Chapter 6.

Pheromone Trap Catch of the Harmful Microlepidoptera Species in Connection with the Geomagnetic C9 Index

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Abstract: The study deals with the change of pheromone trap catch of six harmful Microlepidoptera species in connection with the geomagnetic C9 index. The numbers of specimens caught by generation of all species were calculated relative catch values. These daily relative catch data were assigned to the daily values of geomagnetic C9 index. We correlated the daily catch results pertaining to the daily values of geometric C9 values. The pheromone trap catch of four examined species increased in the higher values of the C9 index. These species are as follows: Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius), Peach Twig Borer (*Anarsia lineatella* Zeller), Plum Fruit Moth (*Grapholita funebrana* Treitschke) and Oriental Fruit Moth (*Grapholita molesta* Busck). The catch decreased of two species European Vine Moth (*Lobesia botrana* Denis et Schiffermüller) and Codling Moth (*Cydia pomonella* Linnaeus) when the value of C9 index increased.

6. 1. Introduction

It has been known for decades that the insects detect the geomagnetic field, and even can use it as a three-dimensional orientation. A number of laboratory experiments and comprehensive studies are devoted to the physiological bases of perception and the ways of orientation (Wehner and Lobhart, 1970; Kirschvink, l983; Wehner, 1984 and 1992; Jahn, 1986).

Studying some species of termites (Isoptera), beetles (Coleoptera), flies (Diptera), orthopteroids (Orthoptera), and hymenopterans (Hymenoptera), Becker (1964) found that they orient according the natural magnetic field. Way of their mobility is North-South, rarely East-West. Their original way of movement could be modified by artificial magnetic field.

Mletzko (1969) carried out his experiments with specimens of ground beetles (*Broscus cephalotes* L., *Carabus nemoralis* Mull. and *Pterostichus vulgaris* L.) on a 100 square meter asphalt coated area in the Moscow botanical garden. He placed the insects in the middle of the area and followed their movement with a compass. After some uncertainty, the insects flew in a given direction with an accuracy of +5° at daylight and + 60° at night. The author assumes that orientation is guided by geomagnetism. Iso-Ivari and Koponen (1976) studied the impact of geomagnetism on light trapping in the northernmost part of Finland. In their experiments they used the K index values measured in every three hours, as well as the ΣK and the δH values. A weak but significant correlation was found between the geomagnetic parameters and the number of specimens of the various orders of insects caught. Studying the few Willow Ermine *(Yponomeuta rorella* Hbn.), Pristavko and Karasov (1970) revealed a correlation between the C and ΣK values and the number of individuals caught. In a later study (Pristavko and Karasov, 1981) they also established that at the time of magnetic storms ΣK has a greater influence on the flying activity of the above species. The influence is also significant in years when ΣK is not higher than 16-26. Equally interesting is the observation that if ΣK < 26, flying activity intensifies the same day, if ΣK = 27-30, this happens the following day and if ΣK = 33-41, intensification follows only on the second or third day. Studying the termite species *Heterotermes indicola* Wasmann, Becker and Gerisch (1977) found a stronger correlation between this activity and the vertical component of geomagnetism (z) than with the values of the K index. Tshernyshev and his colleagues have discussed in a series of studies the results of their laboratory and light trapping experiments with species of different orders of insects to reveal a connection between geomagnetism and certain life phenomena. Tshernyshev (1966) found that the number of light-trapped beetles and bugs rose many times over at the time of geomagnetic storms in Turkmenia. He found a high positive correlation between the horizontal component and the number of trapped insects. In laboratory conditions, Tshernyshev and Danilevsky (1966) could not reveal the influence of an alternating magnetic field on the activity of flies at low temperature (22 °C), but observed a significant rise at (29 °C). Tshernyshev (1968) studied the changes in the biological rhythm of the *Trogoderma glabrum* Herbst as a function of the perturbations of the magnetic field. His assessment was based upon the K-index values over 4, i.e. over 40y measures at 6 and 9 p.m. as well as at 3 a.m. It was proved that the biological rhythm of the species observed was influenced by factors that coincided with perturbations of the magnetic field. It was also observed by Tshernyshev (1965) that the number of light-trapped insects significantly raised at the time of magnetic perturbations. Later, however, he reported that while light-trap catches of some Coloptera and Lepidopera species increased, that of other Lepidoptera and Diptera species fell back during magnetic perturbations (Tshernyshev, 1971 and 1972). Tshernyshev and Afonina (1971) also observed that the activity of certain moths and beetles increased, but in some cases fell back under the influence of a weak and changing magnetic field induced in laboratory conditions. Based on international literature and his own results, Tshernyshev (1989) published a comprehensive study to give a summary of the latest state of knowledge on the relation between geomagnetism and the activity of insects. Tshernyshev and Danthanarayana (1998) used an infrared actograph to study in laboratory conditions the activity of Scarcere Bordered Straw *(Helicoverpa* *armigera* Hübner), Native Budworm *(Helicoverpa punctigera* Wallengren) and Ruby Quaker Moth *(Orthosia rubescens* Walker). Examining the influence of the geomagnetic K index also in the context of the four typical lunar quarters (First Quarter, Full Moon, Last Quarter and New Moon), a significant negative correlation was found in the Last Quarter and a positive correlation in the other three. Moths are also disturbed by geomagnetic perturbations. 30 hours after perturbations the influence was still felt.

