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Influence of the High Efficiency Mészáros-Type Light-Trap on Moth Species in Serbia

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ABSTRACT

This study deals with geomagnetic disturbance storm time (D_{st}) in relation with the moth (Lepidoptera) species caught by the high efficiency Mészáros-type light-trap in Bečej (Serbia). 32 moth species were selected for our calculations, those that were collected by the light-trap on at least 200 nights. The numbers of catching moths by generation were calculated relative catch (RC) values. These daily relative catch data were assigned to the daily values of geomagnetic D_{st} index. The relative catch data were divided accordance with the D_{st} index values. For each species, a relationship was found between the D_{st} index and the number of moths captured. Four types of variation were identified: ascending, ascending then descending, descending and descending then ascending. However, the results were not identical.

Keywords: Moths; D_{st} Index; Light-Traps

Introduction

The influence of the earth's magnetism on the light-trap collection of insects has been investigated for a long time by researchers of various nations, primarily Finns, Russians, Hungarians and others too. It has been established that various insects use the earth's magnetism for their spatial orientation. We must necessarily refer to the most important works published by Tshernyshev, et al. [1-5], found that the efficiency of light-trap collection of moths (Lepidoptera), beetles (Coleoptera) and flies (Diptera) decreased during geomagnetic perturbations. Becker and Gerich [2], found that the vertical component (Z) of geomagnetism has a greater influence on insect flight activity than the geomagnetic K-index. Iso-Ivari and Koponen [3], collected with a light-trap in the far north of Finland. A weakly significant effect was found between the geomagnetic parameters K, ΣK and δH and the number of insects collected. Between the flight activity of the Spotted Ermel (*Iponomeuta irrorella* Hbn.) and the ΣK values, Pristavko and Karasov [4], found a relationship. In the last decade, Shimonda and Honda [5], showed a correlation between the indices ΣK and C and the number of insects caught. Extremely important experiments were carried out by Baker and Mather and Baker [6], on the basis of which they proved that the Large Yellow Underwing (*Noctua pronuba* L.) and Heart & Dart (*Agrotis exclamationis* L.) moths use both the Moon and the Earth's magnetism for spatial orientation and are even able to integrate them. Fleischmann, et al. [7], suggest that insects have a geomagnetic compass sufficient for proper orientation. Dreyer, et al. [8], show that the moth, *Agrotis infusa*, Boisduval, senses the Earth's magnetic field and uses it together with visual landmarks to steer migratory flight behavior.

We also refer to the most important ones from the results of our previous research. We verified the influence of the horizontal (H-index) component valid for the entire territory of Hungary (Nowinszky, et al. [9,10]) on the collection of European Corn-borer (*Ostrinia*

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nubilalis Hbn.), *Agrotis exclamationis* L. (Nowinszky and Puskás [9,11]) and caddisflies (Trichoptera) species (Nowinszky, et al. [12]). In addition to the Kp index, the collection of Microlepidoptera species is modified by the M-index developed for the Carpathian Basin (Nowinszky and Puskás [13]). The M-index is a modified version of the planetary C9-index. We also verified the modifying influence of the M-index for 11 moth species from the light-traps of the Hungarian Forestry Research Institute (Nowinszky, et al. [12]), In our latest book (Nowinszky, et al. (Eds.)., [14]), we demonstrated the influence of a hitherto untested D_{st} index for 8 species of caddisflies (Trichoptera). In this study, we aim to verify the influence of the D_{st} index for 16 species of moths.

Material

The data of hourly equatorial D_{st} values (Final) we use, was published by WDC Kyoto Observatory. Large disturbances of the Earth's magnetic field, the so called geomagnetic storms, are defined by changes in the D_{st} (disturbance storm time) index. The D_{st} index determine the globally averaged change of the horizontal component of the Earth's magnetic field at the magnetic equator. It is computed once per hour based on measurements from a few stations at low latitudes (Honolulu, San Juan, Hermanus, and Kakioka). The size of a geomagnetic storm is classified as moderate (−50 nT > minimum of D_{st} > −100 nT), intense (−100 nT > minimum D_{st} > −250 nT) or super-storm (minimum of D_{st} < −250 nT). While D_{st} is between +20 and −20 nanoTesla (nT) during quiet times. The D_{st} (Disturbance storm time) index has been used since 1957. A very powerful light-trap was designed by Professor Mészáros and collected near the village of Bečej in Serbia between 1969 and 1973 by Gy. Varga in collaboration with him (Varga and Mészáros [15]), The light source of this Butcher type light-trap is an IPR WTF 220V, 250W mercury lamp, placed 2 meters above the ground. A large cage was placed under the funnel of the light source, which was divided into 4 equal parts with plastic nets. This solution protected the smaller ambush moths from being destroyed by the larger beetles, because the butterflies climbed onto the net and settled there. This cage was placed in a box in the morning, in which a little carbon-hydrogen sulphide was burned. Its gases quickly killed the insects. Several Mészáros-type traps operated in Serbia (Varga and Mészáros [16]), The data of the butterflies caught in the first two years were published (Mészáros, et al. [17]), In 1971, containing beetle material a book was also published by Mészáros, et al. (18), Several researchers collected in Serbia with the Mészáros-type light-trap (Kereši & Almáši, [19], Vajgand [19,20]), The moth data of Mészáros-type light-trap were processed and published (Vojnits, et al. [17], Mészáros, et al. [17]), This light-trap operated in Bekes Agricultural and Industrial Combine in the years 1969-1973. We process 32 moth species from the total catching data. The names of the species, the years of collection and the number of individuals are shown in Table 1.

Table 1: Catching data of examined moth (Lepidoptera) species.

Species	Years	Moths	Nights
Tortricidae, Tortricinae			
1 Green Oak Tortrix *Tortrix viridana* Linnaeus, 1758	1969-70 1972-73	1,041	54
Pyralidae, Phycitinae			
2 Pea Pod Borer *Etiella zinckenella* Treitschke, 1832	1970-73	3,294	152
4 European Corn-borer *Ostrinia nubilalis* Hübner, 1796	1970-73	38,120	341
Crambidae, Spilomelinae			
5 Rush Veneer *Nomophila noctuella* Denis & Schiffermüller, 1775	1970-73	14,689	278
Geometridae, , Ennominae			
6 Latticed Heath *Chiasmia clathrata* Linnaeus, 1758	1969-73	3,540	272
7 Sand Bordered Bloom *Tephrina arenacearia* Denis & Schiffermüller, 1775	1970-73	4,461	231
Arctidae, Arctiinae			
8 Autumn Webworm *Hyphantria cunea* Drury, 1773	1970-73	4,504	250
Erebidae, Arctiinae			
9 Ruby Tiger *Phragmatobia fuliginosa* Linnaeus, 1758	1970-73	10,181	345
Erebidae, Boletobiinae			
10 Lesser Belle *Colobochyla salicalis* Denis & Schiffermüller, 1775	1969-73	3,355	272
Noctuidae, Acontiinae			

