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Light-trap Catch of Coleoptera Species in Connection with Environmental Factors

Bogár fajok fénycsapdás fogása környezeti tényezőkkel összefüggésben

János Puskás & László Nowinszky

Abstract. In this study there was examination of light-trap catch of three beetle (Coleoptera) species in connection with four environmental factors: the solar activity featured by Q-index, height of tropopause, geomagnetic C9-index and the Moon characteristics. We used the catch data of the Hungarian Forestry light trap network of the Forest Research Institute. Between 1969 and 1974, light-traps were operating across the whole territory of Hungary. The data were processed of following species: Coleoptera, Tenebrionidae: *Hymenalia rufipes* Fabricius, 1792; Scarabaeidae: *Rhizotrogus aestivus* Olivier, 1789 and *Serica brunnea* Linnaeus, 1758). The number of the environmental factors and the caught beetles were assigned into classes. The results obtained were plotted. We determined the regression equations, and the levels of significance. We found that the behaviour of the studied beetle species can be divided only into two types: if the values of environmental factors increase the catch increase or decrease.

Keywords. Coleoptera, Beetles, environmental factors, light trapping, Hungary.

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Összefoglalás. A tanulmány három bogár (Coleoptera) faj fénycsapdás fogásával foglalkozik, négy környezeti tényezővel összefüggésben: A naptevékenységet jellemző Q-index, a tropopauza magassága, a földmágneses C9-index és a Hold egyes jellemzői. Az Erdészeti Kutató Intézet országos fénycsapda hálózatának gyűjtési adatait dolgoztuk fel, az 1969 és 1974 közötti évekből. A következő fajok adatait használtuk: Coleoptera, Tenebrionidae: *Hymenalia rufipes* Fabricius, 1792; Scarabaeidae: *Rhizotrogus aestivus* Olivier, 1789 and *Serica brunnea* Linnaeus, 1758). A környezeti tényezők és a befogott bogarak számát osztályokra osztottuk. A kapott eredményeket ábrázoltuk. Meghatároztuk a regressziós egyenleteket és a szignifikáns szinteket. Megállapítottuk, hogy a vizsgált bogárfajok viselkedése csak kétféleképpen történhet: a környezeti tényezők növekvő értéke növeli vagy csökkenti a fogást.

Introduction

The researchers published many studies connected with different environmental factors, in most cases meteorological elements and the moonlight, and the light trap catch. Very few studies can be found in the literature dealing with the effect of the solar activity, the tropopause and the geomagnetism. Therefore, we investigated the effect of these factors.

Kleczek (1952) was the first researcher, who introduced the concept of Q-index to use the daily flare activity through quantification of the 24 hours of the day.

$$Q = (i \times t)$$

where i = flare intensity, t = the time length of its existence.

He assumed that this relationship gives roughly the total energy emitted by the flares. In this relation, "i" represents the intensity scale of importance and "t" the duration (in minutes) of the flare. Most daily flare activities are characterised by Turkish astronomers, Özgüç & Ataç (1989) by index Q that expresses the significance of flares also by their duration. The solar activity also exerts influence on life phenomena. In the literature accessible to the authors, however, no publication can be found that would have dealt with the influence of flares on the collection of insects by light-traps. Earlier we have published our studies and demonstrated the Q-index on light-trap catches (Nowinszky & Puskás 1999, 2001, 2013a**,** Puskás et al. 2010). Other authors did not publish studies on theme of solar activity and light trapping of insects.

The changes in mid latitude air mass circulation are caused by a rise in the height of the tropopause, and other factors as increased moisture content in the atmosphere (Lorenz & DeWeaver 2007). If there are changes in the air mass circulation it must be changes in the elements of the weather such as temperature, air humidity, air pressure, wind speed and direction. The tropopause is a surface separating the lower layers of the atmosphere (troposphere) from the upper layers (stratosphere). It is of varying height. The changes in tropopause height more weather elements contain a complex way: air temperature, humidity, strength of wind, air pressure, precipitation. In the presence of very cold air masses from the Arctic it may be a mere 5 kilometres, while in the presence of sub-tropical air it may grow to 16 kilometres. Sometimes there are two or three tropopauses one above the other.