Examinations over the last decade**s** have also confirmed that some Lepidoptera species, such as Large Yellow Underwing *(Noctua pronuba* L.) (Baker and Mather, 1982) and Heart & Dart (*Agrotis exclamationis* L) (Baker, 1987) are guided by both the Moon and geomagnetism in their orientation, and they are even capable of integrating these two sources of information. On cloudy nights, the imagos of *Noctua pronuba* L. orientated with the help of geomagnetism. In this case, too, their preference lay with the direction they had chosen when getting their orientation by the Moon and the stars. Using hourly data from the material of the Kecskemét fractionating light-trap, we have examined the light trapping of Turnip Moth *(Agrotis segetum* Den. et Schiff.), Heart & Dart *(Agrotis exclamationis* L.) and Fall Webworm Moth *(Hypantria cunea* Drury) in relationship with the horizontal component of the geomagnetic field strength (Kiss et al., 1981).

According to the authors of recent publications (Srygley and Oliveira, 2001; Samia et al., 2010) the orientation/navigation of moths at night may becomes not by the Moon or other celestial light sources, but many other phenomena such as geomagnetism.

The results of our calculations have shown that in the period of the New Moon when there is no measurable moonlight, the higher values of the horizontal component are accompanied by a falling relative catch. In the other moon phases, i.e. in the First Quarter, Full Moon and the Last Quarter, growing values of the horizontal component are accompanied by an increasing catch in both the moonlit and moonless hours (Nowinszky and Puskás, 2011).

In a recent study (Nowinszky and Puskás, 2012) our research have shown that in the period of the New Moon when there is no measurable moonlight, the higher values of the vertical component are accompanied by a falling relative catch. In the other moon phases, i.e. in the First Quarter, Full Moon and the Last Quarter, growing values of the vertical component are accompanied by an increasing catch in both the moonlit and moonless hours.

However, we did not found any studies that investigate the relationship between geomagnetism and the pheromone trap catch.

6. 2. Material

Six harmful Microlepidoptera species were caught by the Csalomon type sticky traps at Bodrogkisfalud in Borsod-Abaúj-Zemplén County (Hungary) between 1993 and 2000. The caught species were the followings: Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius, 1781), 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). The catching data of examined moths (Lepidoptera) species and pheromone trapping stations are shown in Table 6. 2. 1.

The average field strength of the Earth as a magnetic dipole is 33,000γ. [1γ $=10^{-5}$ Gauss = 10^{-9} Tesla = 1 nanotesla (nT)]. Geophysical literature uses γ as a unit.

