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Influence of Geomagnetic M-Index on Light-Trap Catch of Macrolepidoptera Species Selected from Different Families and Subfamilies

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Abstract

The study deals with the number of Macrolepidoptera species caught by light-trap, in connection with the geomagnetic M-index. We found close correlation between the nightly sum values of geomagnetic M-index and relative catch of Macrolepidoptera species separated from different families and subfamilies caught by light-traps of the Hungarian Forestry Light-Trap Network. Three behaviours were identified, but these behaviours do not depend on the taxonomic location of the species. We suggest that the geomagnetic M-indices provide more trouble-free spatial orientation of moths.

Keywords: Geomagnetism; M-Index, Light-Trap Moths

Introduction

It is well known for a long time 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 [1-5].

The magnetic field of the Earth is an omnipresent, reliable source of orientation information. A magnetic compass has been demonstrated in 18 species of migrating birds [6].

After investigation of different species of termites (Isoptera), beetles (Coleoptera), flies (Diptera), orthopteroids (Orthoptera), and hymenopterans (Hymenoptera), Becker [7] found that these species use the natural magnetic field in their orientation. According to the examinations the way of their mobility is North-South, rarely East-West. Their original way of movement could be modified by artificial magnetic field.

Mletzko, et al. [8] made the 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, et al. [9] examined the influence of geomagnetism on light-trap catch of insects 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.

Examinations over the last decades Baker, et al. [10] have also showed that some Lepidoptera species, such as Large Yellow Underwing *(Noctua pronuba* L.) and Heart & Dart (*Agrotis exclamationis* L.) Baker, et al. [11] is helped by both the Moon and geomagnetism in their orientation, and they are even capable of integrating these two sources of information.

We used in the investigation the catch 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 (*Hyphantria cunea* Drury) in connection with the horizontal component of the geomagnetic field strength [12]. The fractionating light-trap gave hourly data of insects.

According to the authors of recent publications [5,13,14] 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.

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 *(Hyphantria cunea* Drury) in relationship with the horizontal component (H-index) of the geomagnetic field strength [12].

We have already found that the H-index influence the efficiency of light trapping [15-17]. We found connection between Microlepidoptera spec. indet and C9 index [18]. We examined the effect of Kp and M-index of changes the number of Macrolepidoptera individuals and species [19]. Carlier, et al. [20] investigated the relationship between Kp-index and insects.

In a previous study we studied light-trapped of caddisfly (Trichoptera) species in connection with the geomagnetic H-index. Different results were obtained for different species. Growth and decrease results were both on the rising values of the H index [21]. The study of Puskás, et al. [22] deals with the light-trap catch of Microlepidoptera spec. indet. in connection with the geomagnetic M-index. They found the catch of Microlepidoptera species decreased at high M-index values.

Worthy to note our own studies other researchers did not make any researches dealing with the connection between light-trap catch of insects and the M-index.

Our aim was to determine relationship between geomagnetic M-index and light trapping of Macrolepidoptera species separated from other families and subfamilies.

Material

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 of the city Sopron and 60 km SE of 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: Observatoriums Berichte des Geophysikalischen Forschungslaboratoriums der UAdW in Sopron, 1962-1966 and Geophysical Observatory Reports of the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences in Sopron, 1967-1976.

The geomagnetic M-index data measurements are made at Nagycenk, near Sopron in the Geodetical and Geophysical Research Institute of the Hungarian Academy of Sciences.

The M-index is similar to the C-index, but the C9 values have no dependence on the value of the index in local time, but globally are characterized by geomagnetic activity.

The three-hour magnetic M-index is local in nature. It has strong dependence on local time and its moderate widths include less magnetic disturbances typical of the polar zone and equation zones. In the case of a local phenomenon such as the flying night butterflies, the M-index is much more useful than any other global index, as it expresses local conditions (Verő, personal communication).

The Observatory determined and reports between 1962-1991 M-index and a range of up to 0-9 integer values contains. The M-index is a linear scale, 7 nT (nanoTesla) steps. The 9 degrees are > less than 63 nT (Judit Szendrői personal communication).

The Hungarian forestry light-trap network with the same Jermy-type light-traps [23] has been operating continuously to this day since 1962. Between 1962 and 1970, 20 light traps operated in all regions of the country (Table 1).

