Chapter 11.

Pheromone Trap Catch of Harmful Microlepidoptera Species in Connection with the Air Pollutants

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Abstract: In this study, seven species of Microlepidoptera pest pheromone trap collection presents the results of the everyday function of the chemical air pollutants (SO_2, NO, NO_2, NO_x, CO, PM10, O_3). Between 2004 and 2013 Csalomon type pheromone traps were operating in Bodrogkisfalud (48°10'N; 21°21E; Borsod-Abaúj-Zemplén County, Hungary, Europe). The data were processed of following species: Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius, 1781), Hawthorn Red Midget Moth (*Phyllonorycter corylifoliella* Hübner, 1796), Peach Twig Borer (*Anarsia lineatella* Zeller, 1839), European Vine Moth (*Lobesia botrana* Denis et Schiffermüller, 1775), Plum Fruit Moth (*Grapholita funebrana* Treitschke, 1846), Oriental Fruit Moth (*Grapholita molesta* Busck, 1916) and Codling Moth (*Cydia pomonella* Linnaeus, 1758). We found that the behaviour of the studied species can be divided into three types: if the air pollution increases the catch increase or decrease. In the third group there is an increase first and then a decrease will appear. The relation can be characterized with tertiary polynomial functions.

Keywords: Microlepidoptera, pests, pheromone traps, air pollution

11. 1. 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 as well.

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 product strong growth and consequently cause serious damage to the polluted forests (Baltensweiler, 1985). There is a response of insect populations change from negative to positive environmental pollution (Führer, 1985).

There are some hypotheses which refer to the polluting effect on plant consuming insects. These are 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 they decrease because of this or they disappear (Zvereva and Kozlov, 2000).

Kozlov and Haukioja (1993) publish the densities of males of the Large Fruit-tree Tortrix *Archips 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.

According to Malinowski (1992) there are differences among the answers of different animal groups given to the air pollution. Sometimes these separate clearly the different subgroups, in other cases, their susceptibility or resistance seems to be individual against air pollution against air pollution.

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, e.g. 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* Fabricius 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* Linnaeus) 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 & 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, the studies examining the activity and daily pheromone trapping the insects in connection with air pollution we not found in the literature.

11. 2. Material

Between 2004 and 2013 Csalomon type pheromone traps were operating in Bodrogkisfalud (48°10' N, 21°21' E; Borsod-Abaúj-Zemplén County, Hungary, Europe). These traps attracted seven Microlepidoptera species. Every year 2-2 traps per species were collected; one night after a 2-2 catching, data were available. The caught species were the followings: Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius, 1781), Hawthorn Red Midget Moth (*Phyllonorycter corylifoliella* Hübner), Peach Twig Borer (*Anarsia lineatella* Zeller, 1839), European Vine Moth (*Lobesia botrana* Denis et Schiffermüller, 1775), Plum Fruit Moth (*Grapholita funebrana* Treitschke, 1846), Oriental Fruit Moth (*Grapholita molesta* Busck, 1916) and Codling Moth (*Cydia pomonella* Linnaeus, 1758).

Data on the Hawthorn Red Midget Moth (*Phyllonorycter corylifoliella* Hbn.) were collected between 2008 and 2013 only. The catch data of the collected species is displayed in Table 11. 2. 1.

The distance between the traps were 50 meters and they were in operation all the year on the same branch of leafy trees or vines. The height of each species was different from 1.5 to 2 meters. The traps operated from start of April to the end

Table 11. 2. 1. The number and observing data of the examined species

Species	Number of	
	moths	data
Gracillariidae »Lithocolletinae Spotted Tentiform Leafminer *Phyllonorycter blancardella* Fabricius, 1781	65,478	2,991
Gracillariidae »Lithocolletinae Red Midget Moth *Phyllonorycter corylifoliella* Hübner, 1796	10,156	1,820
Gelechiidae » Anacampsinae Peach Twig Borer *Anarsia lineatella* Zeller, 1839	9,090	2,352
Tortricidae » Olethreutinae European Vine Moth *Lobesia botrana* Denis et Schiffermüller, 1775	9,751	2,639
Tortricidae » Olethreutinae Plum Fruit Moth *Grapholita funebrana* Treitschke, 1846	30,534	3,118
Tortricidae» Tortricinae Oriental Fruit Moth *Grapholita molesta* Busck, 1916	17,402	3,117
Tortricidae » Olethreutinae Codling Moth *Cydia pomonella* Linnaeus, 1758	10,490	2,857

of September. The capsules exchange was in every 6-8 weeks as it was proposed by Tóth (2003). The number of caught moths was daily recorded. This is different from the general practice, because generally the catch of the traps is counted two or three days together in most cases.