A low tropopause is related the presence of cold and high tropopause the presence of warm types of air, while insect activity is increased by warm and reduced by cold air. An over 13 km height of the tropopause often indicates a subtropical air stream at a great height. This has a strong biological influence. These results may lead us to assume that the electric factors in the atmosphere also have an important role to play, mainly when a stream of subtropical air arrives at great height. On such occasions, the 3Hz aspheric impulse number shows a decrease, while cosmic radiation of the Sun will be on the increase (Örményi 1984). The preponderance of negative ions in polar air reduces activity, while the preponderance of positive ions in subtropical maritime air may spur flight activity (Örményi 1967). The warm air increases the activity of the insects; the cold reduces it on the other hand. As the changes in tropopause height cause also changes in the weather in the lower layers of air in large areas, we examined the efficiency of the catch of the light-traps in connection with changes in the tropopause height. We did not find communications dealing with this topic in the literature apart from our own works.

In earlier, a few studies have been published, which deal with the efficiency of the light trap and the altitude of the tropopause of the Heart and Dart (*Agrotis exclamationis* L.), the Common Cockchafer (*Melolontha melolontha* L.), the Turnip Moth (*Agrotis segetum* Den. et Schiff.) and Fall Webworm Moth (*Hyphantria cunea* Drury) Puskás & Nowinszky (2000), (Örményi et al. 1997) and Puskás &

Nowinszky (2011). It has been stated that the subtropical air masses, observed in the high altitudes, differently affect the efficiency of light-trap collection according to whether they come from that route over Hungary. The light-trap catch of Turnip Moth (*Agrotis segetum* Den. et Schiff.) and Heart & Dart (*Agrotis exclamationis* L.) is high during subtropical residence time of air masses, but during the Saharan air mass residence time it is low. It is just opposed the results to the Fall Webworm Moth (*Hyphantria cunea* Drury) light trapping catch. In our earlier works we have examined the light-trap catch of European Corn-borer (*Ostrinia nubilalis* Hübner) and Setaceous Hebrew Character (*Xestia c-nigrum* L.) and the caddisfly (Trichoptera) species as a function of the height of the tropopause, too (Nowinszky & Puskás 2013b, Nowinszky et al. 2015).

We found in our former studies that the light trapping efficiency of parallel increases if the tropopause height is about 13 kilometres. However, the catch of the different species is not growing already longer on the higher values of the tropopause, but decreasing.

It has been known for decades that the insects detect the geomagnetic field, and even can use it as a three-dimensional orientation. 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. A weak but significant correlation was found between the geomagnetic parameters and the number of specimens of the various orders of insects caught. 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. Examinations over the last decades have also confirmed that some Lepidoptera species, such as Large Yellow Underwing (*Noctua pronuba* L.) (Baker & 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 (*Hyphantria 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, Samia et al. 2010) the orientation/navigation of moths at night may become not by the Moon or other celestial light sources, but many other phenomena such as geomagnetism.

Great many studies in professional literature are devoted to the role of the Moon in modifying light trapping catch. The conclusions are contradictory and up to this day a good many questions have remained unclarified. True, the authors usually collected differing species at the most different geographical locations and have not even registered the moon phase in every case. However, our researches have recently resulted in new knowledge about a number of issues.

Matalin (1998) examined 10 parameters in order to estimate the influence of weather conditions on the migration activity of ground beetles. These day and night mean parameters were calculated: temperature, air humidity, barometric pressure, precipitation, wind force, moon phases and cloudiness.

The lowest flight activity was recorded on days with low air temperature and strong winds and rain in conjunction with full moon. The highest flight activity was found on warm moonless and windless nights, often with drizzle, when the amount of precipitation did not exceed 0.5 mm per night.

Our investigations revealed that the catches of Winter Moth (*Operophtera brumata* L.) were the greatest in the First and the Last Quarters, and the lowest at Full Moon. The reason for this is that the proportion of polarized moonlight in the different lunar quarters varies, with the catches highest when the proportion is greatest (Nowinszky et al. 2012). The catching peaks of 21 Macrolepidoptera species can be seen at First- and Last Quarter. Then there is the maximum ratio of polarized moonlight (Nowinszky & Puskás 2013c).