Light-trap stations	Years	Geographical coordinates	Light-trap stations	Years	Geographical coordinates
Budakeszi	1962-1970	47°30'N 18°56'E	Sopron	1962-1970	47°41'N 16°34'E
Felsőtárkány	1962-1970	47°58'N 20°25'E	Szakonyfalu	1967-1970	46°51'N 16°13'E
Gerla	1967-1970	46°40'N 21°05'E	Szentpéterfölde	1968-1970	46°37'N 16°45'E
Gyulaj	1969-1970	46°30'N 18°17'E	Szombathely	1962-1970	47°14'N 16°37'E
Makkoshotyka	1962-1970	48°21'N 21°31'E	Tolna	1962-1970	46°25'N 18°46'E
Mátraháza	1962-1970	47°46'N 19°55'E	Tompa	1962-1970	46°12'N 19°32'E
Répáshuta	1962-1970	48°02'N 20°31'E	Várgesztes	1962-1970	47°28'N 18°23'E
Farkasgyepű	1965-1970	47°12'N 17°38'E	Kunfehértó	1962-1970	46°21'N 19°24'E
Erdősmecske	169-1970	46°10'N 18°30'E	Kömörő	1969-1970	48°01'N 22°35'E
Kőkút	1969-1970	46°11'N 17°34'E	Zalaerdőd	1970	47°03'N 17°08'E

Table 1: The stations of Forestry light-traps, their catching years and geographical coordinates.

Families, Species	Individuals	Data
Drepanidae, Thyatirinae		
Poplar Lutestring (*Tethea or* Denis & Schiffermüller, 1775)	3,503	620
Geometridae, Sterrhinae		
Maiden's Blush (*Cyclophora punctaria* Linnaeus, 1758)	110,543	1,393
Geometridae, Ennominae		
Sharp-angled Peacock (*Macaria alternata* Denis & Schiffermüller, 1775)	26,473	1,176
Notodontidae, Pygaerinae		
Chocolate-tip *Clostera curtula* Linnaeus, 1758)	620	375
Erebidae, Rivulinae		
Straw Dot *Rivula sericealis Scopoli,* 1763	7,747	797
Erebidae, Herminiinaee		
Jubilee Fan-foot *Zanclognatha lunalis* Scopoli, 1783	19,127	674
Erebidae, Boletobinae		
Lesses Belle *Colobochyla salicis* Denis & Schiffermüller, 1775	2,245	423
Noctuidae, Eustrotiinae		
Marbled White Spot *Deltote pygarga* Hufnagel, 1766	8,987	714
Noctuidae, Pantheinae		
Nut-tree Tussock *Colocasia coryli* Linnaeus, 1758	2,648	303
Noctuidae, Hadeninae		
Athetis furvula Hufnagel, 1808	52,404	501
Noctuidae, Noctuinae		
Setaceous Hebrew Character *Xestia c-nigrum* Linnaeus, 1758	3,950	867

Table 2: Catching data of caught moths.

They have provided invaluable data for scientific researches. The light source of this light-trap is a 100W normal electric bulb and the killing agent is chloroform [23]. Lepidoptera is the best-processed taxon. During these years, all caught moths were identified and the number of trapped individuals of all species recorded daily in the light-trap registers.

From this vast amount of collection data, we selected species to represent as many families and subfamilies as possible (Table 2). Our aim was to determine whether different species would react identically or differently to the effect of the M magnetic index.

Methods

Relative catch values were calculated from the number of caught moths for each species and sampling night until the trap of the year worked. The relative catch was defined as the quotient of the number of moth caught during a sampling time unit (1 night) per the average catch (number of moths) within the same catching period to the same time unit. For example, when the actual catch was equal to the average moth number caught in the same catching period, the relative catch was 1 [24].

The values of M-index were arranged into groups. The number of groups was determined according to Sturges' methods [25]. Following we arranged the data of averaged M-index in classes. The averaged data of relative catch values were placed according to the features of the given night, and then were summed up and averaged. The data are plotted for each relative catch values in Figures.

Results and Discussion

Our results are shown in Figures 1-11.