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 Hernádszurdok (48°28'98″N, 21°12'38″E). Distance between the two villages from each other is 37 km as the crow flies.

11. 3. Methods

From the catching data of the examined species, relative catch (RC) data were calculated for each observation posts and days. 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 (Nowinszky, 2003). The introduction of RC enables us to carry out a joint evaluation of materials collected in different years and at different traps.

The data from different years were treated with combined. The number of the chemical air pollutants and the moths caught was calculated 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, these levels of significance, which were shown in the figures.

11. 4. Results and Discussion

All of our results are shown in Table 11. 4. 1.

We found that the behaviour of the studied species can be divided into three types: if the air pollution increases the catch increase or decrease. In the third group there is an increase first and then a decrease will appear. These types of behaviour are also presented Figures 11. 4. 1–11. 4. 11. for each pollutant.

Our results are without antecedents in the literature. Partly because the catching results of pheromone traps are not suitable for tests on daily events, and partly because of flight activity and trapping insects of our knowledge, have not been studied in entomologists.

We can only mention one of our own studies, dealing with examination between the pheromone trap catches and PM10 (Nowinszky et al. 2015).

Our results may explain at present only assumptions, but they cannot even prove or disprove. The increase the content of particular matter in air may therefore increase the catch, because the light is reflected from the solid particles, thus increasing the amount of polarized light by day and night. The pheromone traps that male moths collected throughout the day. As we have previously demonstrat-

Table 11. 4. 1. The behaviour types of the examined species (I = increasing, D = decreasing, I→D: increasing after decreasing)

Species	SO_2	NO_2	NOx	NO	CO	O_3	PM10
Ph. blancardella Fabr.	—	D	I→D	I	I	I→D	I
Ph. corylifoliella Haw.	—	I→D	I→D	I	D	I→D	I
A. lineatella Zeller	I→D	I→D	—	—	I→D	I→D	—
L. botrana Den. et Schiff.	—	I	I	I→D	—	I	I
G. funebrana Tr.	—	I	I	—	—	I	I
G. molesta Busck	I→D	I	I	—	—	I	I
C. pomonella L.	I→D	I→D	I→D	I→D	I→D	I→D	I

ed the polarized light increases the activity of insects (Nowinszky et al., 1979, 2010a, 2010b, 2012a, 2012b, Nowinszky & Puskás 2009, 2010, 2011, 2012, 2013a, 2013b, 2014). Another possibility is that the solid particles of the pheromone molecules bind well, so the greater activity male moths need for finding the females.

The particulate matters adsorb toxic materials (e.g. metals, mutagenic substances) as well as bacteria, viruses, fungi and promote them getting inside the body.

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 pollutants are the industry, energy production and the population, but growing of transport sector can be seen during last years. 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. The only exception is the temperature and the (polarized) moonlight. The temperature is one reason because special temperature values are necessary for the flight activity. This is not the same value for different species but at a higher temperature the activity can be higher. Another reason is that the flying period is relatively short and it is in that season when the rough changes of temperature are very rare. The moonlight and especially its polarized proportion significantly increase the flight activity (Nowinszky, 2004 and 2008). 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 be different effect. The species have different survival strategy (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 do "to carry out their duties in a hurry."
It may be more of the reason of this for contrary behavioural forms:

The different species needs different circumstances and tolerance to environmental factors. Environmental factors interact with each other to exert their effects. Thus the same factor can cause different influence.

It is possible 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 quickly his tasks.

The fact that on the higher and increasing values of air pollutants the catches are not suddenly, but gradually decline, we deduce that the tolerance and response of insect specimens adverse effects to individually change.

Further studies are planned. We will continue our research in other insect species and trap types for analyses.

