuccae* (Hinds, 1902) (VASILIU, 1976). The species most able to tolerate low outdoor winter temperatures in Europe, *Haplothrips niger* (Osborn, 1883), has a preferential niche in *Trifolium pratense,* while *Frankliniella intonsa* (Trybom, 1895) is an opportunistic species which can be found on many plant species.

Results and Discussions

Thrips may represent a useful tool in differentiating between polluted and unpolluted areas; those species growing in polluted areas may function as long-term biomonitors. Soil pollutants are taken up by plants and transferred through the terrestrial invertebrates to vertebrates.

The influence of pollutants on the Thysanoptera insects was visible at the following levels: specific diversity, ecological indices, morphological and chemical analysis.

a. the specific diversity and ecological indices

A large number of individuals, 5,920 individuals/m^2 belonging to 38 species, specifically, were collected from the three sites during the two consecutive years, 2006 and 2007. The "basic nucleus" of thrips was made up of 6 species common to the parks: *Anaphothrips obscurus* (Műller, 1776), *Frankliniella intonsa* (Trybom, 1895), *Thrips tabaci* Lindeman, 1889 (S/Ord Terebrantia), *Haplothrips aculeatus* (Fabricius, 1803) and *H. niger* (Osborn, 1883) (S/Ord. Tubulifera) (Figures 1 - 3). The specific diversity in polluted areas is much lower compared to non-polluted sites (VASILIU-OROMULU, 1995).

The temporal dynamics show lower values of the numerical density in 2007 compared to those obtained in 2006, and a slight increase in xero-termophylous thrips species was noted, to the detriment of the mesophylous species. The summer of 2007 was characterized by extremely high temperatures which, together with the pollutants, impacted the normal development of thrips.

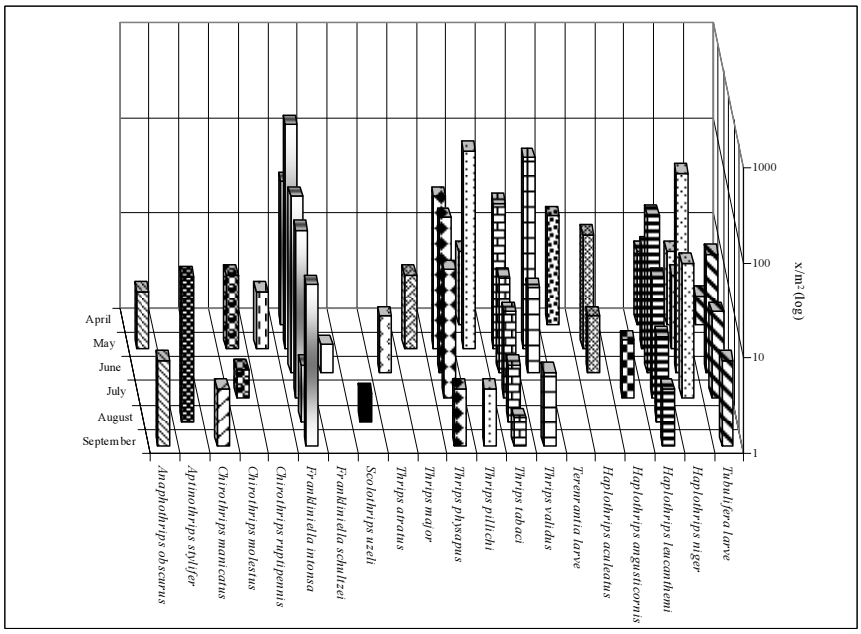

Figure 1. Thysanoptera species in Cişmigiu Park, 2007

Frankliniella intonsa was a dominant species, presenting the highest values of the relative abundance, 24-81%, for the two years, even in areas neighboring large polluted roads.

b. morphological changes

Biological effects of pollutants were found on *Frankliniella intonsa*: discoloration of various body parts; large variations in body size between individuals, 10% of populations with anomalies of the antennae, phenomenon which had not been encountered in our earlier studies on mountainous, non-polluted grasslands (VASILIU-OROMULU, 2002). However, the other Thysanoptera species collected on the same sites displayed no antennal abnormalities.