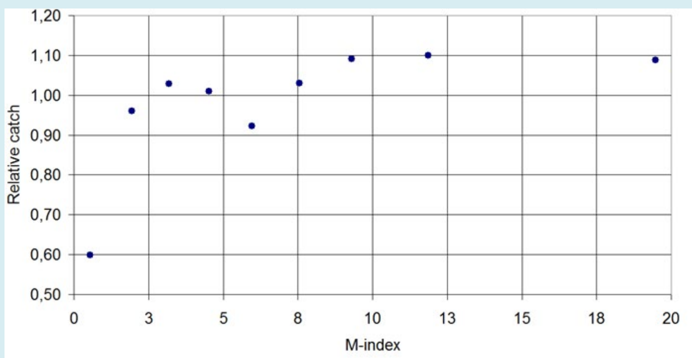

Figure 1: Light-trap catch of Poplar Lutesting (*Tethea or* Denis et Schiffermuller , 1775 Drepanidae, Thyatirinae) in connection with the the geomagnetic M-index.

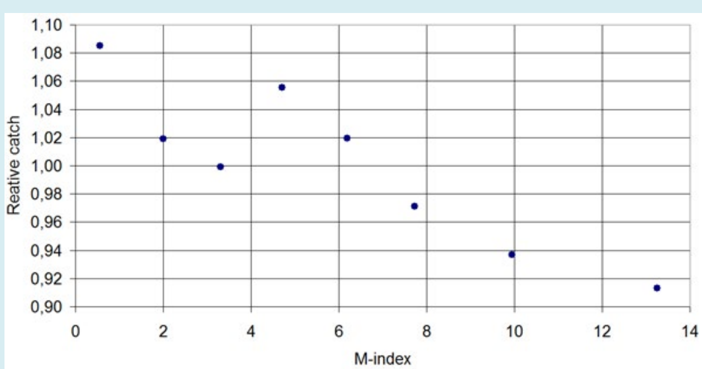

Figure 2: Light-trap catch of Maiden's Blush (*Cycclophora punctaria* Linnaeus, 1758 Geometridae, Sterrhinae) in connection with the geomagnetic M-index

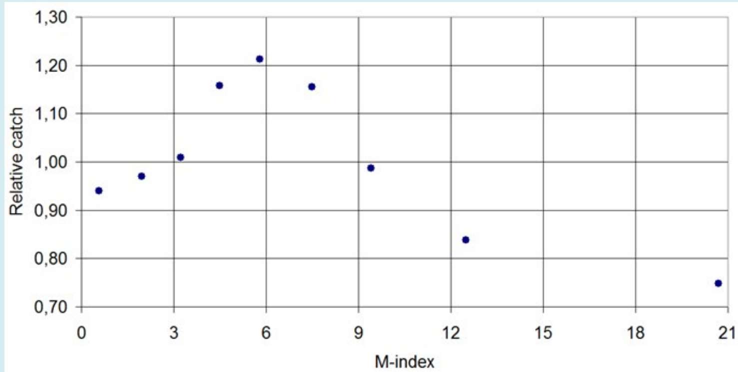

Figure 3: Light-trap catch of Sharp-angled Peacock (*Macaria alternata* Denis & Schiffermuller, 1775 Geometridae, Ennominae) in connection with the geomagnetic M-index.

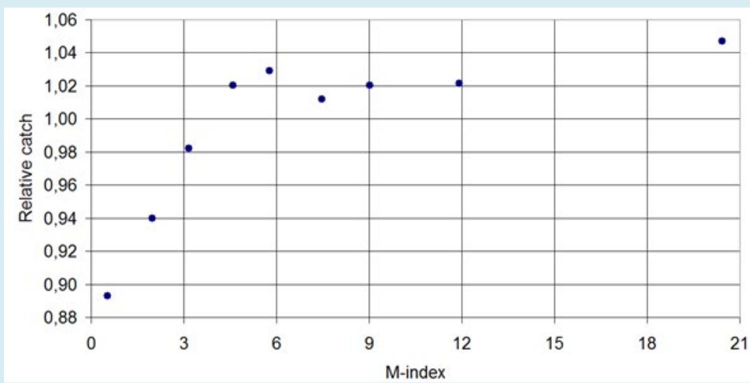

Figure 4: Light-trap catch of Chocolate-tip (*Clostera cultraria* Linnaeus, 1758 Notodontidae, Pygaerinae) in connection with the geomagnetic M-index.