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11 Spotted Sulphur *Acontia trabealis* Scopoli, 1763	1970-73	18,678	312
12 Dog's Tooth *Lacanobia suasa* Denis & Schiffermüller, 1775	1970-73	4,594	205
13 Common Wainscot *Mythimna pallens* Linnaeus, 1758	1969-70 1972-73	3,577	200
Noctuidae, Noctuinae			
14 Heart & Dart *Agrotis exclamationis* Linnaeus, 1758	1970-73	2,348	177
15 Turnip Moth *Agrotis segetum* Denis & Schiffermüller, 1775	1970-73	10,028	321
16 Setaceous Hebrew Character *Xestia c-nigrum* Linnaeus, 1758	1970-73	29,447	349

Methods

We cannot directly work with the exact number of insects caught with the light-trap in the research, even if the light-trap operates in the same place in consecutive years. Environmental conditions (moonlight, temperature, wind, air pressure, etc.) are different every night. Therefore, the number of caught individuals always represents a different ratio among the catchable individuals of the given species. We developed a very simple method to solve the problem (Nowinszky [21]), The relative catch (RC) values for each species were calculated as follows. The relative catch (RF) is the quotient of the number of individuals caught in the given sampling time unit (this can be 1 hour or even 1 night) and the average number of individuals of the generation in the sampling time unit. The average value of the relative catch is therefore 1. This can be considered the expected catch. Numbers less than one mean a smaller catch, while numbers greater than one mean a larger catch. In cases where we work with data from the same years, but from different light-trap locations, it seems appropriate to calculate relative catch values for generations. And when we work with data from the same location but from different years, all the data of a given species can be considered as a single sample. This is what we did in this study as well. Thus, the differences in the number of individuals caught in different years also differ in the relative catch values. The relative catch values were added separately for each species to the D_{st} values of each night. After that, classes were formed from the data pairs according to Sturges' method (Ódor and Iglói, [22]), Within the classes, we calculated the average of both D_{st} and relative catch values, which were also plotted.

Results and Discussion

(Figures 1-16) A striking result is that the catch results of different species differ for the same D_{st} values.

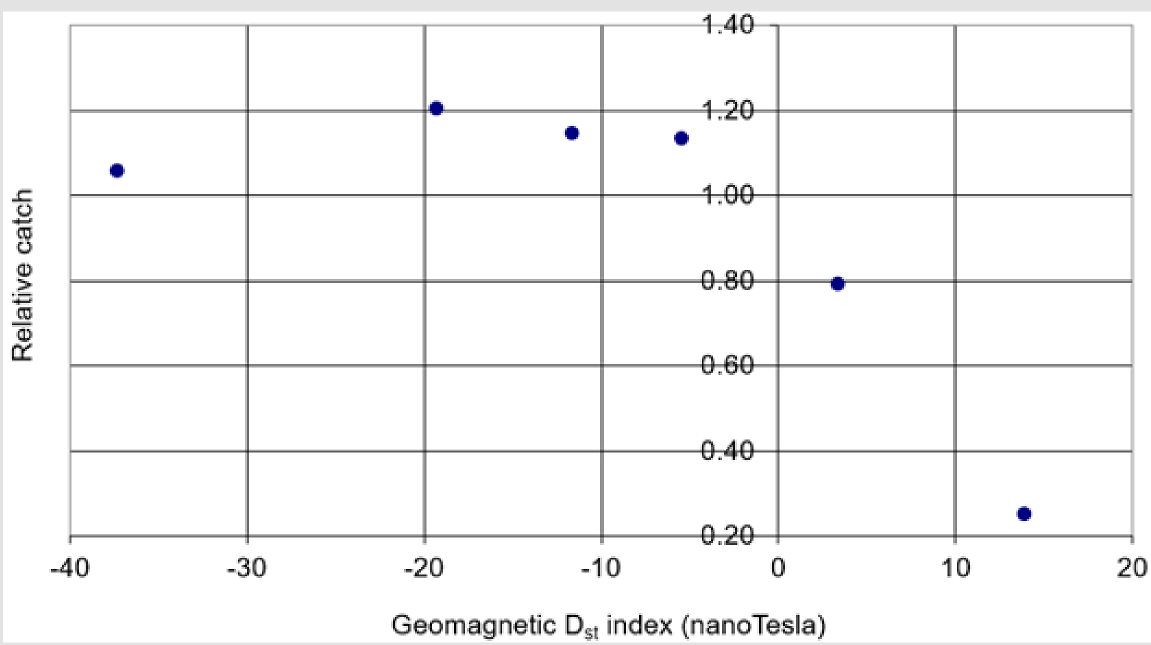

Figure 1: Light-trap catch of Green Oak Tortrix (*Tortrix viridana* Linnaeus, 1758) in connection with the geomagnetic D_{st} index.

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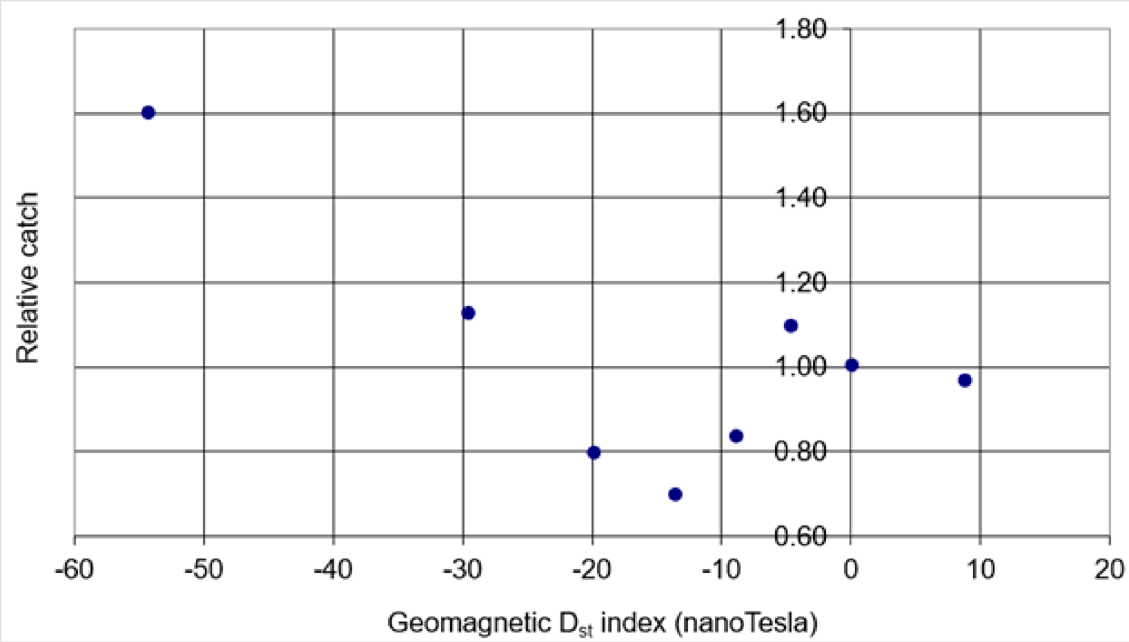

Figure 2: Light-trap catch of Pea Pod Borer (*Etiella zinckenella* Treitschke, 1832) in connection with the geomagnetic D_{st} index.