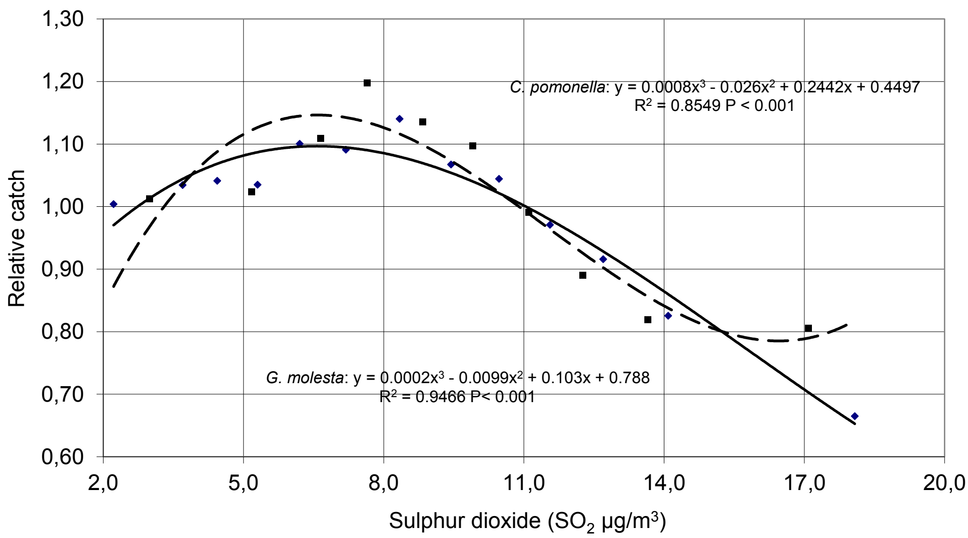

Figure 11.4.1

Figure 11. 4. 1. Pheromone trap catch of the *Grapholita molesta* Busck and *Cydia pomonella* Linnaeus in connection with the sulphur dioxide (SO_2) content of the air (Bodrogkisfalud, 2004-2013)

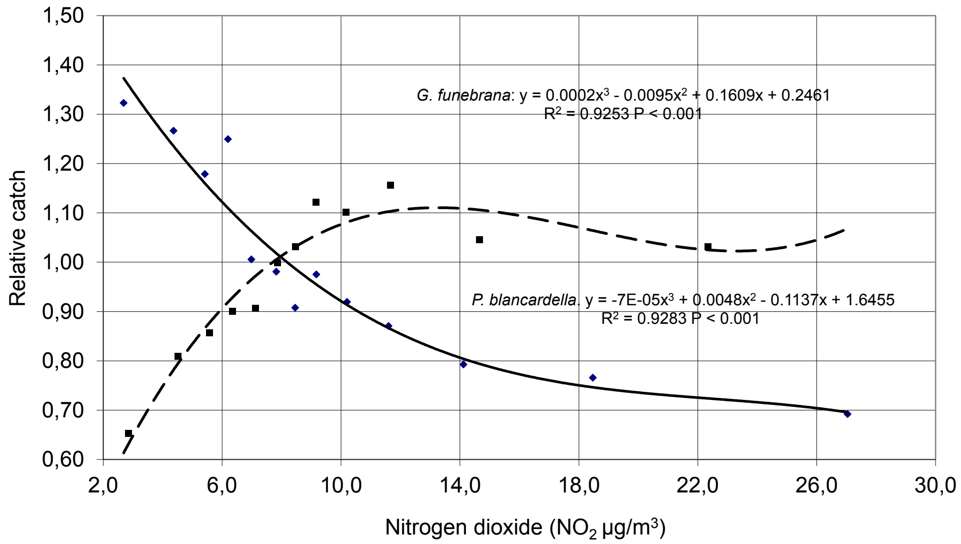

Figure 11. 4. 2

Figure 11. 4. 2. Pheromone trap catch of the *Phyllonorycter blancardella* Fabricius and *Grapholita funebrana* Treitschke in connection with the nitrogen dioxide (NO_2) content of air (Bodrogkisfalud, 2004-2013)