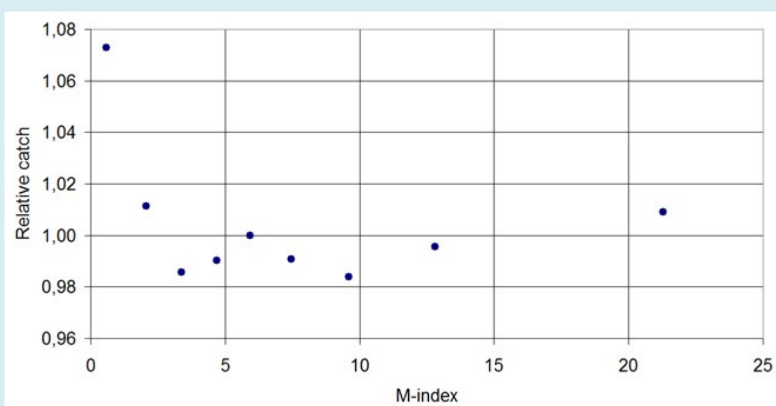

Figure 5: Light-trap catch of Straw Dot (*Rivula sericealis* Scopoli, 1763 Erebidae, Rivulinae) in connection with the geomagnetic M-index.

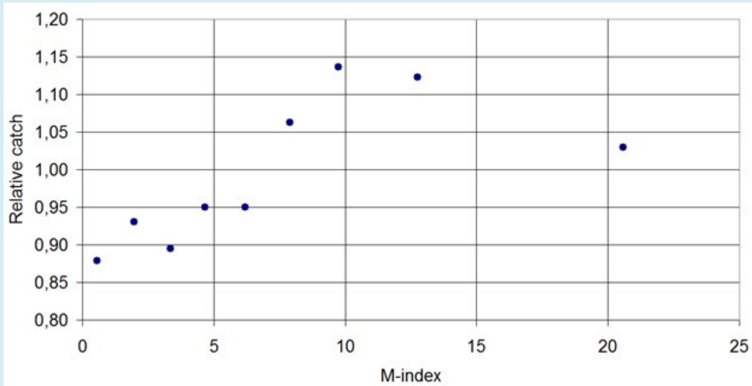

Figure 6: Light-trap catch of Jubilee Fan-foot (*Zanclognata lunalis* Scopoli, 1763 Erebidae, Herminiinae) in connection with the geomagnetic M-index.

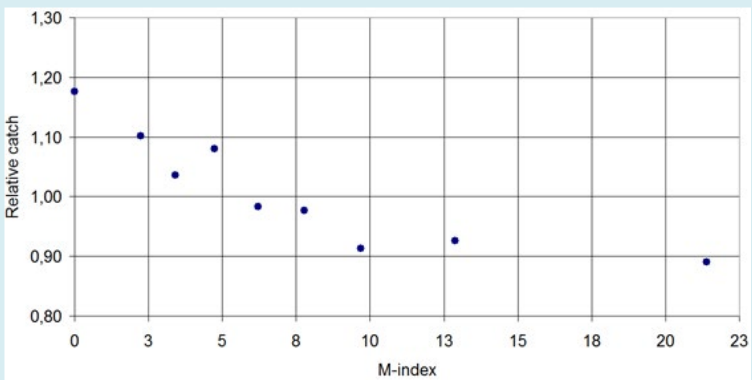

Figure 7: Light-trap catch of Lesses Belle (*Colobochyla salicis* Denis et Schiffermuller, 1775 Erebidae, Boletobinae) in connection with the geomagnetic M-index.

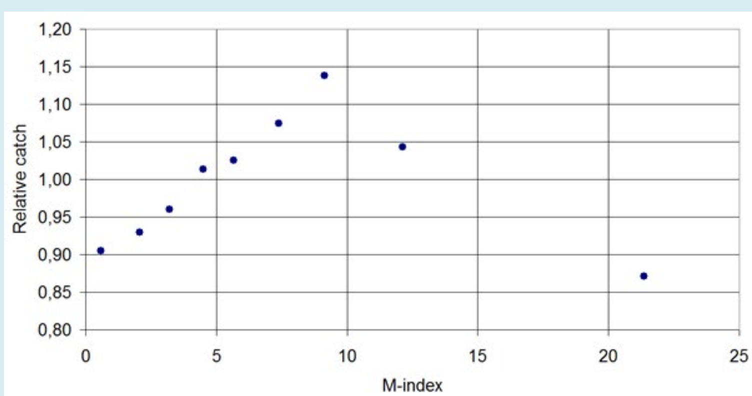

Figure 8: Light-trap catch of Marbled White Spot (*Deltote pygarga* Hufnagel, 1766 Noctuidae, Eustrotiinae) in connection with the geomagnetic M-index.