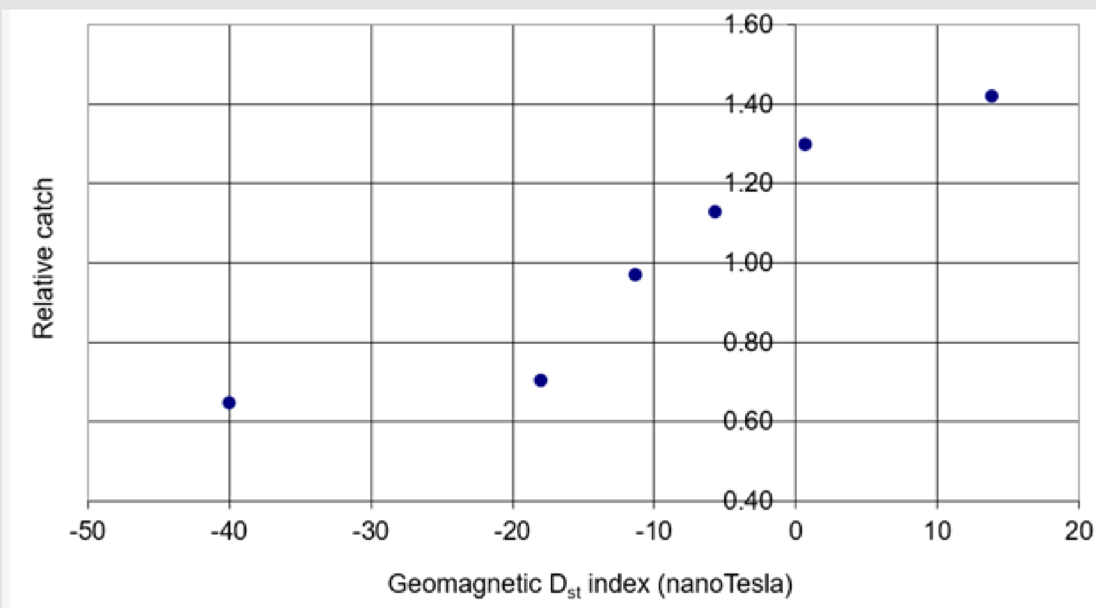

Figure 3: Light-trap catch of Rosy-striped Knot-horn (*Oncocera semirubella* Scopoli, 1763) in connection with the geomagnetic D_{st} index.

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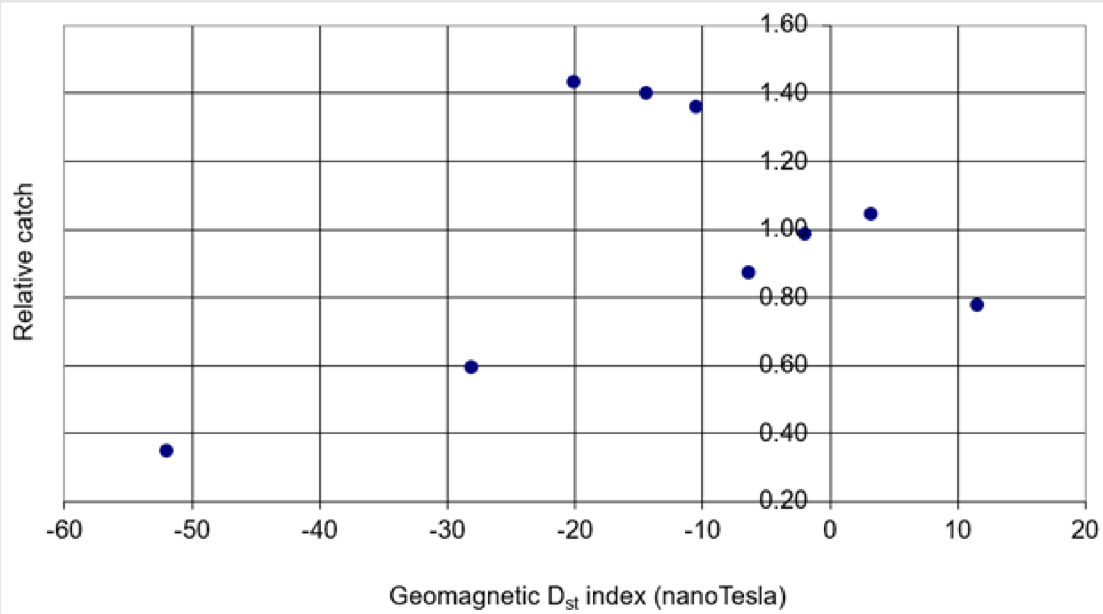

Figure 4: Light-trap catch of European Corn-borer (*Ostrinia nubilalis* Hübner, 1796) in connection with the geomagnetic D_{st} index.

