Chapter 5.

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

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Abstract: The study deals the efficiency of pheromone trapping of the seven harmful Microlepidoptera species depending on the ozone content of air. Between 2004 and 2011 Csalomon type pheromone traps were operating in Bodrogkisfalud (48°10' N, 21°21' E; Borsod-Abaúj-Zemplén County, Hungary, Europe). We calculated relative catch values from the number of caught insects. We assigned these to the ozone values, we averaged them, and we depicted the results together with the regression equation though. We established that the pheromone trapping of this species is most fruitful when the ozone content of the air is high. By contrast, low ozone values reduce the successfulness of the catching to a moderate level. Our results will be exploitable in plant protecting and environment conservation research.

Keywords: Microlepidoptera, pheromone trapping, ozone content of air

5. 1. Introduction

Summer daytime ozone concentration correlates strongly with temperature. Tropospheric ozone is expected to increase at 40-60 % up to the end of the 21st century which is linked to air quality and climate change (Meleux et al., 2007).

Ozone is a harmful agent causing oxidative stress on plants which may vary in their tolerances. Changes in agricultural productivity can be, in one hand, the result of direct effects of ozone at the plant level, or, in the other hand the consequence of indirect effects at the system level, for instance, through shifts in nutrient cycling, crop-weed interactions, insect pest occurrence, and plant diseases (Fuhrer, 2003).

The instruments used for measurements and description of the methods were described in the previous studies (Nowinszky et al., 2012; Puskás and Nowinszky, 2010; Nowinszky and Puskás, 2011; Puskás and Nowinszky, 2011a and 2011b; Puskás et al., 2013); we refer here only to our former work.

Kalabokas and Bartzis (1998), Kalabokas et al. (2000), Kalabokas (2002), Papanastasiou et al. (2002 and 2003), Papanastasiou and Melas (2006) in Greece have been studying both the monthly changes and those in the different periods of each day of the ozone content. Ozone content in the summer months - from May until August - is higher than in other months of the year. There are typical daily changes. The ozone content is high from noon to evening and goes down from evening to dawn. It hits its lowest point in the dawn hours and begins to rise again in the early morning. Ozone concentrations in the atmosphere depended on several meteorological factors, too (Tiwari et al., 2008). According to Juhász et al. (2006) the ozone content of the atmosphere is still significantly high during the night.

The high concentration of ozone is maleficent to insects. The study of Kells et al. (2001) evaluated the efficacy of ozone as a fumigant to disinfect stored maize. Treatment of 8.9 tonnes of maize with 50 ppm ozone for 3 days resulted in 92-100 % mortality of adult Red Flour Beetle, *Tribolium castaneum* (Herbst), adult Maize Weevil, *Sitophilus zeamais* (Motsch.), and larval Indian Meal Moth, *Plodia interpunctella* (Hbn.). Biological effects of ozone have been investigated by Qassem (2006) as an alternative method for grain disinfestations. Ozone at a concentration of 0.07g/m^3 killed adults of the Grain Weevil *(Sitophilus granarius* L.), Rice Weevil *(Sitophilus oryzae* L.) and Lesser Grain Borer *(Rhyzopertha dominica* Fabr.) after 5-15 hours of exposure. Adult death of the Rice Flour Beetle *(Tribolium confusum* Duv.) and Saw-toothed Grain Beetle *(Oryzaephilus surinamensis* L.) was about 50% after 15 -20 hours of exposure. The total adult death of all insect species occurred with 1.45 g/m^3 ozone concentration after one hour of exposure. Valli and Callahan (1968) examinations made with light traps indicated an inverse relationship between O_3 and insect activity.

The our recent study (Ladányi et al. 2012) investigates the effect of the tropospheric ozone content on the relative catch of European Vine Moth (*Lobesia botrana* Den. et Schiff.), Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabr.), Setaceous Hebrew Character *(Xestia c-nigrum* L.), Latticed Heath *(Chiasmia clathrata* L.), April Beetle (*Rhizotrogus aequinoctialis* Herbst) and *Ecnomus tenellus* Rambur trapped between 2004 and 2011 in Hungary. In order to describe the empirical connection between the ozone content of the air and the relative number of trapped insects, we introduce some nonlinear regression models of the same general model as origin. We show that elevated ozone content of air stimulates basically two different kinds of response in flying activity of insects.