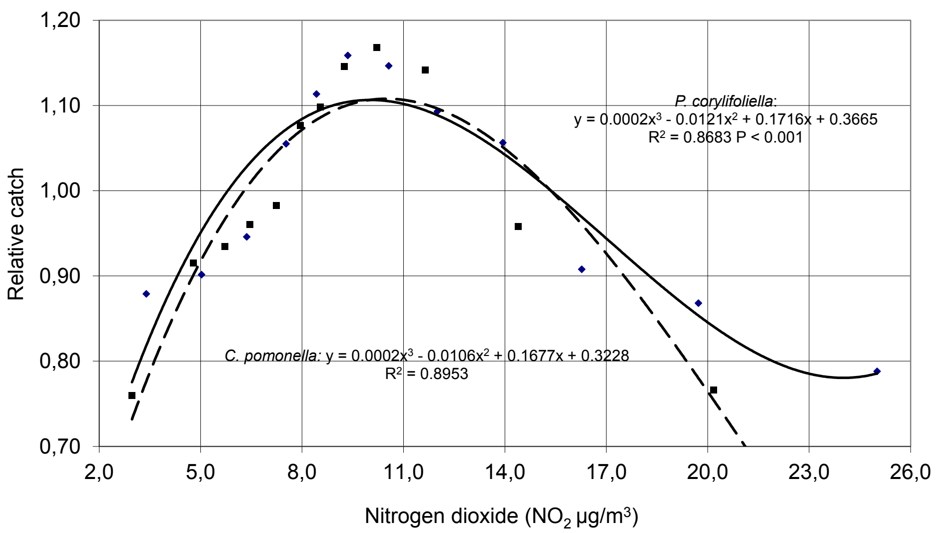

Figure 11. 4. 3.

Figure 11. 4. 3. Pheromone trap catch of the *Phyllonorycter corylifoliella* Hübner and *Cydia pomonella* Linnaeus in connection with the nitrogen dioxide (NO_2) content of air (Bodrogkisfalud, 2008-2013 and 2003-2013)

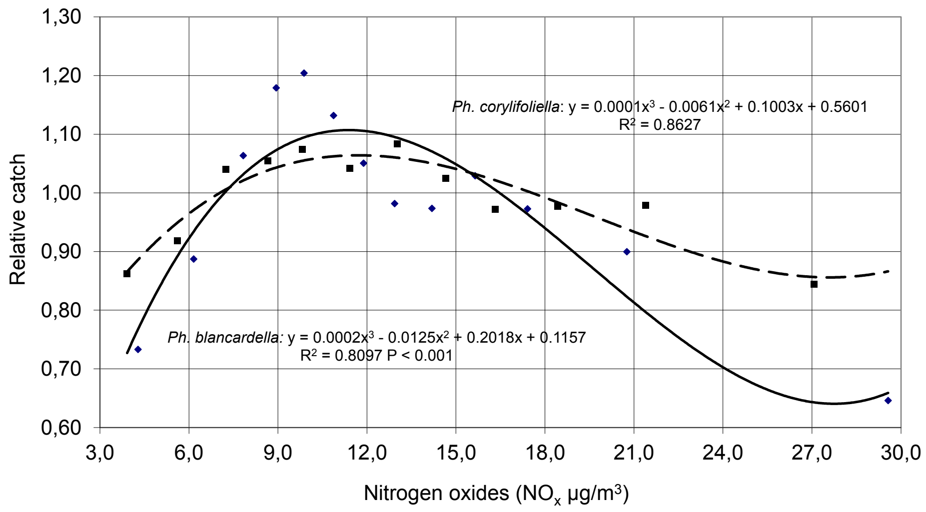

Figure 11. 4. 4.

Figure 11. 4. 4. Pheromone trap catch of *Phyllonorycter blancardella* Fabricius and *Phyllonorycter corylifoliella* Hübner in connection with the nitrogen oxides (NO_x) contents of air (Bodrogkisfalud 2004-2013 and 2008-2013)

