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CHANGES IN THE NUMBER OF MACROLEPIDOPTERA INDIVIDUALS AND SPECIES CAUGHT BY LIGHT-TRAP, IN CONNECTION WITH THE GEOMAGNETIC Kp AND M-INDEX

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Abstract

The authors studied the number of Macrolepidoptera individuals and species caught by light-trap, in relationship with the geomagnetic Kp and M-index.

A correlation was found between the averaged geomagnetic M-index values measured at night, and the number of individuals and species caught by light-trap in the Kámon Botanic Garden (Hungary).

KEY WORDS: Light-trap, moths, geomagnetic Kp and M-index

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 & Lobhart, 1970; Kirschvink, 1983; Wehner, 1984 & 1992; Jahn, 1986).

The magnetic field of the earth is an omnipresent, reliable source of orientational information. A magnetic compass has been demonstrated in 18 species of migrating birds (Wiltschko & Wiltschko, 1996).

It is known that the geomagnetic field can influence animal migration and homing. The magnetic field detection by animals is known as magnetoreception and it is possible due to behaviour is the magnetic alignment where animals align their bodies to the geomagnetic field (Belova & Acosta-Avalos, 2015).

Magnetoreception in the animal kingdom has focused primarily on behavioural responses to the static geomagnetic field and the slow changes in its magnitude and direction as animals navigate/migrate (Prato et al., 2016).

Becker (1964) has found that certain species of termites (Isotermes), beetles (Coleoptera) flies (Diptera), orthopteroids (Orthoptera), and hymenopterans (Hymenoptera), 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.

Iso-Ivari & 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.
Examinations over the last decades have also confirmed that some Lepidoptera species, such as the Large Yellow Underwing *(Noctua pronuba* L.) (Baker & Mather, 1982) and the 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.

Using hourly data from the material of the Kecskemét fractionating light-trap, we have examined the light trapping of the Turnip Moth *(Agrotis segetum* Den. et Schiff.), the Heart & Dart *(Agrotis exclamationis* L.) and the 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 & Oliveira, 2001; Gillet & Gardner, 2009; 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.

Material

The Forest Research Institute operated a JERMY-type light-trap in Kámon Botanic Garden (Szombathely, Hungary) between 1962 and 1970. The geographical coordinates of this Botanic Garden are 47°25'66"N and 16°60'36"E.

All Macrolepidoptera species and individuals were identified from the catch of this period. This Jermy-type light-trap operated continuously in all the years, except on snowy winter days and a few malfunctioning nights.

There were caught altogether the specimen of 549 different Macrolepidoptera species by light-trap during 9 years.

The number of caught species, individuals and yearly swarming are shown in Table. We worked up only the catch data of early and late summer aspects, because only some individuals of some species were caught by the light-trap in spring and autumn aspects.

Table I. Light-trap collecting data of early and late summer aspects in Kámon Botanic Garden of Szombathely, Hungary as well as the number of caught species and swarming.

Years	Early and late summer aspects (1st May to 31st October)	
	Number of species	Number of individuals
1962	291	3359
1963	300	5446
1964	303	2562
1965	146	919
1966	113	599
1967	229	4096
1968	226	2364
1969	268	3670
1970	268	4268

We applied only the collecting data of early and late summer aspects 1st May to 31st October because in both the spring and autumn aspects few species and specimens were caught by light-trap.

The average field strength of the Earth as a magnetic dipole is 33.000 γ (1 γ = 10^{-5} Gauss = 10^{-9} Tesla [nanoTesla]). The geomagnetic field strength can be decomposed into three components: H -horizontal, Z - vertical and D - declination components. With regard to the entomologic trials the extent of total field strength, on the one hand, and the value of horizontal component, on the other, are important because, insects fly rather horizontally than vertically.

It is well known that the magnetic poles and the geographic one of the Earth do not coincide, therefore besides the geographic coordinates, the geomagnetic latitudes and longitudes are to be distinguished; and these coordinates are characteristic for the geomagnetic reasons of a given geographic coordinate. The geomagnetic parameters are significantly different on various regions of Earth's surface at a given time. As an average of 300 km distance may result in significantly different characteristics along the geomagnetic meridian (Nowinszky and Tóth, 1987).