We found the catching peak of ten species of 25 Microlepidoptera species is in First Quarter, another ten species have the peak in the First Quarter and Last one, and only in two cases the peak is in Last Quarter. Then there is the maximum ratio of polarized moonlight (Nowinszky & Puskás 2013d). We established the duration of the Moon staying above the horizon unambiguously causes the increase of the catch of *Lygus* sp. from New Moon to Full Moon and also from Full Moon to New Moon. The proportion of polarized moonlight also leads to the increase in the catch both in the First Quarter of the Moon and the Last Quarter of the Moon (Nowinszky & Puskás 2014).

The data were processed of following species: Coleoptera, Tenebrionidae: *Hymenalia rufipes* Fabricius, 1792; Scarabaeidae: *Rhizotrogus aestivus* Olivier, 1789 and *Serica brunnea* Linnaeus, 1758).

The *Hymenalia rufipes* Fabricius is widespread throughout Europe and Hungary but it belongs to rare species (Kaszab, 1957).

This species inhabits mainly in southern Europe, and in xerothermic habitats in its northern part, including Poland. The larvae develop in soil among roots of grasses and perennial plants (they are particularly connected with field wormwood, *Artemisia campestris* (L.). This beetle is rarely captured in Poland (Iwan et al. 2010).

The *Serica brunnea* Linnaeus is widespread and common species in Europe, in the Carpathian Basin. Tóth (1975) wrote in his study the forest species of Hungarian forestry light-trap network were detected in the Bakony and Vértes mountains and the sand in Danube–Tisza.

The *Rhisotrogus aestivus* Olivier is collectible en masse mainly at sandy soils in Hungary (Kiskunság, Nyírség and around Budapest). Its swarming is expected in May (Járfás & Tóth 1977, Tóth 2014).

Material

Accompanying the gradation of winter geometrids, the first six forestry light-traps were set up in 1961 under the leadership of Pál Tallós and Pál Szontagh at the observation posts of the Forestry Research Institute (Szontagh 1975). Further traps were set up in the following years.

Employed in the national light network equipped with Jermy-type traps, normal bulbs are in extensive use only in Hungary (Jermy 1961).

The light-trap consists of a frame, a truss, a cover, a light source, a funnel and a killing device. All the components are painted black, except for the funnel, which is white. The frame is fixed to a pile dug into the ground. A metal ring holding the funnel and a flattened conical cover made of zinc-plated tin joins the steel frame. The cover is 100 cm in diameter and 14 cm in height. The distance between the lower edge of the cover and the higher edge of the funnel is 20-30 cm. The light source is a 100W normal electric bulb with a colour temperature of 2900°K. The lamp is in the middle of the trussing, 200 cm above the ground. The upper diameter of the funnel is 32 cm, the lower one is 5 cm, and its height is 25 cm. The female thread of the killing device joins the male thread of the 5-cm appendage at the lower part of the funnel. The killing jar of the device modified by Bozai (1966) is a glass lamp globe of 1.5 -2 litres in volume. At the lower edge of the appendage tube, a frame made of steel wire holds the evaporating vessel fitted with a protective cap made of haircloth to prevent insects from falling into the vessel. The insects caught must not get in contact with the chloroform used for killing because of its strong fat-dissolving action. Before it is put into operation, some wadding is placed in the bottom of the vessel to reduce the danger of the collected material becoming damaged. The evaporating vessel should be filled with a generous amount of chloroform to get the maximum killing power, if not; the material might easily become unidentifiable (Kovács 1957). In the morning, it is practical to embark on a few hours of post killing. The lamp is turned on before dawn and is switched off after sunrise. The material collected over the night gets into the same vessel, so one night's catch makes one sample.

The forestry light traps are operational from 6 p.m. (UT) to 4 a.m. every night of the year, regardless of weather, or the time of sunrise and sunset. The operation is suspended only on days when the temperature is below 0 °C and the ground is covered by an unbroken layer of snow. All the insects trapped during the course of a night go into the same collecting jar and so a single set of data will represent the nightly catch result at the given observation site.

In this study we used the catch data of the Hungarian Forestry light trap network of the Forest Research Institute. The light traps were operating in 8 light trap stations across the whole territory of Hungary in these years. The light trap stations, geographic coordinates and years of operation are presented in Table 1.