5. 2. Material

Between 2004 and 2011 Csalomon type pheromone traps were operating in Bodrogkisfalud (48°10' N, 21°21' E; Borsod-Abaúj-Zemplén County, Hungary, Europe). These traps attracted 7 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* Hübner.) were collected between 2008 and 2011 only. The catch data of the collected species is displayed in Table 5. 2. 1.

5. 3. Methods

The traps near each other worked all year. They were placed on leafy trees of the same branches and vines at a distance of 50 meters between the traps. The height of each species was different, from 1.5 to 2 meters. The traps operated from the beginning of April to the end of September. According to Tóth (2003) the proposed capsules exchange was in a 6-8 week period. The number of moths captured per day was recorded, which is different from the general practice of counting the catch two or three days together.

The pheromone traps operated in the same orchards and vineyards in every year. There were no performed chemical pest control treatments.

In Hungary, ozone monitoring is carried out at four stations of the Hungarian National Meteorological Service. Monitoring at K-puszta (46° 58' N, 19° 33' E) has been done since 1973 and in 37 other cities and villages since 2004. Today 10 minute average concentration values are detected at every station with the help of the ozone monitors. Since 1998, MILOS has forwarded data and QLC that were collected earlier by local data collecting software (SCANAIR) and stored in PCs. SCANAIR reduced 15-minute data into half-hour averages which were then entered in the data base. At the stations the job is performed by an Environment type monitor. A Thermo Electron type monitor executes parallel monitoring at stations. The ozone monitors are UV photometric ozone analysers which, with a UV lamp, establish ozone concentration by illuminating an air sample drawn into an absorption cell, then measure the decline of illumination at a wavelength of 254 nm. The extent of this is proportional to the ozone content of the air. The instrument establishes the ozone concentration in a ppb unit, by taking samples in every 10 minutes. The data are in a 0-150 ppbs range. Sometimes negative values are received after calibration: this is to be handled as 0. High ozone values (> 100 ppb) occur mainly in the summer season, sometimes in early spring. Values over 120 ppb were measured vary rarely (so far in 1-2 cases). A Thermo Electron type ozone calibrator is being used. Every measuring instrument must be calibrated at least once a year. In fact, the ozone calibrator must be regularly adjusted to the international standard (in Prague), too. Calibration and data control cannot be fully automated, as the daily curves must be checked separately and outliers must not be automatically discarded. Each item of data is marked with an error code, which characterizes the quality of the data. Every external circumstance, including the various meteorological features (wind direction, wind speed, temperature, etc.), must be examined in order to explain extreme and clearly incorrect ozone values. A final file of data stores the raw measurement data, the calibrated and controlled data and the mistake code referring to data quality. The database is copied to CDs annually (Puskás et al. 2001). 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 the 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.

The ozone content values and the moths caught were calculated with consideration to the method of Sturges (Odor and Iglói, 1987). The RC values of a species from all sites and years were arranged into the proper classes. The results obtained are plotted. We determined the regression equations, the significance levels which were shown in the figures.

5. 4. Results and Discussion

Our results, including regression equations and significance levels, are displayed in Figures 1-7. Our results have shown that high ozone content of the air is accompanied by a higher pheromone trap catch. Our previous work has demonstrated that when the atmospheric ozone content is high, the flying activity of the several insect species increases and their light-trap catch will be more effective.

The relationship of pheromone trap relative catch to ozone concentration can be described using different types of functions. For the following species: *Phyllonorycter blancardella* Fabr., *Cydia pomonella* L., *Lobesia botrana* Den. et Schiff. and *Grapholita funebrana* Treitschke, such ratio can be described by logarithmic function. On the other side, for species such: *Phyllonorycter corylifoliella* Haw., *Anarsia lineatella* Zeller and *Grapholita molesta* Busck, named relation can be described using second or third degree polynomial functions.