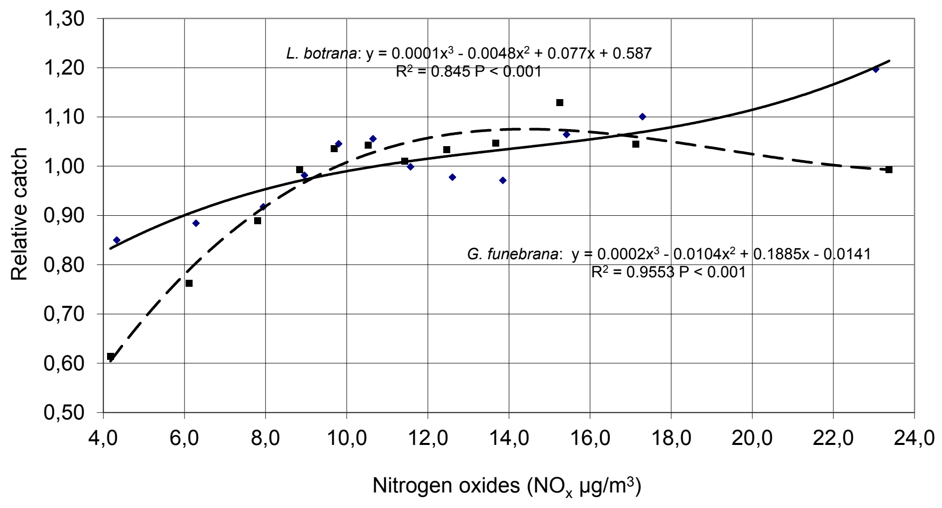

Figure 11. 4. 5.

Figure 11. 4. 5. Pheromone trap catch of *Lobesia botrana* Denis et Schiffermüller and *Grapholita funebrana* Treitschke in connection with the nitrogen oxides (NO_x) content of air (Bodrogkisfalud, 2004-2013)

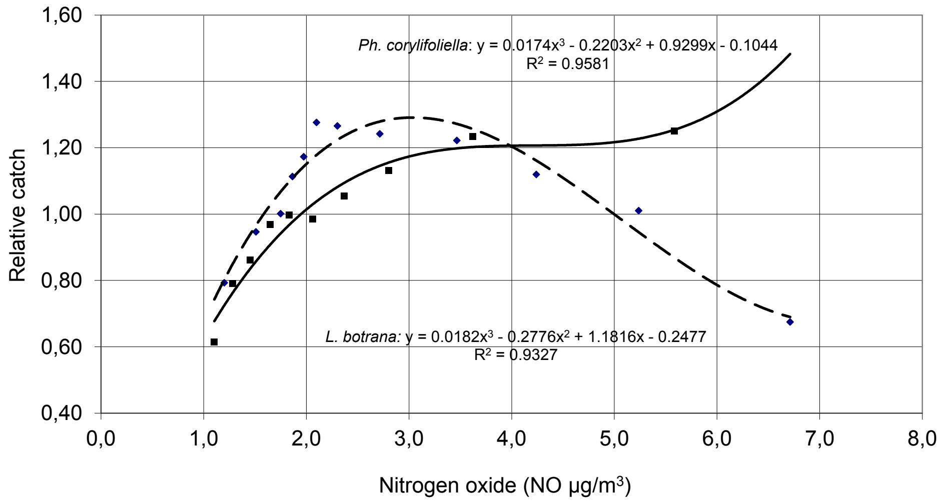

Figure 11. 4. 6.

Figure 11. 4. 6. Pheromone trap catch of the *Phyllonorycter corylifoliella* Hübner and *Lobesia botrana* Denis et Schiffermüller in connection with nitrogen oxide (NO) content of air (Bodrogkisfalud, 2008-2013 and 2004-2013)

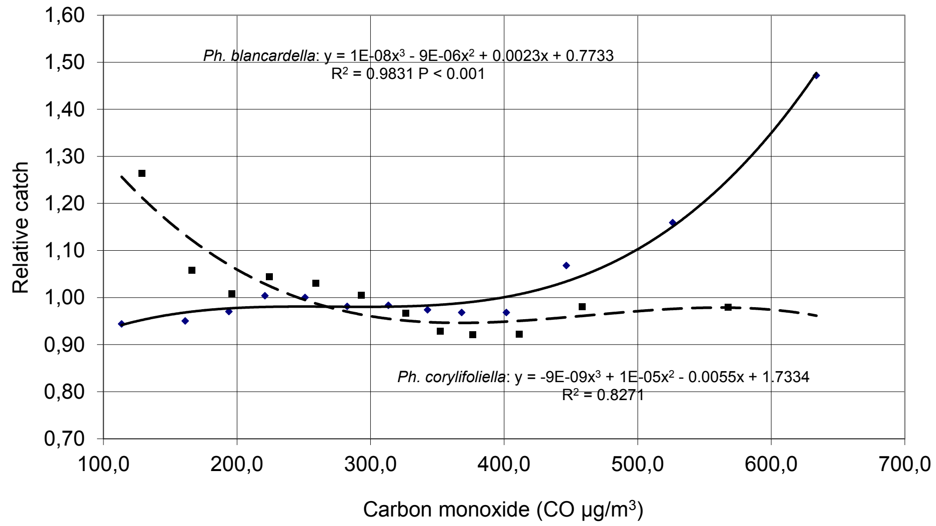

Figure 11. 4. 7.