The three-hour index ap and the daily indices Ap, *Cp* and C9 are directly related to the Kp *index*. In order to obtain a linear scale from Kp, Bartels (1957) gave the following table to derive a three-hour equivalent range, named ap index.

This ap index is made in such a way that at a station at about dipole latitude 50 degrees, ap may be regarded as the range of the most disturbed of the two horizontal field components, expressed in the unit of 2nT.

The daily index Ap is obtained by averaging the eight values of ap for each day. In order to replace the somewhat subjective index Ci, the Cp index - the planetary daily character figure - was developed. Cp is a qualitative estimate of overall level of magnetic activity for the day determined from the daily sum of eight ap amplitudes. Cp ranges, in steps of one-tenth, from 0 (quiet) to 2.5 (disturbed). Another index devised to express geomagnetic activity on the basis of the Cp index is the C9 index. It converts the 0 to 2.5 range of Cp to one digit between 0 and 9.

The simplest local characteristic of magnetic activity is the character number: C_i. The C_p planetary number of characters can be calculated for the total Earth from these numbers based on a few selected observing places, distributed evenly on the Earth.

The three-hour K index shows the activity of the variations created by the solar wind, which is measured in every 3 hours at all observatories. The K index may be a whole number from 0 up to 9 (Völgyesi, 2002).

We investigated, therefore, that the effectiveness of pheromone trap catch of insects changes to the geomagnetic ΣKp or C9 index?

The Kp index were used because other researchers have also successfully applied earlier. We also worked with C9 index which were easily used.

Geomagnetic data, required for our work, were downloaded from the British Geological Survey Natural Environment Research Council website: http://www.bgs.ac.uk/home.html

6. 3. Methods

Than the number of individuals of a given species in different places and different observation years is not the same. The collection efficiency of the modifying factors (temperature, wind, moonlight, etc.) are not the same at all locations and at the time of trapping, it is easy to see that the same number of items capture two different observers place or time of the test species mass is entirely different proportion. To solve this problem, the introduction of the concept of relative catch was used decades ago (Nowinszky 2003).

The relative catch (RC) for a given sampling time unit (in our case, one night) and the average number individuals per unit time of sampling, the number of generations divided by the influence of individuals. If the number of specimens taken from the average of the same, the relative value of catch: 1 (Nowinszky 2003).

From the collection data pertaining to examined species we calculated relative catch values (RC) by pheromone trap stations and by swarming. Following we arranged the data on the ΣKp and C9 index in classes. Relative catch values were placed according to the features of the given day, and then RC were summed up and averaged. The data are plotted for each species and regression equations were calculated for relative catch of examined species and ΣKp and C9 index data pairs.

6. 4. Results and Discussion

Unfortunately we got satisfactory results only with a few species in the context of the ΣKp index. However, the examinations of C9 index showed significant relationship with all the six species. Our results are shown in the Figures 6. 4. 1.—6. 4. 6.

The pheromone trap catch of four examined species increased in the higher values of the C9 index. These species are as follows: Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius), Peach Twig Borer (*Anarsia lineatella* Zeller), Plum Fruit Moth (*Grapholita funebrana* Treitschke) and Oriental Fruit Moth (*Grapholita molesta* Busck). The catch decreased of two species European Vine Moth (*Lobesia botrana* Denis et Schiffermüller) and Codling Moth (*Cydia pomonella* Linnaeus) when the value of C9 index increased.

The increase or decrease of the catch is explainable by our previous hypotheses.

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 unfavourable environmental 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 impacts hindering 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 take refuge in passivity to environmental factors of an unfavourable situation. By the present state of our knowledge we might say that unfavourable environmental factors might be accompanied by both high and low catch (Nowinszky 2003).

It can be explained on the basis of our hypothesis of the first rising and then falling catch results. But however their answer is already the passivity for the additional increase of the radiation. However, it is striking that the taxonomic place of the single species is not attached to by this response, so may be widespread in the world of the insects widely presumably.

It is a remarkable fact, that the swarming peaks of different species can be experienced at totally different C9 index values.

