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Light Trap Catch of Beetle Species (Coleoptera) in Connection with the Chemical Air Pollutants

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ABSTRACT

In this study light-trap catch of three beetle (Coleoptera: Scarabaeidae) species were examined in connection with the everyday function of the chemical air pollutants (SO_2, NO, NO_2, NO_x, CO, PM10, O_3). Between 2004 and 2012 light-traps were operating in Fejér County, Hungary, Europe). The data were processed following species: *Rhizotrogus aequinoctialis* Herbst, 1790; *Rhizotrogus aestivus* Olivier, 1789; *Melolontha melolontha* Linnaeus, 1758. The data from different years were combined. The number of the chemical air pollutants and the caught beetles were assigned into classes. The results obtained were plotted. We determined the regression equations, and the levels of significance. We found that the behaviour of the studied beetle species can be divided only into two types: if the air pollution increases, the catch increases or decreases.

Key words: Light trapping, beetles, air pollution.

INTRODUCTION

Since the last century, air pollution has become a major environmental problem, mostly over large cities and industrial areas (Cassiani *et al*., 2013). It is natural that the air pollutant chemicals influence the life phenomena of insects, such as flight activity. According to Heliövaara and Väisänen (1990) some Lepidoptera groups are used as environmental pollution indicators by heavy metals and carbon dioxide (CO_2) concentrations in locations close to industrial areas and even within urban areas. Presence and consequences of copper, iron, nickel, cadmium, sulphuric acid ions and other substances used in fertilizers were studied with pupae of different Geometridae and Noctuidae species. Study of da Rocha *et al*. (2011) concluded that Insecta has many potential representatives that can be used as environmental bioindicators, among which are some species from the Coleoptera, Diptera, Lepidoptera, Hymenoptera, Hemiptera, Isoptera and others. Lepidoptera species are more sensitive environmental changes heavy metals and CO_2 pollution. Alstad *et al*. (1982) suggested that air pollution has been associated with boot primary (direct) and secondary (indirect) effects on insect populations. In the former case, airborne pollutants are directly implicated in the toxicology and decline of insect numbers. Conspicuous examples are those in which an economically valuable insect is poisoned; the best developed.

According to Buttler and Trumble (2008) the pollutants are harmful onto the plants of the terrestrial ecosystems and the insects, including air pollutants, such as ozone, sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon oxides (CO_x), fluoride and acid rain (fog and rain) and polluting metals and heavy metals. The population density reduction can be most frequently explained by the toxicity of pollutants (Kozlov *et al*., 1996). However, there are some species which prefer pollutants; they can strong growth and consequently cause serious damage to the polluted forests (Baltensweiler, 1985). There is a response of insect populations from negative to positive environmental pollution. Führer (1985) emphasized the urgent need of experimental evidence to demonstrate the modes of action of air contaminants upon forest insects. There are some hypotheses which refer to the polluting effect on plant consuming insects. These are the following:

(1) it causes a change in the quality of the habitat on plant consuming ones,

(2) it may modify the quality of the plant,

(3) it is harmful for the natural enemy, so decreases because of this (Zvereva and Kozlov, 2000).

Kozlov and Haukioja (1993) published the densities of males of the Large Fruit-tree Tortrix *A. podana* Scopoli which were determined by pheromone traps in the Lipetsk district, central Russia, in 1991. The sulphur dioxide was significant at Lipetsk among industrial emissions. The individual density of *Archips podana* Scopoli reached a peak at about 3-7 km from the nearest source of emission.

Some examples are given below:

Terrestrial insects: distinct types of response to SO_2 pollution have been identified which distinguish some groups of land-living insect, for example: very sensitive: e.g. many butterflies and moths; moderately sensitive - the Pine Engraver (*Ips dentatus* Sturm) and the Pine Flat-bug *Aradus cinnamoneus* Panz.; very tolerant and sometimes benefitted by SO_2 pollution - aphids. The Migratory Grasshopper (*Melanoplus sanguinipes* F.) density tended to decrease with increasing SO_2 concentration. Sulphur dioxide did not alter the relative proportions of this species in the total population (Mcnary *et al*.,1981). The abundance and dynamics of the European Spruce Bark Beetle (*Ips typographus* L.) populations was evaluated by Grodzki *et al.* (2014) in 60-80 year old spruce stands in Norway. The mean daily capture of beetles in pheromone traps was significantly higher at sites where the O_3 level was higher. The particulate matter adsorb toxic materials (e.g. metals, mutagenic substances) as well as bacteria, viruses, fungi and promote their getting into the body. PM10 can be cause irritation in the lung and mucous membrane (Dockery, 2009). 211 lives could have been saved in Hungary yearly by the reduction of PM10 to yearly mean of 20 $\mu g/m^3$ (Bobvos *et al*., 2014). Research groups studied in Europe in several cities of PM10 pollution (Makra *et al*., 2011; 2013; Papanastasiou and Melas, 2004; 2008; 2009; Papanastasiou *et al*., 2010). According to Vaskövi *et al.* (2014) and Chłopek (2013) the yearly mean concentration of PM10 is generally higher near the main traffic roads than in areas with less traffic. However, we did not find any studies in the literature examining the activity and daily pheromone trapping the insects in connection with air pollution.