Table 1. The light-trap stations, geographic coordinates and years of operation

1. táblázat. A fénycsapda állomások, azok földrajzi koordinátái és a működés évei

Light-trap stations	Geographic coordinates	Years of operation
Budakeszi	47°30′83″N 18°56′03″E	1970–1973
Farkasgyepű	47°12′22″N 17°38′02″E	1969-1974
Kunfehértó	46°21′64″N 19°24′93″E	1967, 1969-1974
Gyulaj	46°42′01″N 21°11′07″E	1967, 1971–1973
Makkoshotyka	46°30′51″N 18°17′76″E	1967, 1969
Mátraháza	48°21′52″N 21°31′17″E	1967, 1969, 1972-1973
Tompa	46°25′60″N 18°46′95″E	1969–1973
Várgesztes	46°12′28″N 19°38′08″E	1962–1970

Table 2. The name of families, species, years, number of individuals and nights

2. táblázat. A családok, fajok, évek, az egyedek és éjszakák száma

Families and Species	Years	Traps	Number of Beetles	Data
	Tenebrionidae			
Hymenalia rufipes Fabricius, 1792	1969-1974	3	3,585	385
	Scarabaeidae			
Brown Chafer *Serica brunnea* Linnaeus, 1758	1969-1974	6	7,700	499
Rhizotrogus aestivus Olivier, 1789	1967-1974	2	1,953	160

Hymenalia rufipes
(Source: https://www.biolib.cz/en/image/id275896/)
Modification: Fazekas I.

For our study, 3 beetle (Coleoptera) species were selected from the national forestry light trap network material dating back to the years between 1967 and 1974 (without 1968).

Flare Index Data used in this study were calculated by Ataç & Özgüç from Bogazici University Kandilli Observatory, Istanbul, Turkey.

Data for Budapest on the height of the tropopause have been collected from the Annals of the Central Meteorological Institute of the Hungarian Meteorological Service. Because area of Hungary is 93 036 km^2 only, so this data is valid for the entire territory of the country (Örményi et. al 1997).

The average field strength of the Earth as a magnetic dipole is 33,000γ. [$1\gamma=10^{-5}$ 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 based on 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 value of C9-index does not have dependence of the local time, but it can globally characterize the geomagnetic activity. The geomagnetic C9 data, required for our work, were downloaded from the British Geological Survey Natural Environment Research Council website: http://www.bgs.ac.uk/home.html

Data on the illumination of the environment were calculated using our own software. This software for TI 59 computers was developed by the late astronomer György Tóth specifically for our joint work at that time (Nowinszky & Tóth 1987). The software was transcribed for modern computers by M. KISS. The software calculates the illumination in terms of lux of the Sun at dusk, the light of the Moon and the illumination of a starry sky for any given geographical location, day and time, separately or summarized. It also considers cloudiness. The data of moonrise and set were got from astronomical yearbooks. From these we counted the period of Moon stay above the horizon during all the investigated nights. The ratio of the percentage polarization of moonlight was taken over from our earlier work (Nowinszky & Tóth 1987). All our data on cloud cover were taken from the Annals of the Hungarian Meteorological Service. The data in these books are in octas of cloud cover (eighth part) recorded every 3 h. The characterisation of moon phase angle groups can be seen in *Table 3.*

Table 3. Characteristics of the moon phase groups
3. táblázat. A holdfázis csoportok jellemzői

Phase angle groups ± 15	Moonlight lux	Polarized light %	Staying time (minutes)	Phase angle groups	Moonlight lux	Polarized light %	Staying time (minutes)
				0	0.1791	0.0000	487
- 14				1	0.1772	-1.1150	515
- 13	0.0097	3.5630		2	0.1713	-0.0410	526
- 12	0.0199	4.4422		3	0.1618	2.5110	497
- 11	0.0332	5.3650		4	0.1497	3.9270	469
- 10	0.0492	6.0000	160	5	0.1345	5.4120	439
- 9	0.0665	6.3240	191	6	0.1181	6.8690	411
- 8	0.0854	6.5760	209	7	0.1001	7.9410	388
- 7	0.1041	6.2850	234	8	0.0825	8.7140	358
- 6	0.1221	5.7880	263	9	0.0646	8.7650	325
-5	0.1389	4.9500	296	10	0.0475	7.2120	291
-4	0.1533	3.6870	323	11	0.0321	6.0830	273
-3	0.1654	2.4120	351	12	0.0193	4.9390	
-2	0.1736	-0.4120	389	13	0.0097		
-1	0.1780	-0.1150	438	14			

Methods

From the catching data of the examined beetle 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 night) per the average number of individuals of the same generation falling to the same time unit. In 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 (Nowinszky 2003). The data from different years were treated with combined. From the collection data pertaining to examined species we calculated relative catch values (RC) by light-trap stations and by swarming. The number of the environmental factors and the beetles caught were calculated classes with consideration to the method of Sturges (Odor & Iglói 1987). The RC values of all species were arranged into the proper classes.