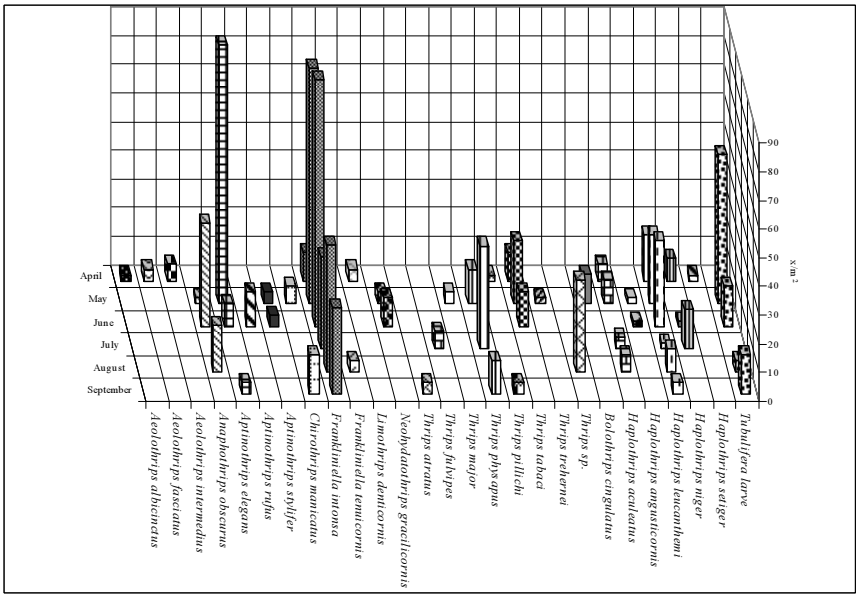

Figure 2. Thysanoptera species in Izvor Park, 2007

c. chemical analysis; transfer of heavy metals from soil to plants to Thysanoptera

The chemical analysis of heavy metal content in the two-step transfer soil-plants-Thysanoptera shows that both abnormally low and abnormally high quantities of these metals represent a stress to which the organism reacts. Many different factors govern the highly variable relation between plants and soil. Many plant species have a good tolerance of different heavy metals and a great selectivity in absorbing them from the soil.

The chemical composition of Thysanoptera should reflect, in general, the chemical composition of the growth media. The values of heavy metal content in the soil of the three central parks (Tab. I) are as follows: Pb and Cu concentrations in Cişmigiu Park are four times higher than MAC (maximum acceptable concentrations) and in Izvor and Unirii Parks they are almost twice as high as MAC. Zn concentration is two times MAC in Cişmigiu Park.

Likely due to the structural complexity of Cişmigiu Park, once deposits (wet and dry) have fallen on the soil, they are unable to rise again; the high vegetation diversity (Tab. II) does not allow the dust particles and pollutants to lift back into the air (ONETE, 2008).