MATERIAL

Between 2004 and 2012 light-traps were operating in Fejér County, Hungary Europe). The light traps were operated at the following villages and years: Csákvár (47º23′73”N; 18º28′17”E), 2004. Pálhalma-Dunaújváros (46º58′03”N; 18º56′13), 2004, 2005, 2006. Kőszárhegy (47º05′71”N; 18º20′62”E), 2004, 2005, 2006. Sukoró (47º17′40”N; 18º19′69”E), 2004, 2005, 2006, 2007, 2009, 2011, 2012. The data were processed of following species: *Rhizotrogus aequinoctialis* Herbst, 1790, *Rhizotrogus aestivus* Olivier, 1789 and *Melolontha melolontha* Linnaeus, 1758. The values of the chemical air pollutants: SO_2, NO, NO_2, NO_x, CO, PM10, O_3 (in milligram per cubic meter) was measured in nearest automatic measurement station Székesfehérvár (47°17’45”N, 18°19’59”E). Distance between the Kőszárhegy and Sukoró from Székesfehérvár are 22 km, Csákvár is 34 km and Pálhalma-Dunaújváros is 58 km as the crow flies.

METHODS

From the catch data of the examined beetle species, relative catch (RC) data were calculated for each observation post and day. The RC is the quotient of the number of individuals caught during a sampling time unit (1 day) per the average number of individuals of the same generation falling to the same time unit. In case of the expected averaged individual number the RC value is 1. The introduction of RC enables us to carry out a joint evaluation of materials collected in different years and at different traps (Nowinszky, 2003). The data from different years were combined. The number of the chemical air pollutants and the beetles caught were calculated in classes with consideration to the method of Sturges (Odor and Iglói, 1987). The RC values of all species were arranged into the proper classes. The results obtained are plotted. We determined the regression equations, the levels of significance, which were shown in the Table 1.

Table 1. The regression equations, levels of significance of air pollutants and beetle species.

Air pollutants	Equations	R^2	P <
Nitrogen dioxide (NO_2)			
Rhizotrogus aequinoctialis Herbst	$y = 0.001x^2 - 0.0625x + 1.7477$	0.7775	0.001
Rhizotrogus aestinus Olivier	$y = 0.002x^2 - 0.0645x + 1.3443$	0.8595	0.01
Melolontha melolontha Linnaeus	$y = 0.0009x^2 - 0.0019x + 0.3263$	0.9802	0.001
Nitrogen oxides (NO_x)			
Rhizotrogus aequinoctialis Herbst	$y= -4E-05x^3+0.0042x^2\ 0.1538x +2.6475$	0.857	0.01
Rhizotrogus aestinus Olivier	$y = 0.0004x^2 - 0.0073x + 0.8371$	0.812	0.01
Melolontha melolontha Linnaeus	$y = 9E-05x^2 + 0.0103x + 0.4733$	0.9525	0.001
Nitrogen oxide (NO)			
Rhizotrogus aequinoctialis Herbst	$y = 1.3843^e-0.1x$	0.8812	0.001
Rhizotrogus aestinus Olivier	$y = -0.003x^2 + 0.1245x + 0.4584$	0.8688	0.001
Melolontha melolontha Linnaeus	$y = -0.0015x^2 + 0.074x + 0.5522$	0.937	0.001

Table 1. Continued.