The K-index scale summarises geomagnetic activity at an observatory by assigning a code, an integer in the range 0 to 9 (0 being the least active field and 9 the most active field). The K-index is quasi-logarithmic local index of the 3-hourly range in magnetic activity relative to an assumed quiet-day curve for a single geomagnetic observatory site. First introduced by Bartels (1935), it consists of a single-digit 0 thru 9 for each 3-hour interval of the universal time day (UT). The planetary 3-hour-range index Kp is the mean standardized K-index from 13 geomagnetic observatories between 44 degrees and 60 degrees northern or southern geomagnetic latitude. The scale is O to 9 expressed in thirds of a unit, e.g. 5- is 4 2/3, 5 is 5 and 5+ is 5 1/3. This planetary index is designed to measure solar particle radiation by its magnetic effects.

We collected the Kp index data from the data.noaa.gov website.

The geomagnetic data measured along the magnetic meridian (direction: North-West to South-East) in function of time. These measurements are made at Nagycenk, near Sopron in the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences. The geographical coordinates of Observatory are 47° 38' N; 16° 43' E. Its distance from the Kámon Botanic Garden (Szombathely) is 43 km.

The observatory is situated about 10 km to E from the city Sopron and 60 km SE from Vienna, on the southern shore of Lake Fertő. The observatory lies on thick conductive sediment and it is surrounded by the Fertő-Hanság National Park.

Values of local horizontal component, M-index for our research have been taken from a series of observations carried out at Nagycenk (Western Hungary) description of which can be found in: Observatoriumsberichte des Geophysikalischen Forschungslaboratoriums der UAdW in Sopron, 1962-1966; Geophysical Observatory Reports of the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences in Sopron, 1967-1976. Data on the field strength changes of the horizontal geomagnetic component are given for each 3-hour-period in a scale from 0 to 9, where the scale unit is 7 γ = 7 nT. The scale is linear.

The value of C9-index does not have dependence of the local time, but it can globally characterize the geomagnetic activity. The magnetic index (M), measured in three hours, has a local character. This index is determined and published by the Geophysical Observatory of Hungarian Academy of Science (HAS), named István Széchenyi. The magnetic index has strong dependence to the local time and it is typical of medium width. The magnetic disturbances can be found only in less number, which are typical at the equatorial and polar zone. According to Prof. József Verő (member of HAS) in the case of a local phenomenon, such as the investigated moths' flight, the M-index is much more usable than any other global indices, because it expresses the local conditions (J. Verő, personal communication).

The M-index was determined between 1962 and 1991, and was published in Observatory's Reports. The M-index can be 0-9 integer value. It is a linear scale with 7 nT (nanoTesla) steps and it reaches the 9 degree level at >63 nT (J. Szendrői, personal communication).

Methods

We summarized and averaged the four published M-index values for every night. The number of caught species and individuals was also averaged.

According to the method of Sturges (Odor & Iglói,1987) we arranged the data of M-index, species and individuals into classes. All data were averaged, and then Kp and M-index, each species and individuals were plotted.

The results obtained are plotted. We determined the regression equations, the significance levels which were shown in the figures. The relationship with second degree parabola was best characterized.

We calculated the determination coefficients of parabolic curves and their significance levels by way of Manczel (1983).

Results and Discussion

Our results are shown in Figures 1-4.