Our current work can be done based on a similar statement of pheromone trap catch in the harmful moth species also. Nowinszky and Puskás (2011), Puskás and Nowinszky (2011a) and for the *Ecnomus tenellus* Rambur (Trichoptera: Ecnomidae) by Puskás et al. (2011).

We found that the pheromone trap catch of five harmful moth species increases in strength when the atmospheric ozone content is more than 40 $\mu g/m^3$ and in the case of two species when it is more than 50 $\mu g/m^3$. In contrast, the low ozone content of air significantly reduces the pheromone trap catch success of these examined species.

Higher concentrations of ozone are generally typical on those days when a stronger UV radiation can be measured. Probably the daily average temperature and temperature of swarming hours are higher on these days because of the more intensive sunshine. This can cause intensive flight activity and also high value in catch. Some literature, however, suggests that direct ozone effect on behaviour cannot be ruled out.

The pheromone trap catch of the death-borer beetles seems to support the theory that the flight activity of some insects is increased as a direct consequence of increased ozone concentration (Grodzki et al*.,* 2004). However, due to expected increased tropospheric ozone concentration in future, to clarify the direct or indirect influence of ozone concentration on the flight activity of the insects, further investigation will be required.

We suggest similar examinations of other harmful insect species be done with other relevant sampling methods (for example light-, suction-, Malaise-, bait traps). If it were proved that the high ozone content of air increases the flying activity of other insect species, it will be necessary to take this fact into consideration when developing the plant protection prognoses. Moreover, more accurate plant protection prognosis could be prepared. Our result contradicts that of Valli and Callahan (1968), who experienced a decrease in the activity of Corn Earworm (*Heliothis zea* Boddie) with the parallel increase of the ozone content. This contradiction may be due to the fact that low relative catch values always refer to environmental factors in which the flight activity of insects diminishes. However, high values are not so clear to interpret. Major environmental changes bring about physiological transformation in the insect organism. The imago is short- lived; therefore an unfavourable environment endangers the survival of not just the individual, but the species as a whole. In our hypothesis, the individual may adopt two kinds of strategies to evade the hindrances to the normal functioning of its life phenomena. It may either display more liveliness, by increasing the intensity of its flight, copulation and egg-laying activity, or it may take refuge in passivity to environmental factors which create an unfavourable situation. And so, given the present state of our knowledge, we might say that both favourable and unfavoura-

Table 5. 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	53,515	2,092
Gracillariidae »Lithocolletinae Hawthorn Red Midget Moth *Phyllonorycter corylifoliella* Hübner, 1796	5,834	929
Gelechiidae » Anacampsinae Peach Twig Borer *Anarsia lineatella* Zeller, 1839	5,957	1,606
Tortricidae » Olethreutinae European Vine Moth *Lobesia botrana* Denis et Schiffermüller, 1775	6,993	1,738
Tortricidae » Tortricinae Plum Fruit Moth *Grapholita funebrana* Treitschke, 1846	23,386	2,144
Tortricidae Oriental Fruit Moth *Grapholita molesta* Busck, 1916	11,830	1,996
Tortricidae » Olethreutinae Codling Moth *Cydia pomonella* Linnaeus, 1758	11,830	1,996