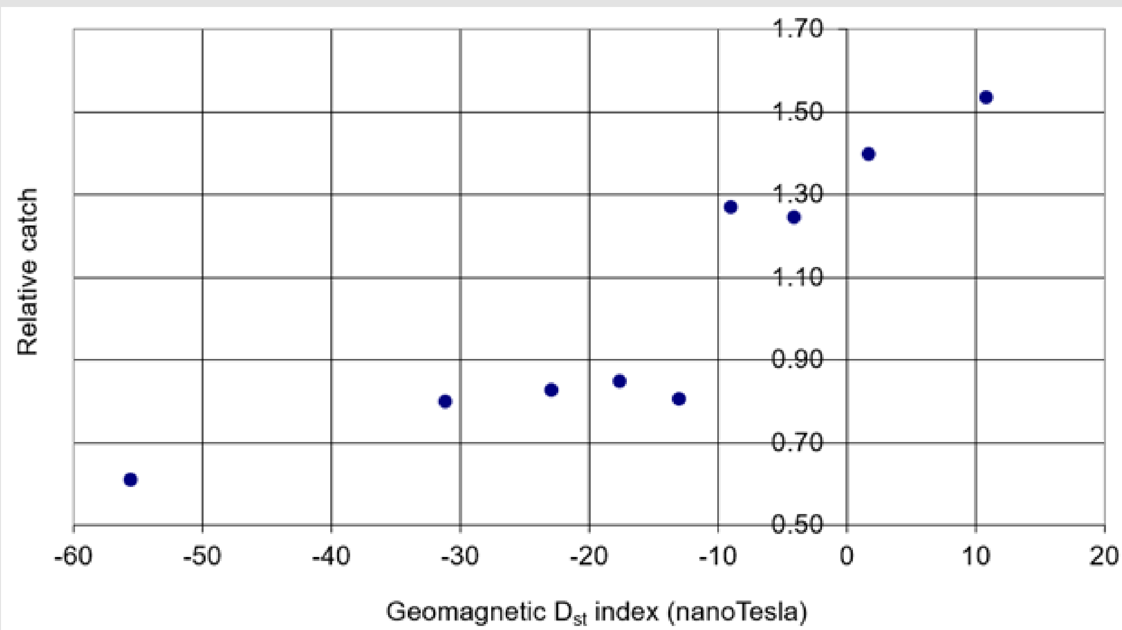

Figure 5: Light-trap catch of Rush Veneer (*Nomophila noctuella* Denis & Schiffermüller, 1775) in connection with the geomagnetic D_{st} index.

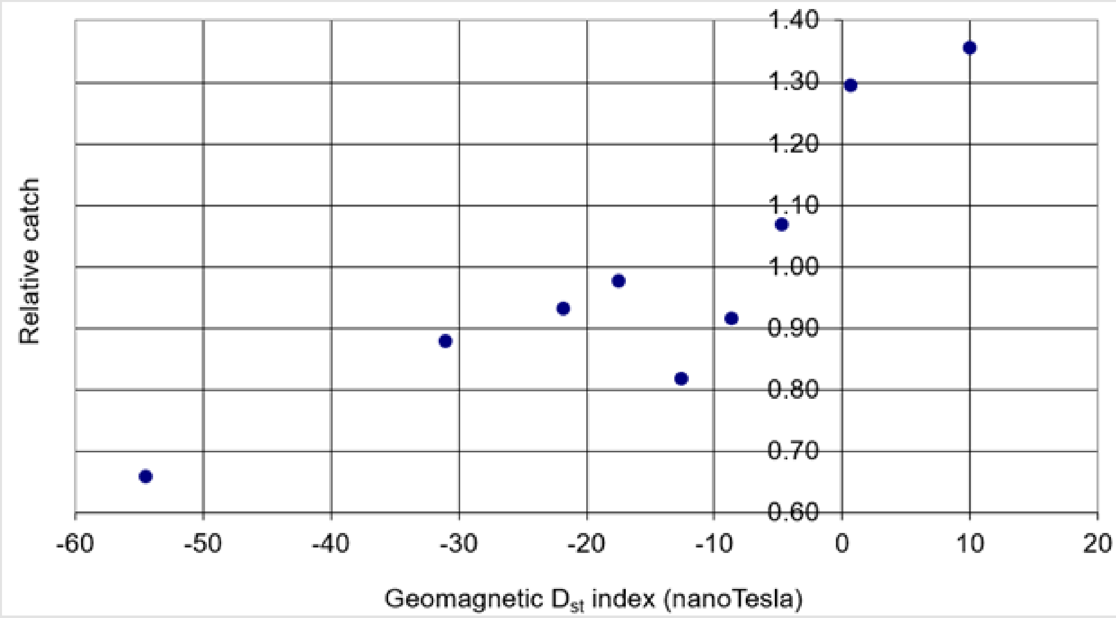

Figure 6: Light-trap catch of Latticed Health (*Chiasmia clathrata* Linnaeus, 1758) in connection with the geomagnetic D_{st} index.

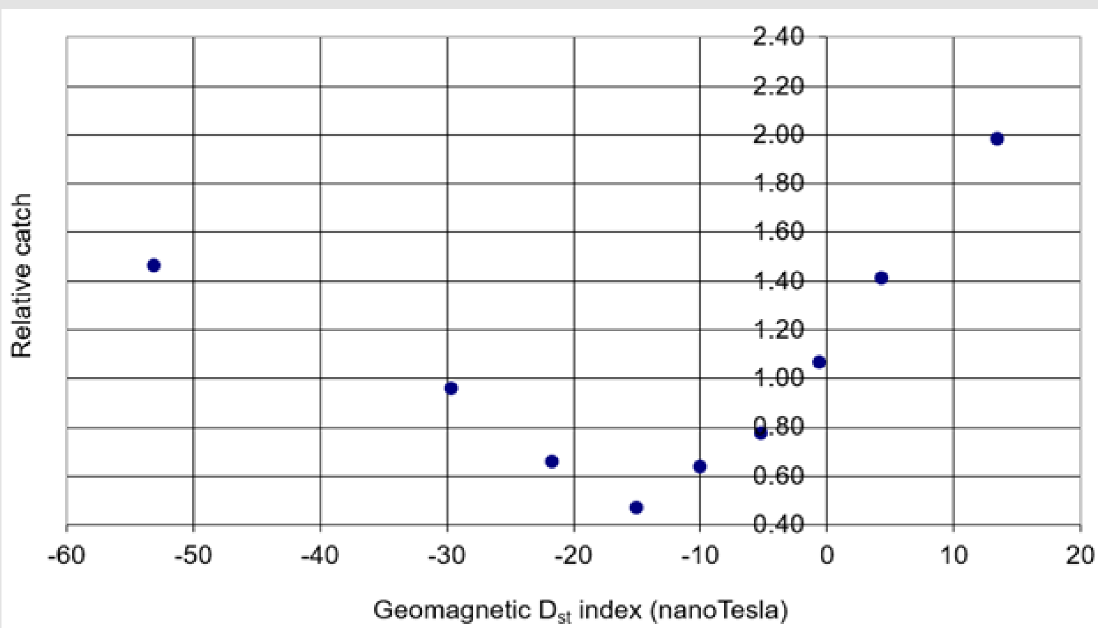

Figure 7: Light-trap catch of Sand Bordered Bloom (*Isturgia arenacearia* Denis & Schiffermüller, 1775) in connection with the geomagnetic D_{st} index.