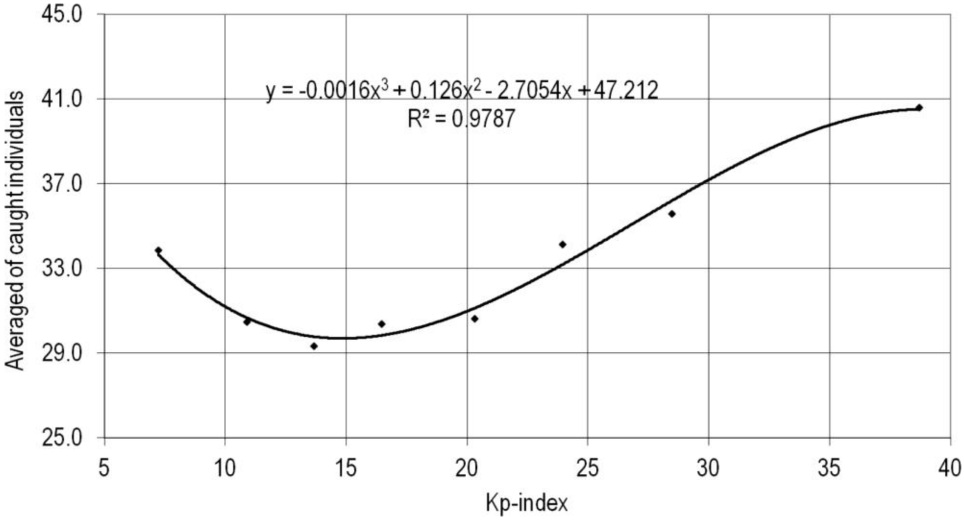

Figure 1. Averaged number of light trapped Macrolepidoptera individuals in connection with geomagnetic Kp-index in summer aspects (Kámon Botanic Garden, 1962-1970).

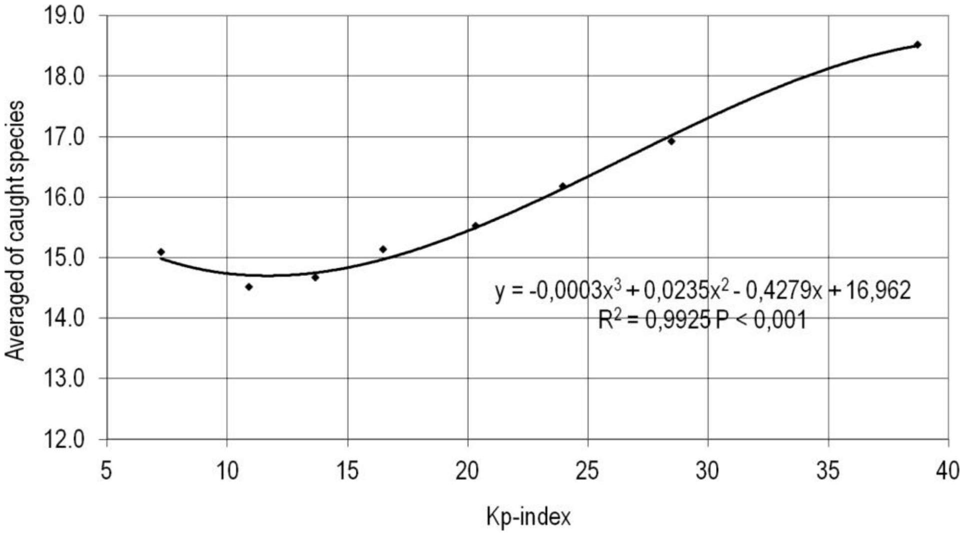

Figure 2. Averaged number of light trapped Macrolepidoptera species in connection with geomagnetic Kp-index in summer aspects (Kámon Botanic Garden, 1962-1970).