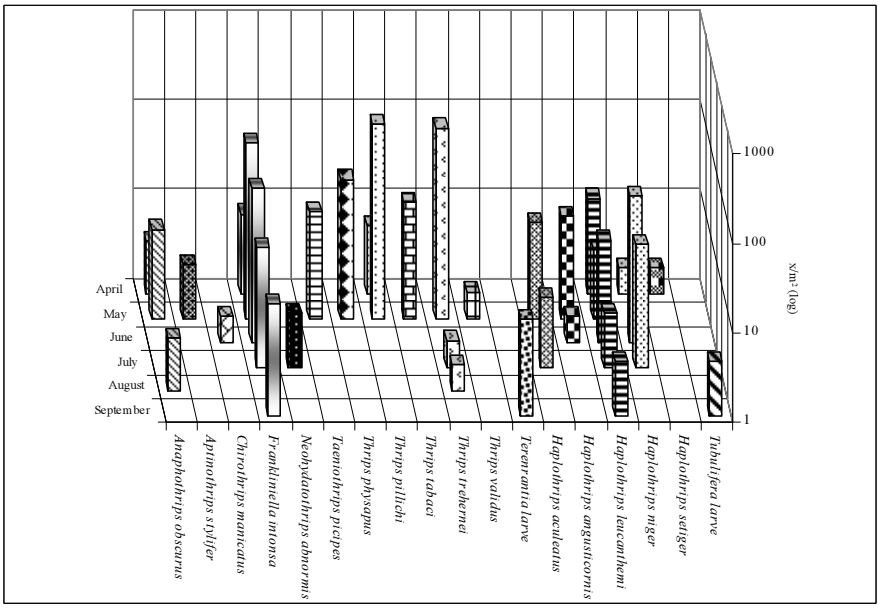

Figure 3. Thysanoptera species in Unirea Park, 2007

Table I. Mean value and range of heavy metals (mg/kg = ppm dw) in the soil of Bucharest central parks (after ONETE, 2008)

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

The transfer of heavy metals from soil to plants continues to phytophagous insects, such as most Thysanoptera species.

Chemical analysis of heavy metal content in the body was performed for those Thysanoptera species considered to be bioindicators, namely *Frankliniella intonsa, Bagnalliella yuccae*, *Haplothrips niger*, species with a high numerical density.

Table II. Values of heavy metals in the plant species from the herbaceous layer (after ONETE, 2008)

Species	Pb	Cd	Cu	Zn
Achillea millefolium L. (Izv)	0.39	0.23	4.62	19.09
Cynodon dactylon (L.) Pers. (Cs)	0.21	0.52	3.3	17.16
Cynodon dactylon (L.) Pers. (Izv)	0.99	0.19	2.8	5.39
Geum urbanum L.	8.32	0.17	23.0	3.03
Glechoma hederacea L.	8.32	0.17	23.5	18.23
Lamium amplexicaule L. (Cs)	2.69	0.46	72.9	5.9
Medicago sativa L. (Izv)	3.29	0.48	3.08	10.87
Plantago lanceolata L. (Cs)	2.97	0.69	3.76	7.3
Setaria viridis (L.) Beauv. (Izv)	2.05	1.02	2.63	22.66
Setaria viridis (L.) Beauv. (Cs)	1.21	0.27	2.73	32.7
Taraxacum officinale Weber ex.Wigg. (Cs)	3.26	0.26	6.82	13.6
Trifolium repens L.	0.37	0.3	6.35	12.94
Veronica arvensis L. (Cs)	0.37	0.3	6.35	12.94
Yucca filamentosa L. (Cs)	0.24	0.19	0.88	5.72
Yucca filamentosa L. (Un)	0.28	0.26	1.32	7.07

Frankliniella intonsa contained the highest values of Pb and Cu in Cişmigiu Park during June 2006 and of Zn in June 2007. 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 for Cu and Zn in June 2007. The content of the three heavy metals is the highest in Cişmigiu Park. Cd is absent in all three species (Tab. III).

Haplothrips niger from the Izvor Park presented the highest level of heavy metals from all the parks: Pb and Zn in July 2007 and Cu in October 2006 (Tab. III).

Bagnalliella yuccae from all three bioindicators concentrated the greatest quantity of pollutants. In Unirea Park the highest concentrations of Pb, Cu, Zn accumulated in May 2007(Tab. III). This insect is monophgous, living only between the leaves of *Yucca filamentosa.*

The accumulation of heavy metals in the leaves of the ornamental plant *Yucca filamentosa* in Unirea Park was of Pb 0.28 ppm, Cu 1.32 ppm and Zn 7.07 ppm, values lower than those found in thrips *Bagnalliella yuccae*, namely Pb 6.94-15.5 ppm, Cu 32.23-44.08 ppm and Zn 1.88-16.62 ppm.