Table 6. 2. 1 The locality of pheromone traps, catching data of the examined species

Species	Number of	
	Individuals	Data
Gracillariidae » Lithocolletinae Spotted Tentiform Leafminer *Phyllonorycter blancardella* Fabricius, 1781	22,076	720
Gelechiidae » Anacampsinae Peach Twig Borer *Anarsia lineatella* Zeller, 1839	3,088	720
Tortricidae » Olethreutinae European Vine Moth *Lobesia botrana* Denis et Schiffermüller, 1775	6,862	744
Tortricidae » Olethreutinae Plum Fruit Moth *Grapholita funebrana* Treitschke, 1835	9,816	1,435
Tortricidae » Olethreutinae Oriental Fruit Moth *Grapholita molesta* Busck, 1916	4,068	906
Tortricidae » Olethreutinae Codling Moth *Cydia pomonella* Linnaeus, 1758	2,135	728

Lobesia botrana

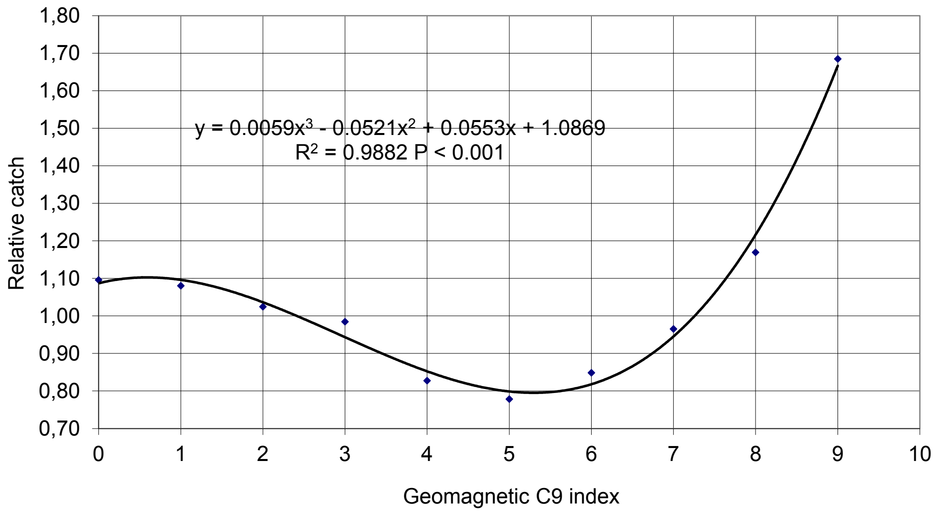

Figure 6. 4. 1.

Figure 6. 4. 1. Pheromone trap catch of Spotted Tentiform Leafminer (*Phyllonorycter blancardella* Fabricius) in connection with the geomagnetic C9 index (Bodrogkisfalud, 1993–2000)

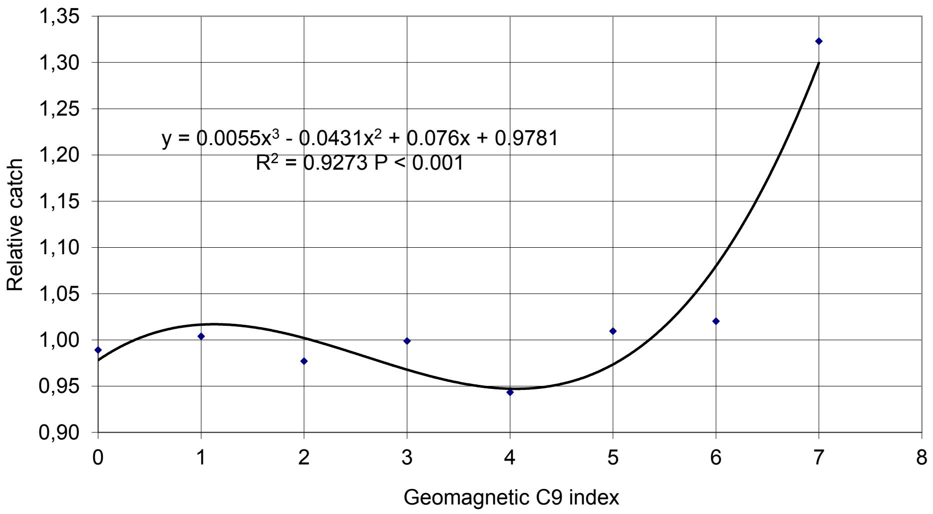

Figure 6. 4. 2.