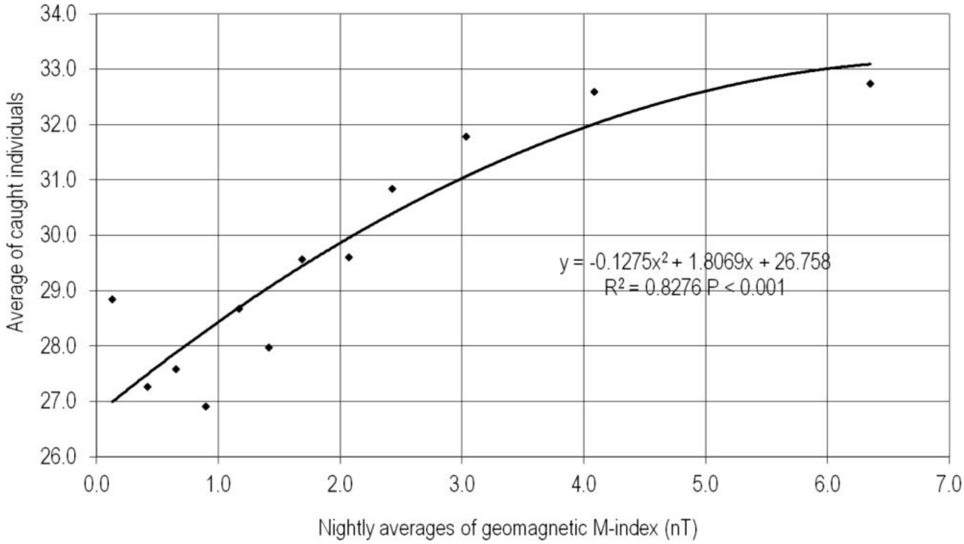

Figure 3. Averaged number of light trapped Macrolepidoptera individuals in connection with geomagnetic M-index (Kámon Botanic Garden, 1962-1970).

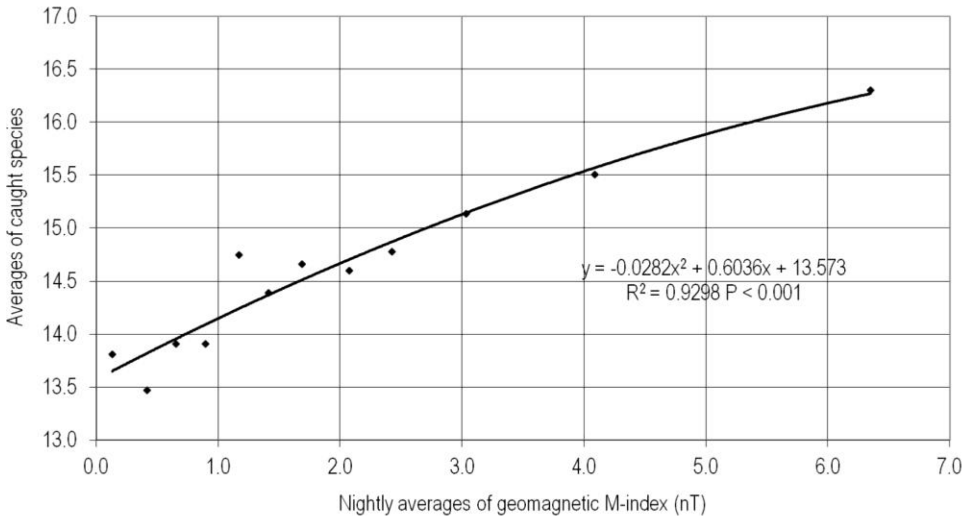

Figure 4. Averaged number of light trapped Macrolepidoptera species in connection with geomagnetic M-index in summer aspects (Kámon Botanic Garden, 1962-1970).

Only a few researchers reported the results of their researches about the relationship between light-trap catch and geomagnetism in the earlier decades and the recent past.

Mletzko (1969) found the insects flew several meters uncertainly, and after these they oriented towards a given direction, with an accuracy of + 5 grades at daylight and + 60 grades at night respectively. The author's hypothesis is that, the orientation follows the terrestrial magnetic field. The orientation shows the same trend the whole day and it does not change at night, when there is no sunlight.

Pristavko & Karasov (1970) studying of Willow Ermine Moth, Y*ponomeuta rorellus* Hbn. (Lepidoptera: Yponomeutidae) were found a correlation between C and ΣK values respectively, and the number of trapped insects.

Tshernyshev (1972) observed that light-trap catches of some beetle (Coleoptera) and moth (Lepidoptera) species increase with the geomagnetic perturbation. On the contrary, activity of other moth (Lepidoptera) and several flies (Diptera) species is reduced by this phenomenon. He found high correlation between the öH and ΣK values and the number of trapped insects.
Iso-Ivari & Koponen (1976) found a weak but significant correlation between the geomagnetic parameters and the number of specimens of the various orders of insects caught. Significant correlation was found only for Lepidoptera and Hymenoptera Parasitica (negative) and for Simuliidae (positive).

In the recent past we managed to prove that the vertical component of the geomagnetic field strength influenced differently the light-trap catch of Turnip Moth (*Agrotis segetum* Denis et Schiffenmüller) in the four quarters of the Moon when there were periods with moonlight and without it.