At the values of Q-index showed considerable differences in course of the respective years, they were preferably expressed as percentages of the averages of swarming periods (this was named relative Q-index). We studied the influence of flare activities on the daily catches. To disclose the latter, the Q/Q average values were co-ordinated with the relative catch data of different observation posts for each day of the catch period. The Q/Q means (relative Q-index) values have been contracted into groups (classes), and then averaged within the classes the relative catches data pertaining to them.

We summarized and averaged the tropopause and C9-index values for every

Table 4. The behaviour types of the examined beetle (Coleoptera) species
4. táblázat. A vizsgált Coleoptera fajok viselkedési típusai

Species	Q-index	Tropo-pause	C9 index	Staying time of Moon	Moon-light	Polarized Moonlight in First Quarter
Hymenalia rufipes Fabr.	D	I	D	I	I	—
Rhizotrogus astivus Oliv.	I	I	I	—	—	I
Serica brunnea L.	I	I	D	—	—	I

Notes: I=increasing, D=decreasing.

night. The number of caught species and individuals were also averaged.
The mean revolution time of the moon on its orbit around the Earth is 29.53 days. This time period is not divisible by entire days, therefore we rather used phase angle data. For every midnight of the flight periods (UT = 23 h) we have calculated phase angle data of the Moon. The 360° phase angle of the complete lunation was divided into 30 phase angle groups. The phase angle group including the Full Moon (0º or 360º) and ± 6º values around it was called 0. Beginning from this group through the First Quarter until a New Moon, groups were marked as -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13 and -14. The next division was ±15, including the New Moon. From the Full Moon through the Last Quarter to the New Moon the phase angle groups were marked as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14. Each phase group consists of 12°. These phase angle groups are related to the four quarters of lunar cycle as it follows: Full Moon (-2 – +2), Last Quarter (3 – 9), New Moon (10 – -10) and First Quarter (-9 – -3). All nights of the periods investigated were classified into the corresponding phase angle group (Nowinszky 2003).

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 Q-index, tropopause, geometric C9-index and characteristics of Moon data pairs. We determined the regression equations, the significance levels which were shown in the figures.

Results and Discussion

The results are shown in Figures 1–13 and Table 4.
From the results several important consequences could be drawn. The results can be written down with second- or third-degree polynomials.

Based on our results, we proved that the light-trap catch of examined species is affected by the solar activity featured by Q-index. Our results proved that the daily catches were significantly modified by the Q-index, expressing the different lengths and intensities of the solar flares. The different form of behaviour, however, is not linked to the taxonomic position.

Two species, the *Rhizotrogus aestivus* Olivier and *Serica brunnea* Linnaeus were collected in connection with the increasing the high values of the Q-index. The increase of the catch can be experienced in one case (*Hymenalia rufipes* Fabricius) and the decrease can be seen, when the value of the Q-index is high.

The reason can be explained, that in subtropical air masses residence at the time of very hot nights have reduced flight activity. The tropopause height above 13 km often indicates the type of subtropical air inflow at high altitude and it has a strong biological effectiveness. Atmospheric electrical factors may also have a role, especially during the high-altitude subtropical air inflow. In this case, for example, 3 Hz spherics pulses are reduced, while the solar cosmic rays increase (Örményi 1984). The atmospheric ions may also have a significant role (Örményi 1967). The arctic air may decrease flight activity factor due to the dominance of negative ions, but the dominance of positive ions in the subtropical air could be a factor in increasing flight activity. We do not know yet every detail of how effects the height of the tropopause the catch results. The connection between weather and tropopause is not completely known; therefore, we hope later investigations will provide a fuller explanation about the causes of the results we obtained. Further researches will hopefully lead to a clear answer.

Two species, the *Hymenalia rufipes* Fabricius and *Serica brunnea* Linnaeus were collected in connection with the decreasing the high values of the C9-index. The increase of the catch can be experienced in one cases (*Rhizotrogus aestivus* Olivier) the increase can be seen, when the value of the Q-index is high.