Figure 6. 4. 2. Pheromone trap catch of the Peach Twig Borer (*Anarsia lineatella* Zeller) in connection with the geomagnetic C9 index (Bodrogkisfalud, 1993–2000)

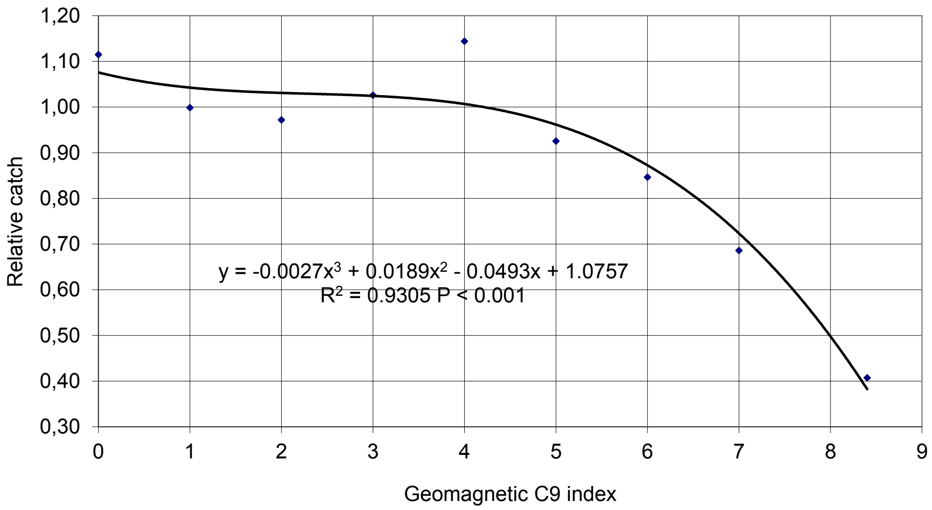

Figure 6. 4. 3.

Figure 6. 4. 3. Pheromone trap catch of European Vine Moth (*Lobesia botrana* Denis et Schiffermüller) in connection with the geomagnetic C9 index (Bodrogkisfalud, 1993–2000)

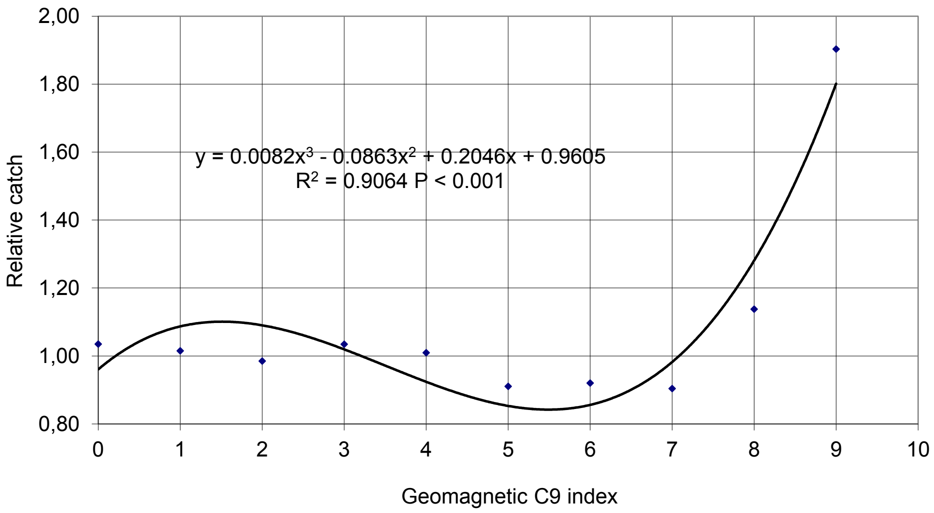

Figure 6. 4. 4.