Air pollutants	Equations	R^2	P <
Carbon monoxide (CO)			
Rhizotrogus aequinoctialis Herbst	$y = 3E\text{-}06x^2 - 0.0053x + 2.79$	0.9856	0.001
Rhizotrogus aestinus Olivier	$y = 3E\text{-}07x^2 + 0.0002x + 0.5624$	0.8925	0.001
Melolontha melolontha Linnaeus	$y = 1.8708Ln(x) - 11.012$	0.8275	0.01
Ozone (O_3)			
Rhizotrogus aequinoctialis Herbst	$y = 3E\text{-}06x^2 - 0.0053x + 2.7909$	0.9856	0.001
Rhizotrogus aestinus Olivier	$y = 3E\text{-}07x^2 + 0.0002x + 0.5624$	0.8925	0.001
Melolontha melolontha Linnaeus	$1.8708Ln(x) - 11.012$	0.8275	0.01
Particulate matter (PM10)			
Rhizotrogus aequinoctialis Herbst	$y = 0.0011x^2 - 0.1924x + 8.8142$	0.9392	0.001
Rhizotrogus aestinus Olivier	$-2E\text{-}05x^3 + 0.0033x^2 - 0.248x + 7.3574$	0.9217	0.001
Melolontha melolontha Linnaeus	$y = 3E\text{-}05x^2 - 0.0144x + 1.7495$	0.9278	0.001

RESULTS AND DISCUSSION

All of our results are shown in Figs. 1-6. and Table 1 and Table 2. We found that the behaviour of the studied beetle species can be divided into two types: if the air pollution increases, the catch increases or decreases. Our results are without antecedents in the literature. We can only mention one of our own studies, dealing with examination between the pheromone trap catches and PM10 (Nowinszky *et al.,* 2015; 2016a; 2016b). We distinguished three types of trends in these studies of ours: increasing, decreasing and increasing then decreasing. We didn't find any studies in the special literature dealing with the contact of the light trap catch results and the air pollution. It is remarkable that the "increasing then decreasing" type is missing at the investigated beetle species. The emission of solid materials (dust, PM10) in Hungary from the early 90s fell by almost half, initially strongly, later with declining pace. The main are the industry, energy production and population. Today, more and more attention is paid to this pollutant. Research results have proved that the health effects of dust is far greater than previously thought. The small amount of material in the air, which is highly toxic, bind on the surface of the small size particles (PM2.5) and together with these particles they directly pass into the blood through the respiratory system. We know little about their effect has on the insects however

The response of different insect groups (Microlepidoptera, Macrolepidoptera, Trichoptera) to environmental factors is strikingly different. We do not know the impact of other pollutants on insect flight activity in the air. This opposite form of behaviour may be the many reasons. The claim and tolerance to environmental factors of the species are different. Environmental factors interact with each other to exert their effects. Thus the same factor can different effects. The species have different survival

(Nowinszky, 2003). Adverse effects of two possible answers: passivity, or hiding or even increased activity, because you want to ensure the survival of the species. Therefore, the insect "to carry out their duties in a hurry."

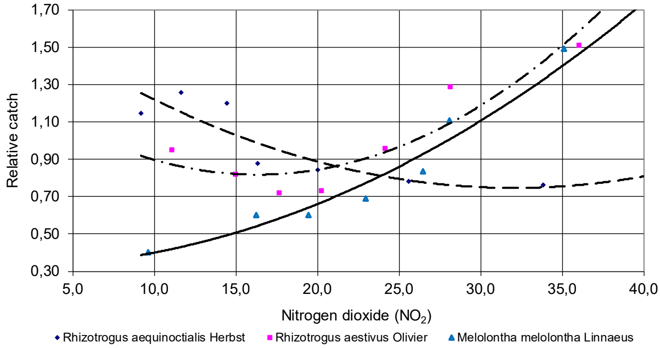

Fig. 1. Light-trap catch of beetle (Coleoptera) species in connection with the nitrogen dioxide (NO_2) content of the air (Fejér County).

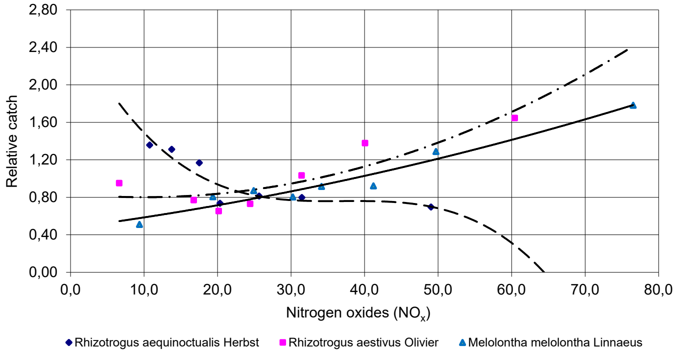

Fig. 2. Light-trap catch of beetle (Coleoptera) species in connection with the nitrogen oxides (NOx) pollution of air.