The study of Nowinszky *et al.* (2015) deals with the change of light-trap catch of twelve caddisfly (Trichoptera) species of Danube and Tisza rivers in connection with the geomagnetic horizontal component (H-index). The catch of nine species increased in parallel with increasing values of the H-index, but the catch of two species declined. There was one species which has decreasing catch at River Danube, but it was increasing at River Tisza.
Our new results demonstrate that low values of geomagnetic Kp and M-index depress both the number of species and individuals in the summer aspects. In contrast, higher values can rise in number of caught species and individuals.
Growth of the geomagnetic field strength may generate an intensification of the flying activity consequently the light-trap catch of insects. Growth of the geomagnetic field strength may generate an intensification of the flying activity of insects.
Our results confirm the statement of previous researches; the insects are able to use geomagnetism for their spatial orientation.

It is assumed that this fact can be widespread at nocturnal active moths, because our results came from the catch data of more than 500 Macrolepidoptera species.

References

Baker, R. R. (1987). Integrated use of moon and magnetic compasses by the heart-and-dart moth, *Agrotis exclamationis*. *Animal Behaviour*. *35*, 94-101.

Baker, R. R. & Mather, J. G. (1982). Magnetic compass sense in the large yellow underwing moth, *Noctua pronuba* L. *Animal Behaviour 30*, 543-548.

Bartels, J (1935). Randomfluctuations, persistance and quasipersistance in geophysical and cosmical periodicities. *Terrestrial Magnetism and Atmospheric Electricity*. *40:* 1-60.

Becker, G. (1964). Reaktion von Insekten auf Magnetfelder, elektrische Felder und atmospherics. *Zeitschtrift für angewandte Entomologie*, *54*(1-2), 75-88.

Belova, N. A & Acosta-Avalos, D (2015). The Effect of Extremely Low Frequency Alternating Magnetic Field on the Behavior of Animals in the Presence of the Geomagnetic Field. *Journal of Biophysics*, doi.org/10.1155/2015/423838

British Geological Survey https.//www.bgs.ac.uk/discoverymetadata/13480122.html

Gillet, M. P. T. & Gardner, A. S. (2009). An unusual observation – attraction of caterpillars to mercury vapour light in the Abu Dhabi (Lepidoptera. Pyralidae). *Tribulus 18*, 56-59.

Iso-livari, L. & Koponen, S. (1976). Insect catches by light trap compared with geomagnetic and weather factors in subarctis Lapland. *Rep. Kevo Subarctic Research Stat. 13*, 33-35.

Jahn, E. (1986). Physikalische Felder und Insekten. Ein Übersichtsreferat. *Anzeiger Schädlingskunde Pflanzenschutz, Umweltschutz*. *59*, 8-14.

Kirschvink, J. L. (1983). Biomagnetic geomagnetism. *Revista Geophysics*., *21*, 672-675.

Kiss, M., Ekk, I., Tóth, Gy., Szabó, S. & Nowinszky, L. (1981). Common effect of geomagnetism and change of moon phases on light-trap catches of fall webworm moth (*Hyphantria cunea* Drury). *Zeitschtrift für angewandte Enomologie.* 91, 403-411.

Manczel, J. (1983). *Application of statistical methods in agriculture (in Hungarian).* Mezőgazdasági Kiadó, Budapest.

Mletzko, G. G. (1969). Orientation rhythm at Carabidae (in Russian). *Zhurnal Obshchei Biologii. 30*, 232-233.

Nowinszky, L. & Tóth, Gy. (1987). Influence of cosmic factors on the light-trap catches of harmful insects (in Hungarian). Ph.D. Dissertation. Szombathely. 123.

Nowinszky, L. & Puskás, J. (2012). Light trapping of Turnip Moth (*Agrotis segetum* Den. et Schiff.) connected with vertical component of geomagnetic field intensity. *e–Acta Naturalia Pannonica*. *3*, 107–111.

Nowinszky, L., Puskás, J. & Kiss, O. (2015). Light-Trap Catch of the Fluvial Trichoptera Species In Connection with the Geomagnetic H-Index. *Journal of Biology and Nature*, *4*(4), 206-216.