Carabid beetle *Harpalus rufipes* (De Geer, 1774) had values of heavy metal accumulations lower than *Bagnalliella yuccae*, that is Pb 5.8 – 7.88 ppm, Cd 0.11 ppm, Cu 14.3 – 14.77 ppm and Zn 13.27 – 14.75 ppm. Chilopoda *Lithobius lucifugus* L. Koch, 1862 had Cu values close to those of *Bagnalliella yuccae*, 33.86 - 59.86 ppm, but larger amounts of Zn, 14.51 - 38.14 ppm. Cd was absent in both *Lithobius lucifugus* and *Bagnalliella yuccae* (ONETE, 2008).

The minuscule thrips *Bagnalliella yuccae* accumulated amounts of Pb larger than the much larger *Harpalus rufipes* but smaller amounts of Zn than *Lithobius lucifugus*.

For the studied thrips, Pb content had maximal values of 6.17 - 15.53 ppm, while for Cu maximal values were 42.68 - 60.64 ppm and for Zn 6.26 - 16.62 ppm.

Table III. The content of the heavy metals in thrips.

Date	Pb (ppm)	Cu (ppm)	Zn (ppm)	Cd (ppm)
Terebrantia, *Frankliniella intonsa*				
Cişmigiu Park				
06.2006	8.40	42.68	1.39	absent
07.2006	0.60	7.53	2.98	absent
08.2006	2.01	42.49	1.45	absent
06.2007	2.31	37.41	6.26	absent
Unirea Park				
07.2006	1.22	22.52	1.28	absent
06.2007	1.77	19.22	1.83	absent
Izvor Park				
07.2006	3.08	23.33	1.83	absent
06.2007	2.35	39.90	3.44	absent
Tubulifera, *Haplothrips niger*				
Cişmigiu Park				
07.2006	1.73	16.91	4.52	absent
08.2006	2.09	24.78	3.65	absent
Unirea Park				
07.2006	0.80	24.74	2.11	absent
06.2007	3.51	30.11	5.38	absent
Izvor Park				
07.2006	1.48	31.34	2.45	absent
08.2006	1.79	31.88	4.37	absent
10.2006	2.71	60.64	6.50	absent
05.2007	2.78	39.89	4.53	absent
06.2007	4.06	27.19	5.57	absent
07.2007	6.17	37.76	15.71	absent

Date	Pb (ppm)	Cu (ppm)	Zn (ppm)	Cd (ppm)
Tubulifera, *Bagnalliella yuccae*				(Table III – continued)
Cişmigiu Park				
08.2006	7.19	37.56	2.03	absent
09.2007	9.20	32.23	9.60	absent
Unirea Park				
10.2006	6.94	34.74	1.88	absent
05.2007	15.53	44.08	16.62	absent

Conclusion

Knowledge of heavy metal levels in Thysanoptera is important from the bioindicative point of view and also for assessing their transfer along the food-chain, soil-plant-consumers, in the polluted areas. The plant species are intermediate reservoirs through which heavy metals from soil are transferred to invertebrates and vertebrates.

The study of the influence of the air pollution on Thysanoptera communities took place during 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 in these urban parks was lower than in non-polluted grasslands. In the second year of the study, to the detriment of the mesophylous species, a slight increase in xero-termophylous thrips species was noted, due most likely to the added stress of the very hot and long summer of 2007.

The impact of environmental changes is reflected in the taxonomical diversity, the values of structural indices, as well as in the incidence of abnormal morphological aspects of *Frankliniella intonsa*.

The chemical analysis of the heavy metals concentrated in the thrips body certifies that *Frankliniella intonsa*, *Haplothrips niger*, *Bagnalliella yuccae* are good biomarkers of the urban pollution.

In the studied thrips, the maximal values of heavy metals were for Pb 6.17- 15.53 ppm, for Cu 42.68-60.64 ppm, for Zn 6.26-16.62 ppm, much higher than in their host plant species. Cd is not present in thrips bodies, which means Thysanoptera is sensitive only to certain heavy metals.