Figure 6. 4. 4. Pheromone trap catch of the Plum Fruit Moth (*Grapholita funebrana* Treitschke) in connection with the geomagnetic C9 index (Bodrogkisfalud, 1993–2000)

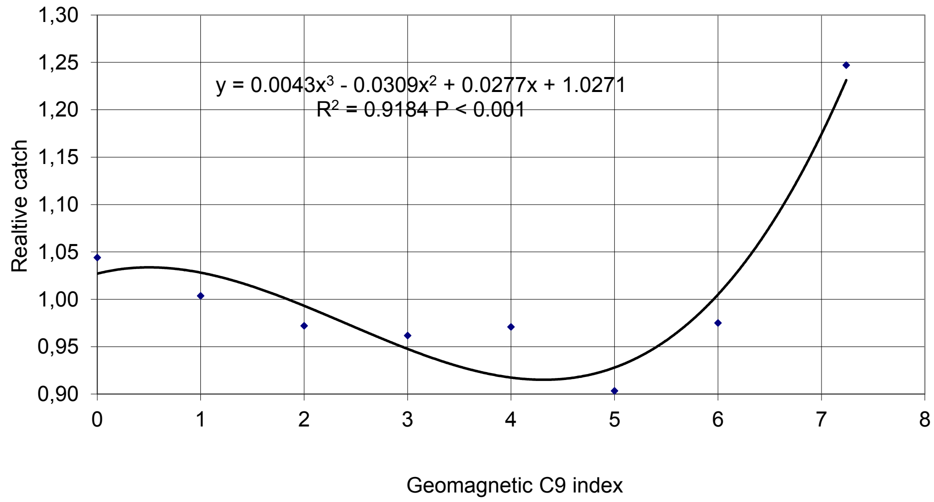

Figure 6. 4. 5.

Figure 6. 4. 5. Pheromone trap catch of Oriental Fruit Moth (*Grapholita molesta* Busck) in connection with the geomagnetic C9 index (Bodrogkisfalud, 1993–2000)

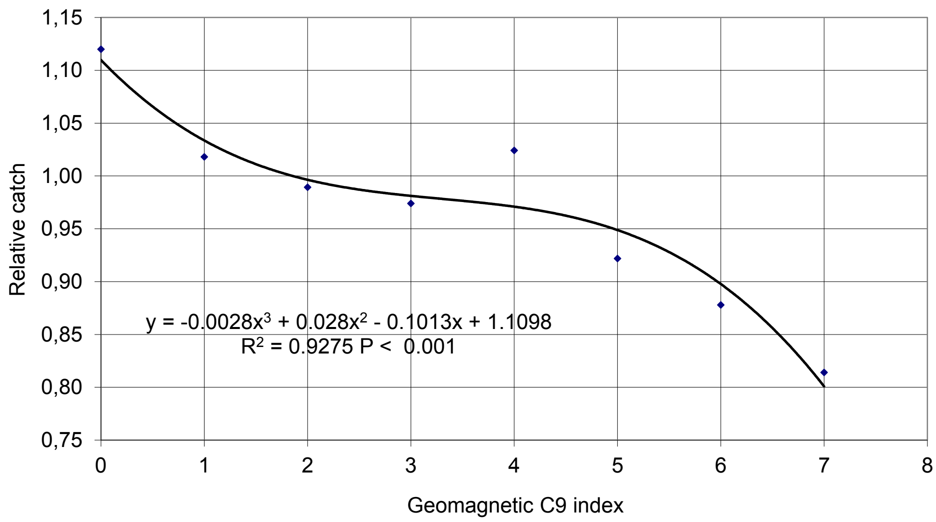

Figure 6. 4. 6.

Figure 6. 4. 6. Pheromone trap catch of the Codling Moth (*Cydia pomonella* Linnaeus) in connection with the geomagnetic C9 index (Bodrogkisfalud, 1993–2000)

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