Cydia pomonella, imago

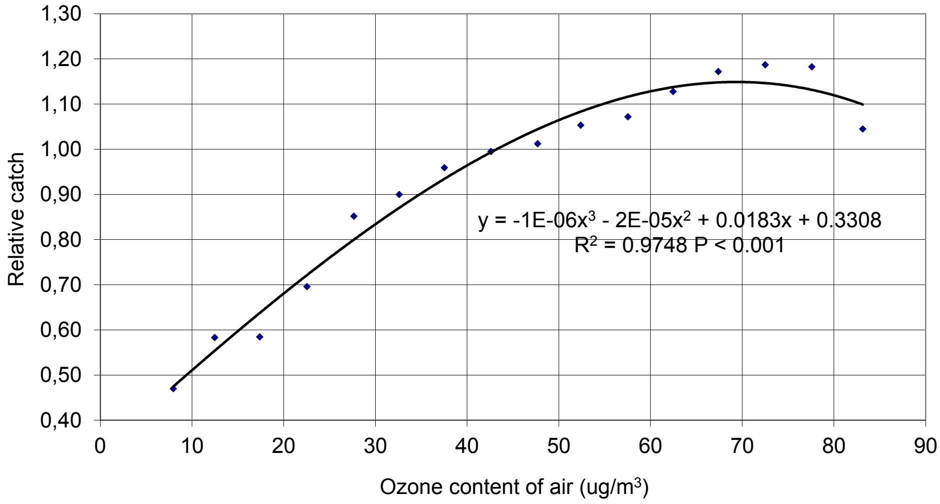

Figure 5. 4. 1.

Figure 5. 4. 1. Pheromone trap catch of Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius) in connection with ozone content of air (Bodrogkisfalud, 2004-2011)

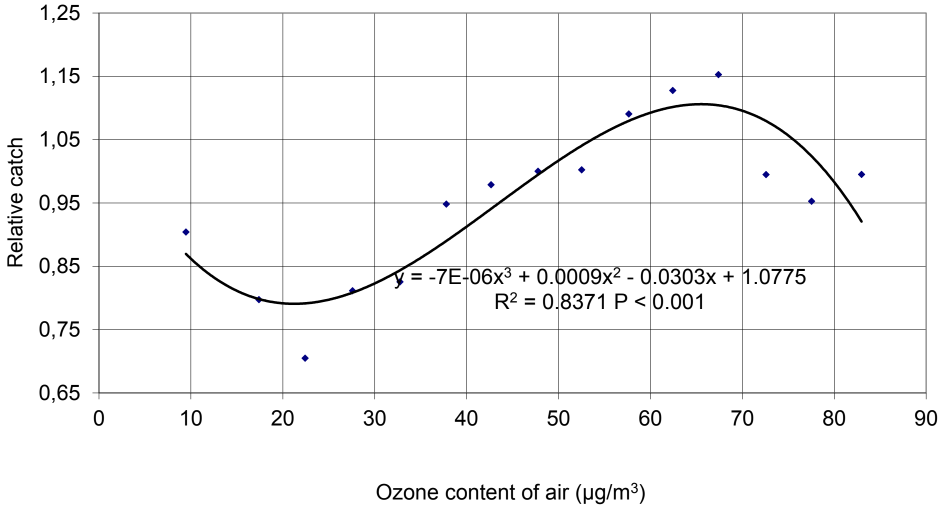

Figure 5. 4. 2.

Figure 5. 4. 2. Pheromone trap catch of Hawthorn Red Midget Moth (*Phyllonorycter corylifoliella* Hübner) in connection with the ozone content of air (Bodrogkisfalud, 2008 -2011)

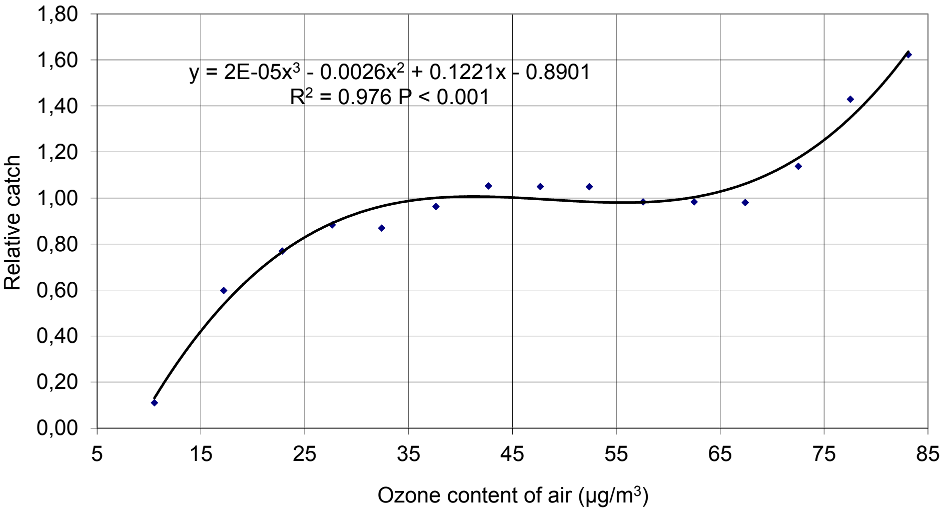

Figure 5 . 4. 3.