Odor, P. & Iglói, L. (1987). *An introduction to the sport's biometry (in Hungarian*). ÁISH Tudományos Tanácsának Kiadása. Budapest.

Prato, F. S., Desjardins-Holmes, D., Keenliside, L. D., DeMoor, J. M., Robertson, J. A. & Thomas, A. W. (2016). Magnetoreception in laboratory mice. sensitivity to extremely low-frequency fields exceeds 33 nT at 30 Hz. Downloaded from http.//rsif.royalsocietypublishing.org/ on February 24, 2016

Pristavko, V. P. & Karasov, V. Sz. (1970). Application of ultraviolet light-traps to investigation of gnat's population (in Ukrainen). *Visnik Silskogospod Nauk*i. *10*, 69-72.

Samia, M.M. Saleh., Layla, A.H. Al-Shareef, Raja, A. & Zahrany, A. Al (2010). Effect of geomagnetic field on whitefly *Bemisia tabaci* (Gennadius) flight to the cardinal and halfway directions and their attraction to different colors in Jeddah of Saudi Arabia. Agriculture and Biology Journal of North America. *1*(6), 1349-1356.

Srygley, R.B. & Oliveira, E.G. (2001). Sun compass and wind drift compensation in migrating butterflies. *The Journal of Navigation. 54*(3), 405-417.

Tshernyshev, W. B. (1972). The catches of insects by light trap and solar activity. *Zoologischer. Anzeiger, Leipzig*. *188*, 452-459.

Wehner, R. (1984). Astronavigation in insects. *Annual Review Entomology, 29,* 277-298.

Wehner, R. (1992). Hunt for the magnetoreceptor. *Nature*, *359*, 105-106.

Wehner, R. & Lobhart, Th. (1970). Perception of the geomagnetic field in the *Drosophila melanogaster. Experientia*. *26*, 967-968.

Wiltschko, W. & Wiltschko, R. (1996). Magnetic Orientation in Birds. *The Journal of Experimental Biology, 199*, 29–38.

ПРОМЕНЕ БРОЈА ЈЕДИНКИ И ВРСТА MACROLEPIDOPTERA УХВАЋЕНИХ СВЕТЛОСНИМ КЛОПКАМА У ВЕЗИ СА ГЕОМАГНЕТНИМ М-ИНДЕКСОМ

Ласло Новински и Јанош Пушкаш

Извод

Деценијама је познато да инсекти детектују геомагнетно поље и да га користе у оријентацији. Урађен је велики број лабораторијских експеримената и свеобухватних студија посвећених физиолошкој перцепцији и парвцима оријентације (Wehner & Lobhart, 1970; Kirschvink, 1983; Wehner, 1984, 1992; Jahn, 1986). Srygley & Oliveira (2001), Gillet & Gardner (2009) и Samia *et al*. (2010) утврдили су да на оријентацију мољаца ноћу не утичу само Месец или свтлост других небеских тела већ и многе друге појаве као што је геомагнетизам.

Подаци објављени у овом раду добијени су коришћењем светлосних клопки - JERMY-type у Камон Ботаничкој башти (Kámon Botanic Garden, Szombathely, Hungary 47°25'66"N 16°60'36"E) у периоду од 1962. до 1970. године.

Сабиране су четири просечне вредности М-индекса за сваку ноћ. Приказане су и просечне вредности броја ухваћених примерака сваке ноћи. Добијени резултати су приказани на гарфиконима.

Резултати наших истраживања показују ниске вредности геомагнетног М-индекса и по броју врста и примерака у току лета. Насупрот томе, веће вредности могу расти са бројем ухваћених врста и јединки. Пораст јачине геомагнетног поља утиче на интензивирање активности летења као и последица коришћења светлосних клопки. Наши резултати потврђују тврдње ранијих истраживања да инсекти користе геомагнетизам за оријентацију у простору. Сматрамо да је ова чињеница широко распрострањена код ноћних активности мољаца што поткрепљују наши резултати урађени на више од 500 врста Macrolepidoptera.

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