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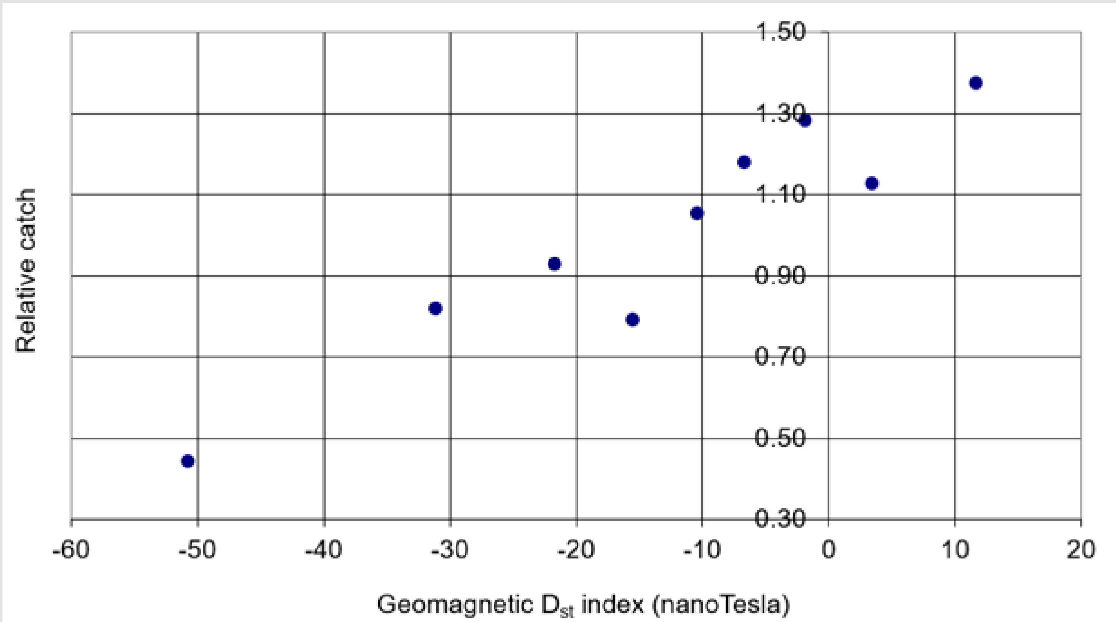

Figure 8: Light-trap catch of Autumn Webworm (*Hyphantria cunea* Drury, 1773) in connection with the geomagnetic D_{st} index.

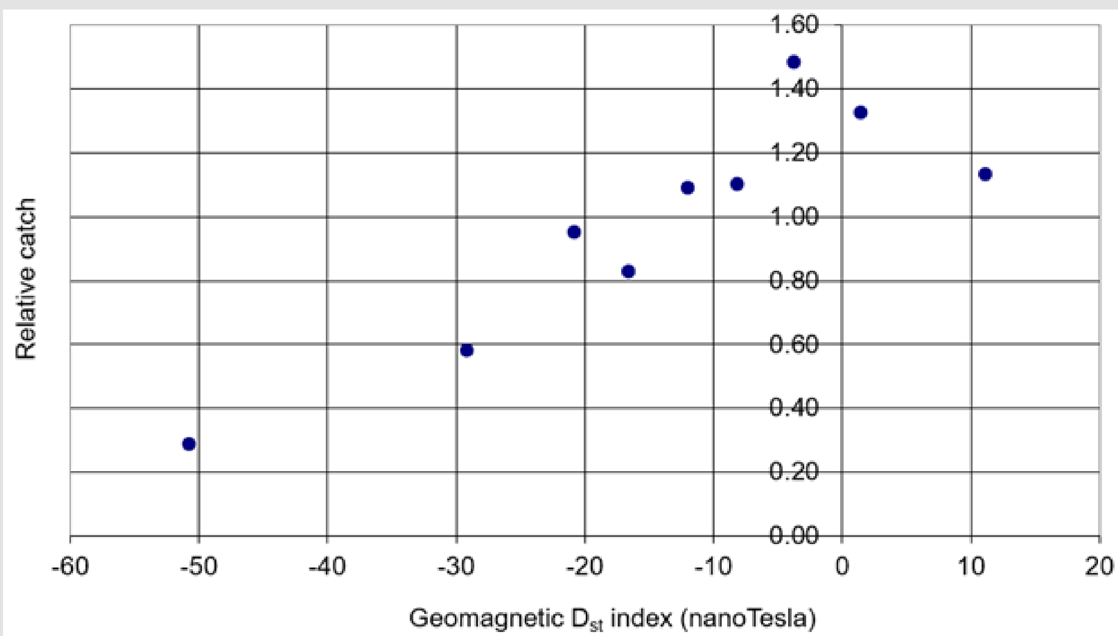

Figure 9: Light-trap catch of Ruby Tiger (*Phragmatobia fuliginosa* Linnaeus, 1758) in connection with the geomagnetic D_{st} index.

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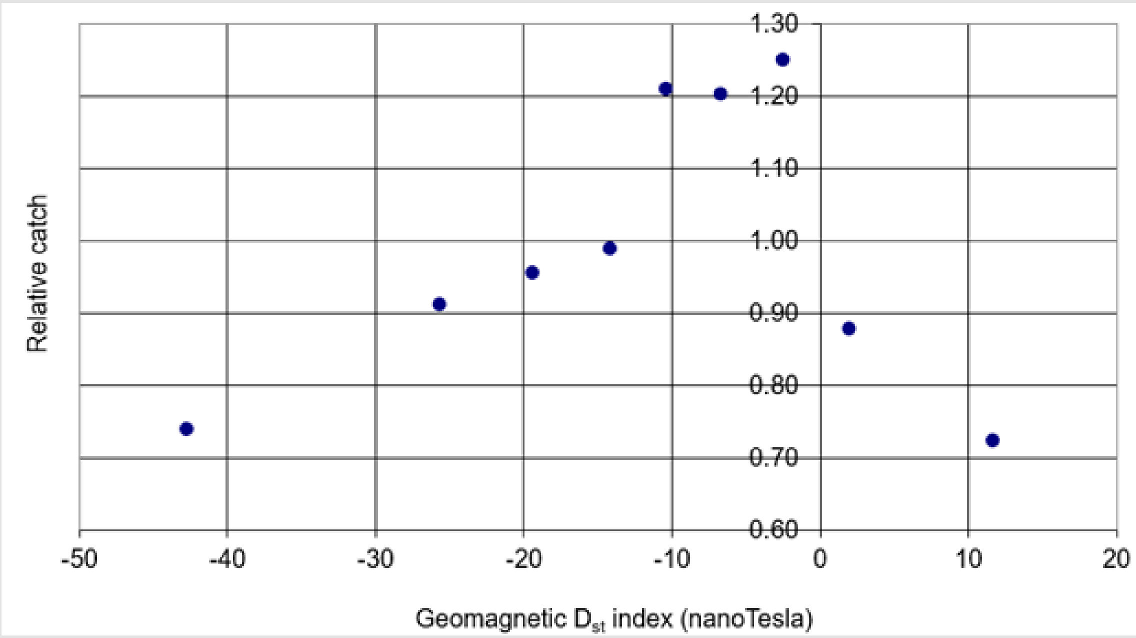

Figure 10: Light-trap catch of Lesser Belle (*Colobochyla salicalis* Denis & Schiffermüller, 1775) in connection with the geomagnetic D_{st} index.