The content of heavy metals in Thysanoptera insects was realized for the first time in the world.

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References

DERBENEVA, N.N., 1959. Life cycle of *Haplothrips yuccae* Sav. (Thysanoptera*:* Phlaeothripidae). Entomologicheskoe Obozrenyie, 36: 64-81. [In Russian]

LEWIS, T., 1973. Thrips – Their Biology, Ecology and Economic Importance. Academic Press, London – New York,

LEWIS, T., 1997. Thrips as crop pests. CAB International, 244 pp.

MOUND, L., 2002. So many thrips - so few tospoviruses? *In*: Marullo R. & Mound, L. (eds.): Thrips and tospoviruses. Australian National Insect Collection, Canberra, pp.: 5 -18.

ONETE, M., 2008. Species monitoring in the central parks of Bucharest. Editura Ars Docendi, Bucharest, 121 pp.

SAVENKO, R.F., 1944. Some new species of Thysanoptera from Zakavkaz'ye. Soobscheniya Akademii nauk Gruzinskoi SSR, Tiflis, 10: 1008-1009.

VASILIU, L., 1973. Mediul şi fauna. *In*: Ionescu, A., Barnea, M., Chiosilă, I., Gavrilă, L., Ghinea, L., Grou, E., Gusic, V., Mihăilescu, A., Mohan, G., Moscalu, T., Popescu, A., Pora, E.A., Rabega, C., Râpeanu, M.D., Sanda, V., Stoian, V., Şerbănescu, G., Vasiliu, L., Vlădescu, C. (eds.): Efectele biologice ale poluării mediului. Editura Academiei Republicii Socialiste România, pp.: 177-193. [in Romanian]

VASILIU, L., 1976, Biology of Thysanoptera *Bagnalliella yuccae* Hinds 1902. Revue Roumaine de Biologie, Série Biologie Animale, 21 (2): 151-154.

VASILIU-OROMULU, L., 1995. Population diversity of Thysanoptera in Romanian meadows. *In*: Parker, B.L., Skinner, M. & Lewis, T. (eds.): Thrips Biology and Management. Plenum Press, New York, NATO ASI Series, Series A, Life Sciences, 276: 469-477.

VASILIU-OROMULU, L., 2002, The temporal and spatial dynamics of the thrips populations from the mountainous meadows. *In*: Marullo R. & Mound, L. (eds.): Thrips and tospoviruses. Australian National Insect Collection, Canberra, pp.: 295 - 313.

VASILIU-OROMULU, L., JENSER, G. & BĂRBUCEANU, D., 2008. *Frankliniella intonsa* (Trybom, 1895) a very sensitive bioindicator for air pollution. Acta Phytopatologica et Entomologica Hungarica, 43(1): 401-408.

ПРИМЕНЉИВОСТ ТРИПСА ЗА ПОТРЕБЕ БИОМОНИТОРИНГА У ГРАДСКИМ ПАРКОВИМА (INSECTA: THYSANOPTERA)

ЛИЛИАНА ВАСИЛИУ-ОРОМУЛУ, ДАНИЕЛА БАРБУЦЕАНУ и ЕЛИЗАБЕТА БИАНУ

Извод

У раду су представљени резултати истраживања потенцијалне улоге и значаја трипса (Thysanoptera) у биомониторингу загађених градских зелених површина – јавних паркова у Букурешту. Анализирано је присуство тешких метала у јединкама следећих врста трипса: *Frankliniella intonsa* (Trybom, 1895) (подред Terebrantia), *Bagnaliella yuccae* Hinds, 1902 и *Haplothrips niger* (Osborn, 1883) (подред Tubulifera). Аутори су нагласили да је ово први рад у светским размерама са подацима о акумулацији тешких метала у телима трипса. У закључку рада је наведено да трипси могу бити корисни као биоиндикатори у одређивању степена загађености паркова у градовима.

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