Figure 11. 4. 7. Pheromone trap catch of the *Phyllonorycter blancardella* Fabricius and *Phyllonorycter corylifoliella* Hübner in connection with carbon monoxide (CO) content of air (Bodrogkisfalud, 2004-2013 and 2008-2013)

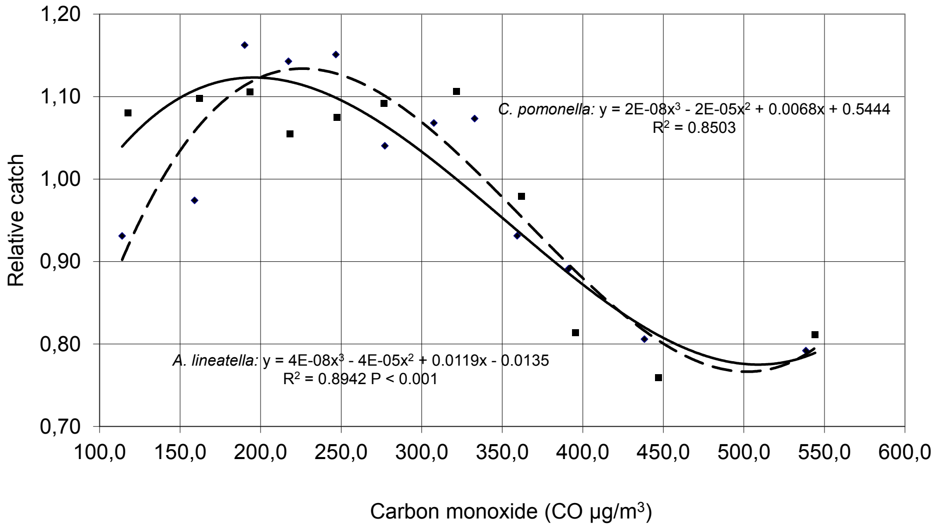

Figure 11. 4. 8.

Figure 11. 4. 8. Pheromone trap catch of the *Anarsia lineatella* Zeller and *Cydia pomonella* Linnaeus in connection with the carbon monoxide (CO) content of air (Bodrogkisfalud, 2004-2013)

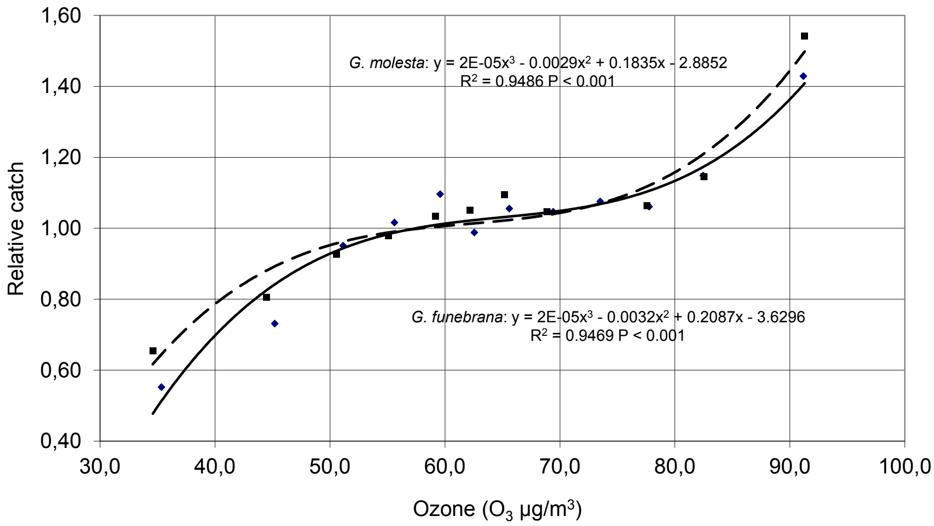

Figure 11. 4. 9.