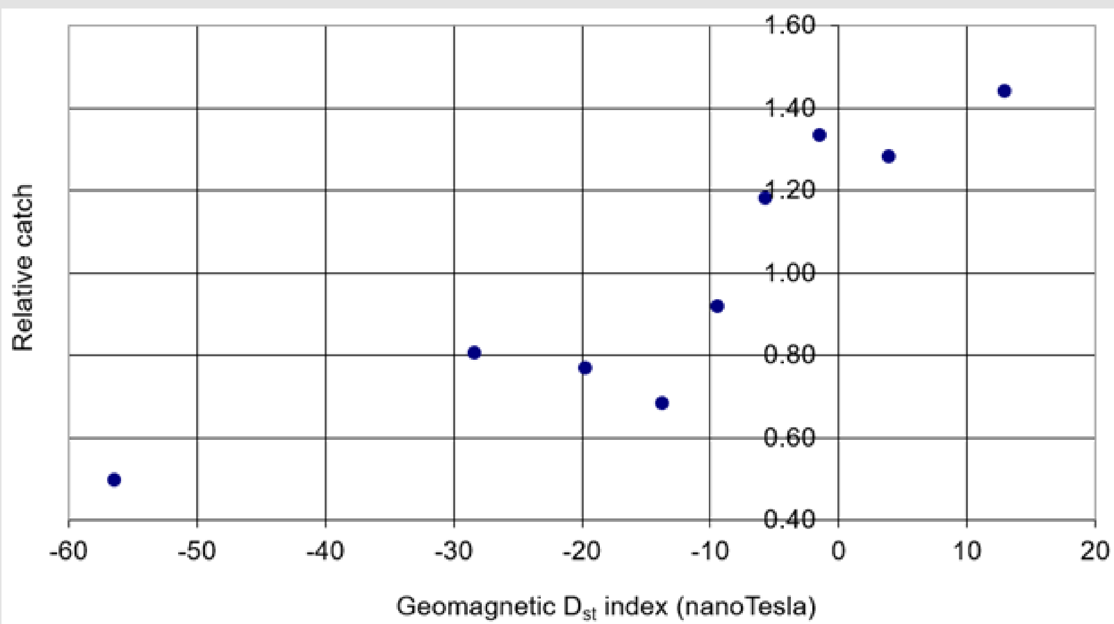

Figure 11: Light-trap catch of the Spotted Sulphur (*Acontia trabealis* Scopoli, 1763) in connection with the geomagnetic D_{st} index.

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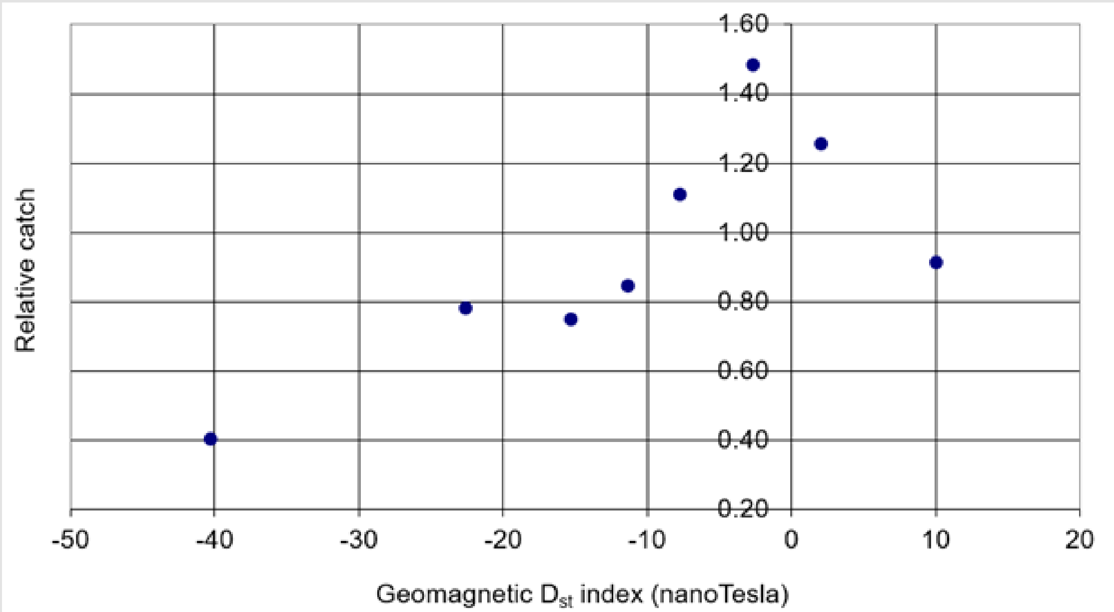

Figure 12: Light-trap catch of Dog's Tooth (*Lacanobia suasa* Denis & Schiffermüller, 1775) in connection with the geomagnetic D_{st} index.