Figure 5. 4. 3. Pheromone trap catch of Peach Twig Borer (*Anarsia lineatella* Zeller) in connection with ozone content of air (Bodrogkisfalud, 2004-2011)

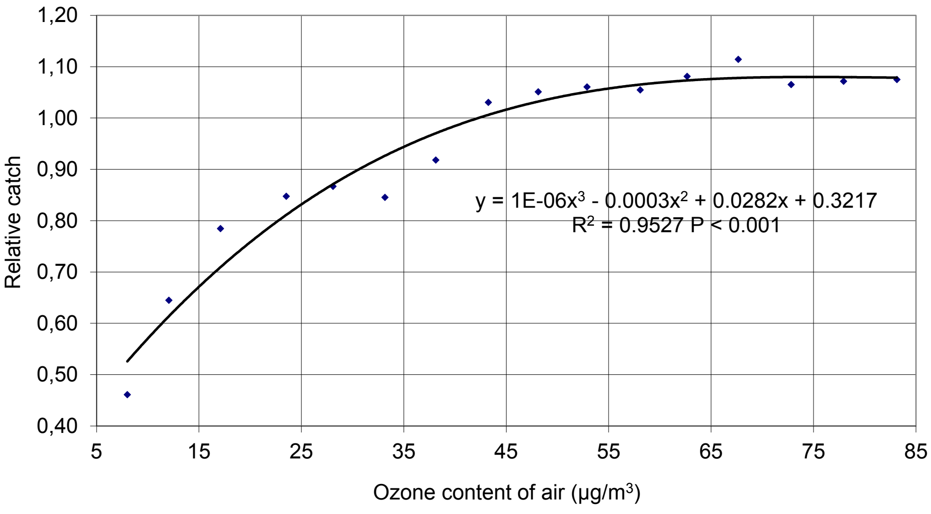

Figure 5. 4. 4

Figure 5. 4. 4. Pheromone trap catch of European Vine Moth (*Lobesia botrana* Denis et Schiffermüller) in connection with the ozone content of air (Bodrogkisfalud, 2004-2011)

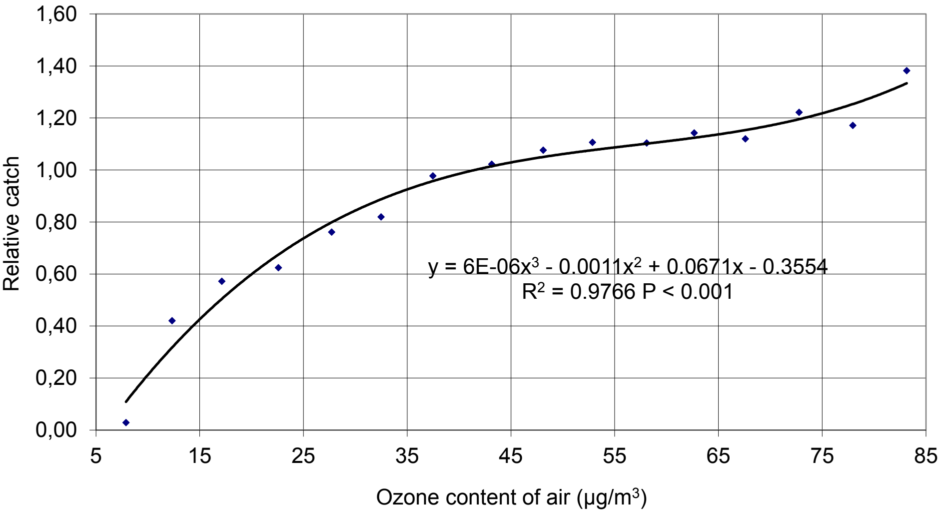

Figure 5. 4. 5.