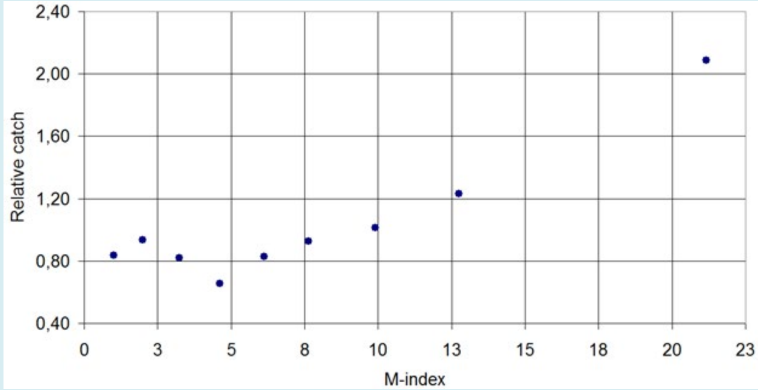

Figure 9: Light- trap catch of Nut-tree Tussock *(Colocasia coryli* Linnaeus, 1758, Noctuidae, Pantheinae*)* in connection with the geomagnetic M-index

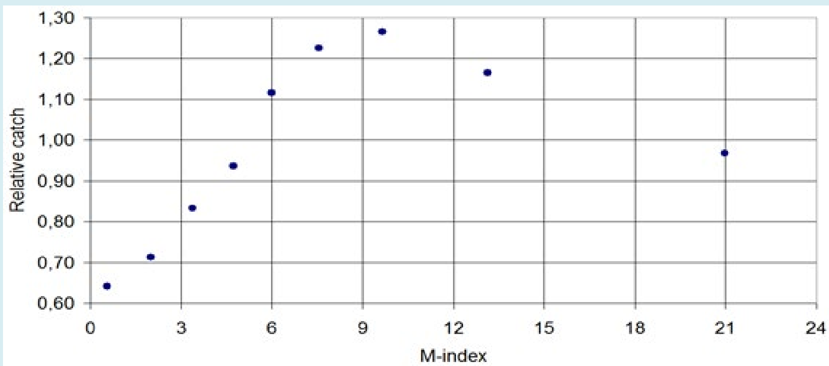

Figure 10: Light- trap catch of *Athetis furvula* Hufnagel, 1808 Noctuidae, Hadeninae in connection with the geomagnetic M-index.

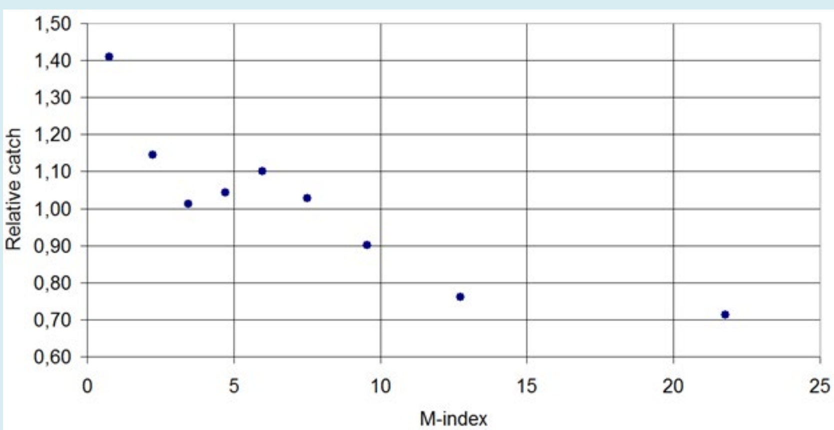

Figure 11: Light-traps catch of Setaceous Hebrew Charecte (*Xestia c-nigrum* Linnaeus, 1758 Noctuidae, Noctuinae) in cconnection with the geomagnetic M-index.

Growth of the geomagnetic field strength may generate an intensification of the flying activity of insects. Three behaviors were identified. As the geomagnetic M-index values increase, the light trapping catch of the given species increases with M-index values, otherwise the light trapping catch of the given species decreases. The third case is a combination of these two ones, initially increasing, but at high M-index values the catch is already decreasing. However, these behaviors do not depend on the taxonomic location of the species. We suggest that the geomagnetic M-indices provides more trouble-free spatial orientation and therefore increases.

Conclusion

The light-trap catches of Macrolepidoptera species depending on the geomagnetic M-index. On this basis, it can be stated that it is also suitable for insect ecological studies.

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