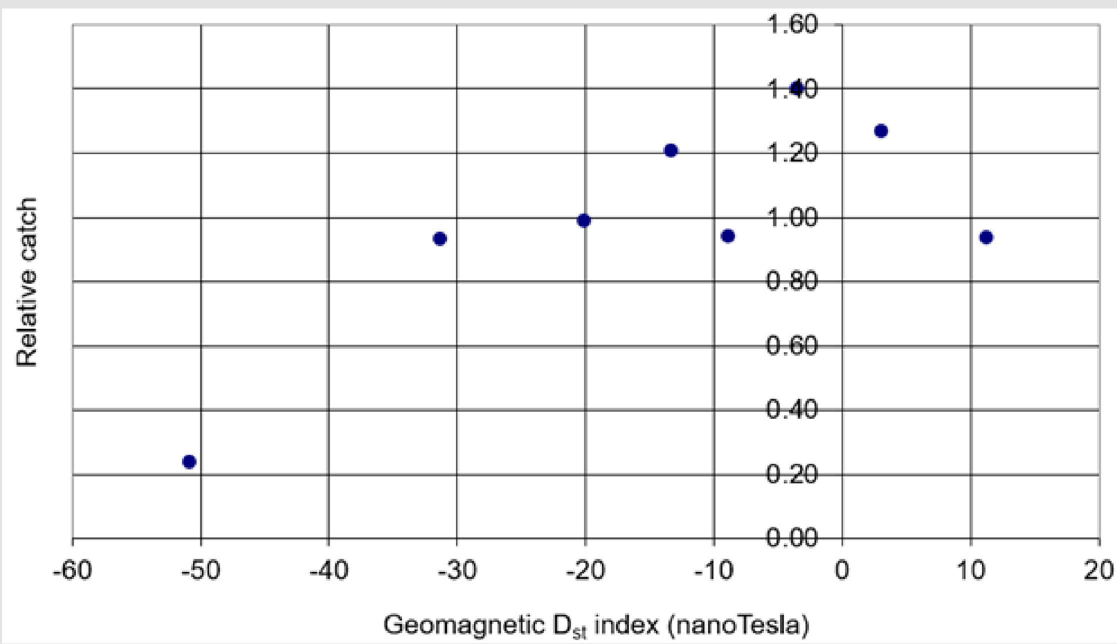

Figure 13: Light-trap catch of Common Wainscot (*Mythimna pallens* Linnaeus, 1758) in connection with the geomagnetic D_{st} index.

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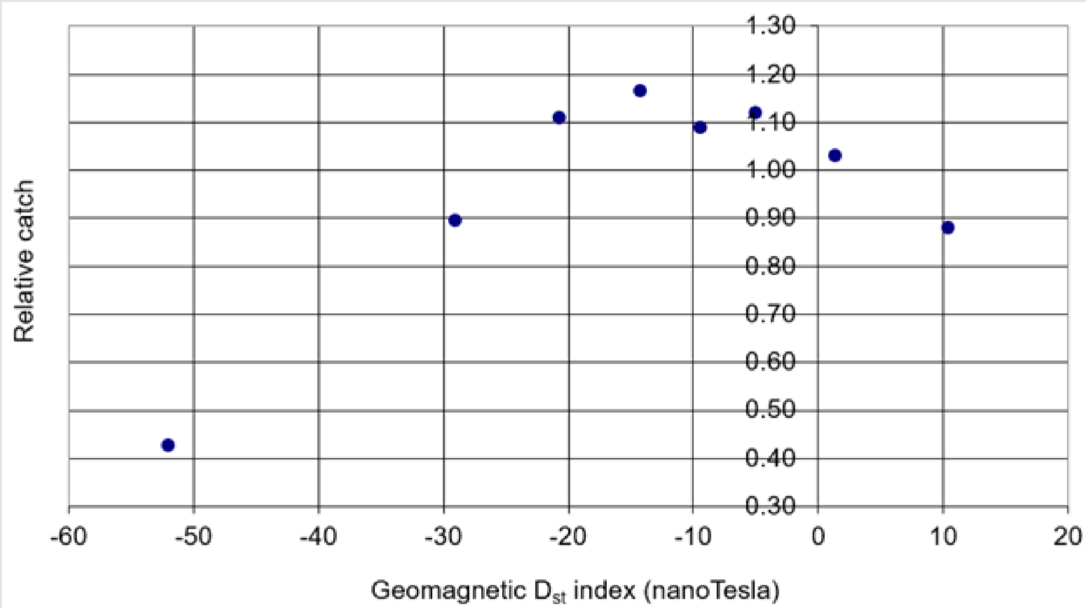

Figure 14: Light-trap catch of Heart & Dart (*Agrotis exclamationis* Linnaeus, 1758) in connection with the geomagnetic D_{st} index.

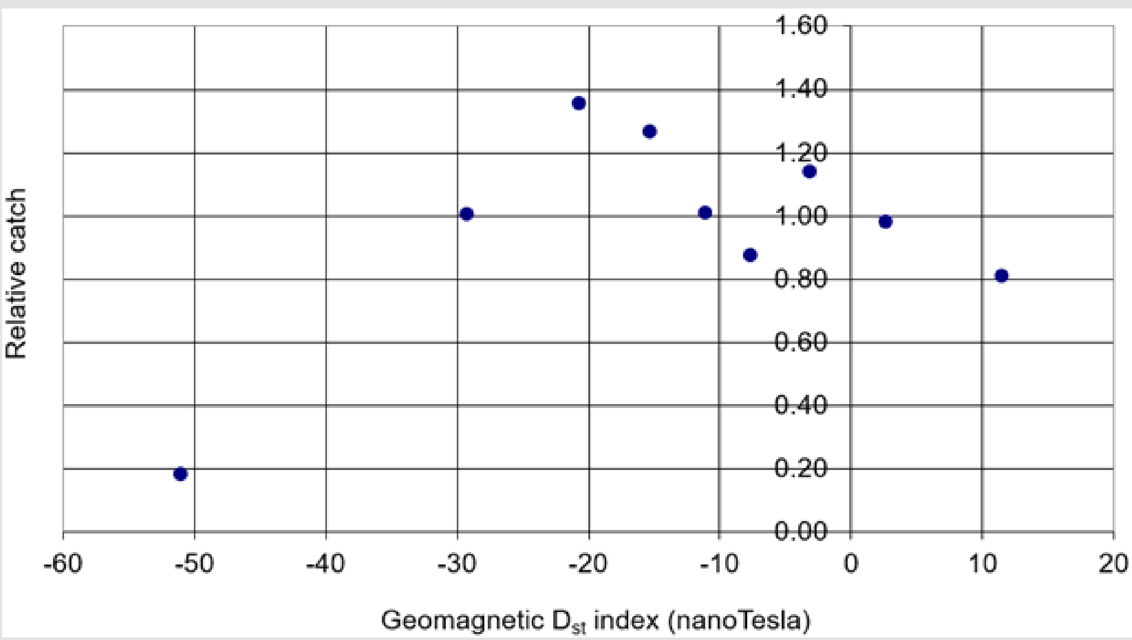

Figure 15: Light-trap catch of Heart & Dart (Agrotis segetum Denis & Schiffermüller, 1775) in connection with the geomagnetic D_{st} index.