Figure 5. 4. 5. Pheromone trap catch of Plum Fruit Moth (*Grapholita funebrana* Treitschke) in connection with ozone content of air (Bodrogkisfalud, 2004-2011)

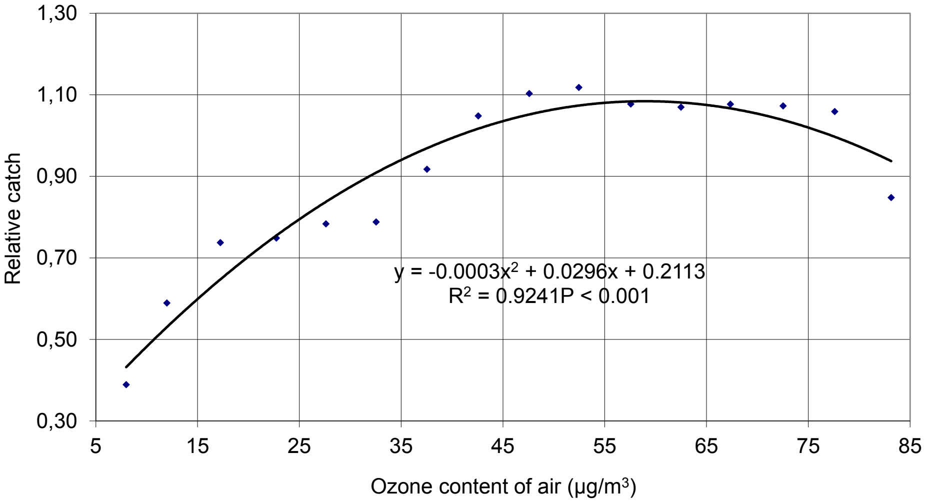

Figure 5. 4. 6.

Figure 5. 4. 6. Pheromone trap catch of Oriental Fruit Moth (*Grapholita molesta* Busck) in connection with ozone content of air (Bodrogkisfalud, 2004-2011)

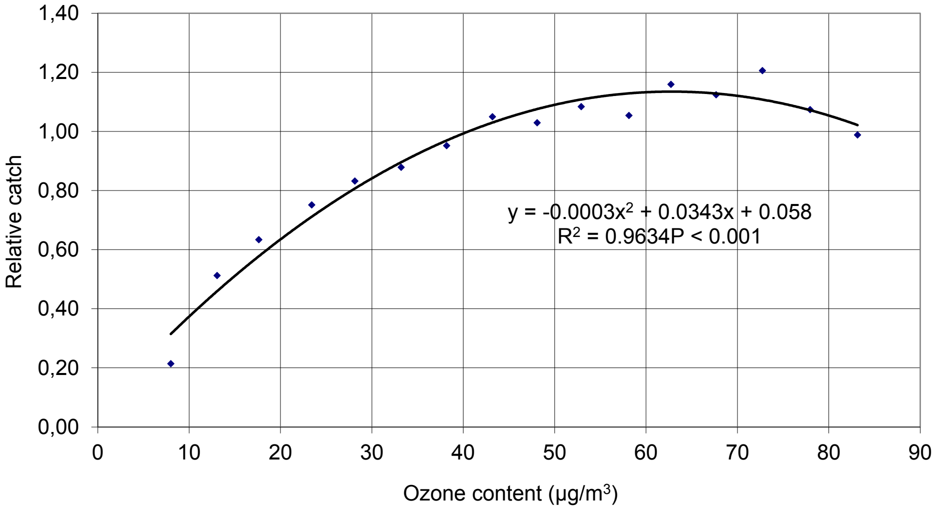

Figure 5. 4. 7.

Figure 5. 4. 7. Pheromone trap catch of Codling Moth (*Cydia pomonella* Linnaeus) in connection with the ozone content of air (Bodrogkisfalud, 2004-2011)

ble environmental factors might be accompanied by an equally high catch (Nowinszky, 2003).

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