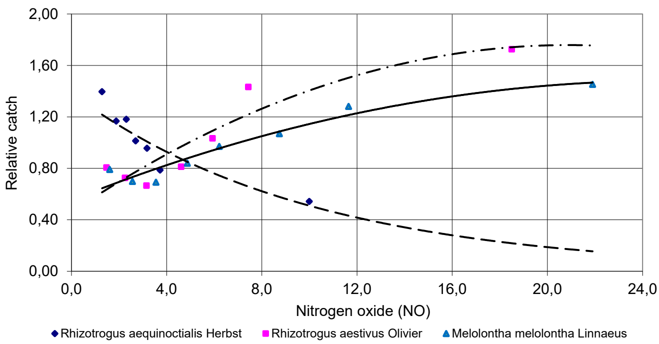

Fig. 3. Light-trap catch of beetle (Coleoptera) species in connection with the nitrogen oxide (NO) content of the air (Fejér County).

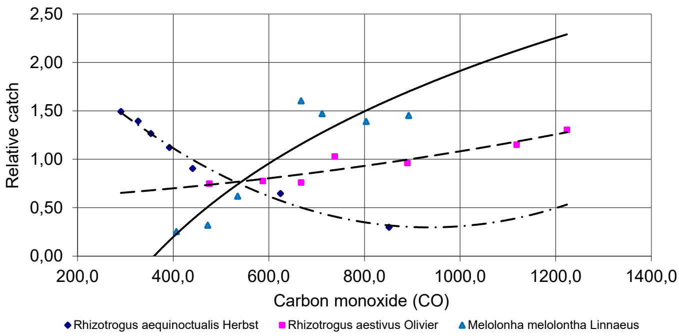

Fig. 4. Light-trap catch of beetle (Coleoptera) species in connection with the carbon monoxide (CO) content of the air (Fejér County).

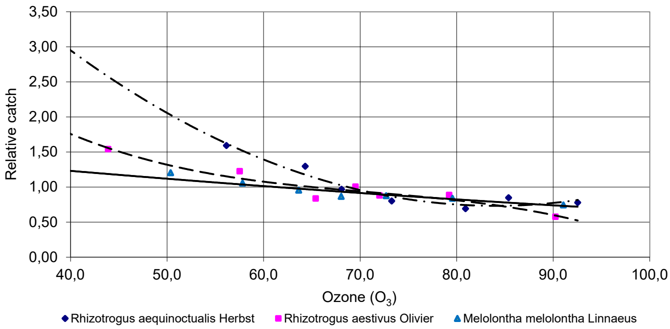

Fig. 5. Light-trap catch of the beetle (Coleoptera) species in connection with the ozone (O3) content of air.

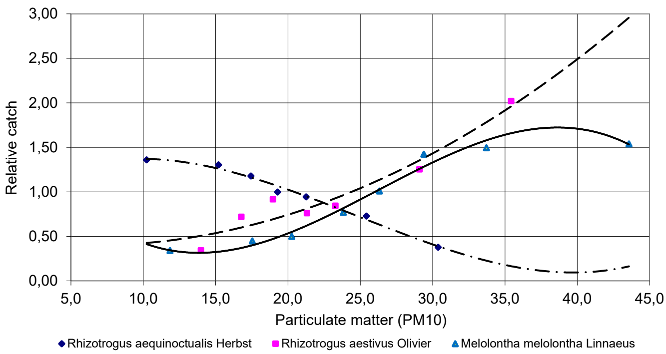

Fig. 6. Light-trap catch of the beetle (Coleoptera) species in connection with the particulate matter (PM10) content of air.

There may be more reasons for this contradictory behavioural forms. The different species need different circumstances and have difference tolerance levels to environmental factors. Environmental factors interact with each other to exert their effects. Thus the same factor can cause different influence. It is possible that there are two answers to the unfavourable environmental factors: passivity (e.g. hiding) or even increased activity, because the insect wants to ensure the survival of the species. Therefore, he does his tasks quickly. The fact that on the higher and increasing values of air pollutants the catches are not suddenly, but gradually, we deduce that the tolerance and response of insect specimens to adverse effects. Further studies are planned. We will continue our research in other insect species and trap types for analyses.

Table 2. The behaviour types of the examined beetle (Coleoptera) species.

Species	NO_2	NOx	NO	CO	O_3	PM10
Rhizotrogus aequinoctialis Herbst	D	D	D	D	D	D
Rhizotrogus astivus Olivier	I	I	I	I	D	I
Melolontha melolontha Linnaeus	I	I	I	I	D	I

Notes: I=increasing, D=decreasing.

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