Figure 11. 4. 9. Pheromone trap catch of the *Grapholita funebrana* Treitschke and *Grapholita molesta* Busck in connection with ozone (O_3) content of air (Bodrogkisfalud, 2004-2013)

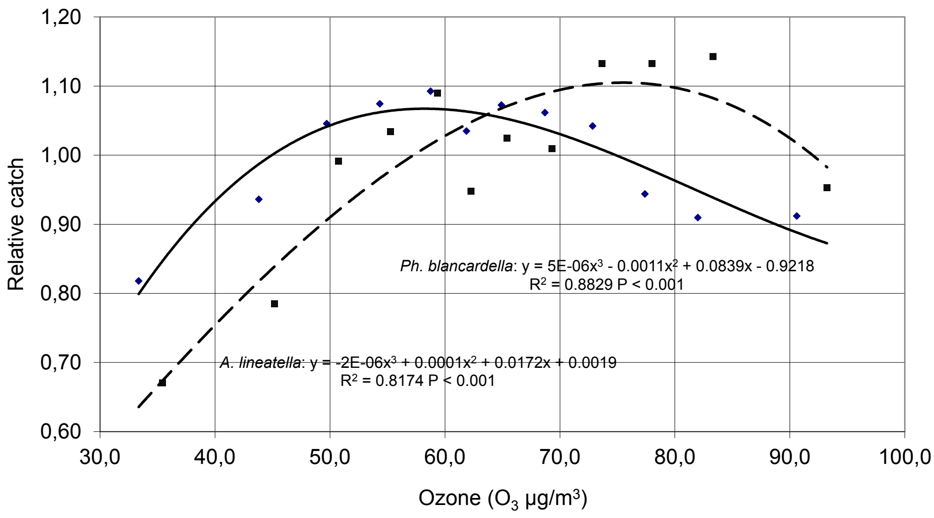

Figure 11. 4. 10.

Figure 11. 4. 10. Pheromone trap catch of the *Phyllonorycter blancardella* Fabricius and *Anarsia lineatella* Zeller in connection with the ozone (O_3) content of air (Bodrogkisfalud, 2004-2013)

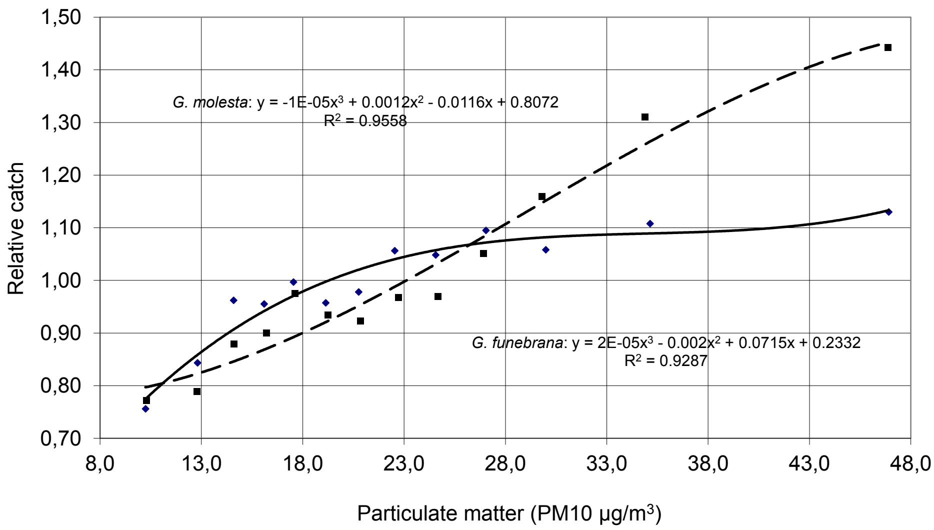

Figure 11. 4. 11.

Figure 11. 4. 11. Pheromone trap catch of the *Grapholita funebrana* Treitschke and *Grapholita molesta* Busck in connection with the particulate matter (PM10) content of air (Bodrogkisfalud, 2004-2013)

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Our Previous Studies

Their Expanded and Reworked Text Were Used in the Chapters of this Book

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