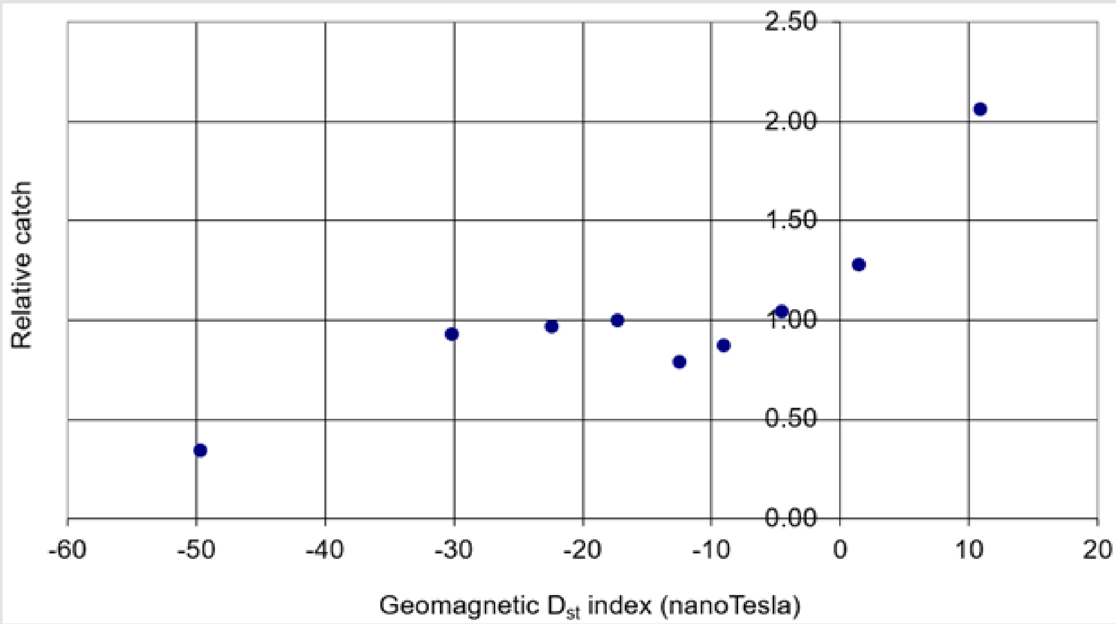

Figure 16: Light-trap catch of Setaceous Hebrew Character (*Xestia c-nigrum* Linnaeus, 1758) in connection with the geomagnetic D_{st} index.

Four types of behavior can be determined based on the results:

Increasing, decreasing, increasing, then decreasing, and finally decreasing, then increasing catch values are the same as D_{st} values. The increasing type can be explained by positive D_{st} values increasing the flight activity of these species. The explanation for the decreasing type is that negative D_{st} values increase the flight activity of other species. According to our hypothesis, the explanation of the increasing and then decreasing type can be as follows. Initially, geomagnetic storms increase insect activity. However, a stronger influence then forces him into passivity. The decreasing and then increasing type is more difficult to explain. We must assume that not all individuals of the same species behave in the same way. According to our hypothesis, the activity of one group of the population increases during the moderate values of the geomagnetic storm, while the activity of other individuals of the population increases in the quiet periods. It can be assumed that this behavior ensures the survival of the population even in extremely unfavorable situations. This phenomenon may be similar to the sensitivity to warm and cold fronts observed in humans. However, the types of responses observed per species are independent of taxonomic classification.

The increase or decrease of the catch can be explained by our previous hypotheses (Nowinszky [21]), There are several reasons for this opposite behavior. Species have different needs and tolerances to environmental factors. Environmental factors exert their effects in interaction with each other. Thus, the same factor may have different effects. Species have different survival strategies. The harmful effects of two possible responses: passivity, or hiding, or even increased activity, because you want to ensure the survival of the species. Therefore, insects try to "do their jobs in a hurry". Low relative grip values always show that the willingness to fly is reduced in the given situation, in this case at the given D_{st} values. However, high values are not clear. In one of our previous books (Nowinszky [21]), we have already published our hypothesis related to this. A high relative catch value may indicate the fact that the situation is favorable for the insect, which is why its flight activity increases. However, high relative catch values can, on the contrary, indicate an unfavorable situation for the insect. In this situation, it may happen that he becomes inactive, tries to seek refuge from danger. However, it may happen that she becomes more active to perform her "tasks", mating and laying eggs.

A high catch result can therefore be thought of as a favorable or unfavorable situation for the insect. The judgment of this is left to the knowledge of the specialist. Examining the light trapping of insects, we often find that individuals of certain species react differently to environmental influences. On the other hand, it is striking that the behavior of even individuals belonging to the same species is different. It is true that most individuals of a given species fly en masse to the light at a high or low value of some environmental factor. However, it is thought-provoking that there has never been a case where there was no catch at all at low or high values. So, if a high value of the geomagnetic D_{st} index favors the capture of a particular species, for exam-

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ple, there are still individuals that are trapped at a low D_{st} index value. A low value is probably favorable for these individuals. In our opinion, this phenomenon helps the population to survive. However, we must explain the fact that our presented results are not significant according to calculations based on standard deviations. Primarily from our own results, but also from the results of many other researchers, we found that important results can rarely be achieved, and we can only work effectively if we have a lot of catch data. The insects appear in extremely different numbers on consecutive nights. This observation of ours is true for most species, but especially for mobile species. However, despite processing a huge amount of catch data, we cannot achieve significant results in two cases. One case is when we have data from a single or only a few light-traps. Then the standard deviations are large due to significantly different catch data on different days. However, certain species, mainly migratory species, but others as well, never appear evenly, but intermittently during the swarming season. There are periods when many insects fly, but often there are few or no catches. The standard deviations are also extremely large in these cases. We have not found a solution for such extreme situations in the literature. Wouldn't it be a realistic expectation that we could interpret a significant part of the results of light-trap collections over many decades in entomological research? This is impossible, a solution had to be found.

It is our opinion that results that meet two conditions can be considered real. One is that those from multiple independent samples are essentially the same. The other condition is that the results can be interpreted based on our prior knowledge. There are many examples of similar types of behavior in our previous studies. We refer to four of them here, which deal with the light trapping of moths (Puskás, et al. [23-26], Nowinszky, et al. [9]), We refer to another book of ours (Nowinszky and Puskás (eds.)., [26]), which deals with the capture of moths with pheromone traps and contains many similar types of behavior. The results of our studies dealing with other species and other environmental factors are extremely like our current results. One of our new studies (Nowinszky, et al. [27]), examined the effectiveness of light trapping of 8 caddisfly (Trichoptera) species in relation to geomagnetic D_{st} index values. Our latest study (Nowinszky, et al. [28]), shows a similar behavior of moths collected with a pheromone trap. The independence requirement was also met in the present study. We can provide sufficient explanations for all four types of behavior. The other condition was also fulfilled in all our studies dealing with the relationship between the D_{st} index. Our opinion is that our present results can be accepted as real in these cases. The species in the tables meet these conditions. Thus, we can accept our current results as real [29-32].

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