The duration of the Moon staying above the horizon unambiguously causes the increase of the catch of *Hymenalia rufipes* Fabricius from New Moon to Full Moon and also from Full Moon to New Moon. The proportion of polarized moonlight also leads to the increase in the catch of all examined species both in the First Quarter of the Moon and the Last Quarter of the Moon.

Acknowledgement: We thank Dr. Pál Szontagh who gave the light-trap data of Forest Research Institute to Dr. Sándor Szabó and Dr. László Nowinszky in the 1970s. These data were used in our study. Flare Index Data used in this study were calculated by Tamer Ataç and Atila Özgüç from Bogazici University Kandilli Observatory, Istanbul, Turkey. The Q-index daily data for the period 1980 and 2000 were provided by Dr. T. Ataç. His help is here gratefully acknowl-edged.

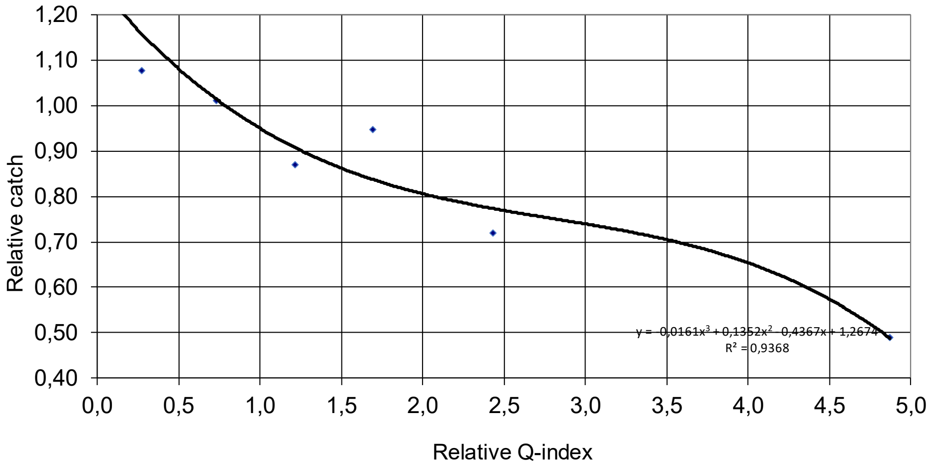

Figure 1. Light-trap catch of *Hymenalia rufipes* Fabricius in connection with the Q-index, 1969-1974
1. ábra. A *Hymenalia rufipes* Fabricius fénycsapdás fogása és a relatív Q-index összefüggése, 1969-1974

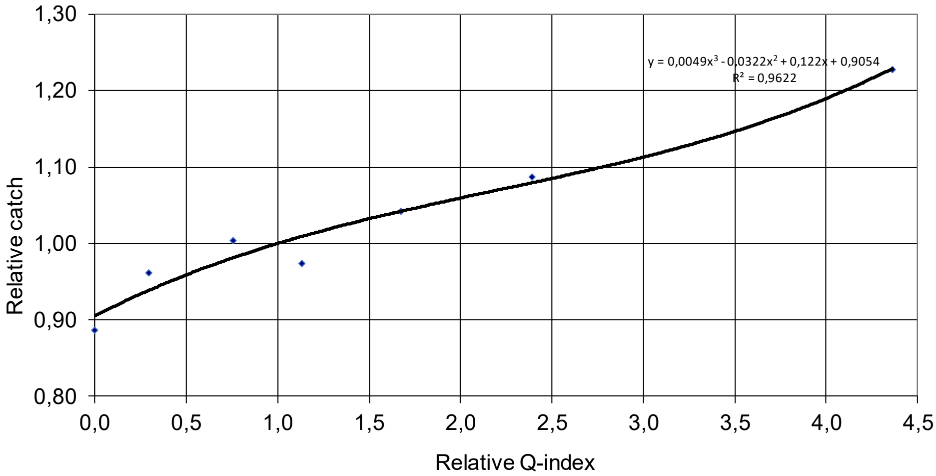

Figure 2. Light-trap catch of *Rhizotrogus aestivus* Olivier in connection with the relative Q-index, 1967-1974
2. ábra. A *Rhizotrogus aestivus* Olivier fénycsapdás fogása és a relatív Q-index összefüggése, 1967-1974

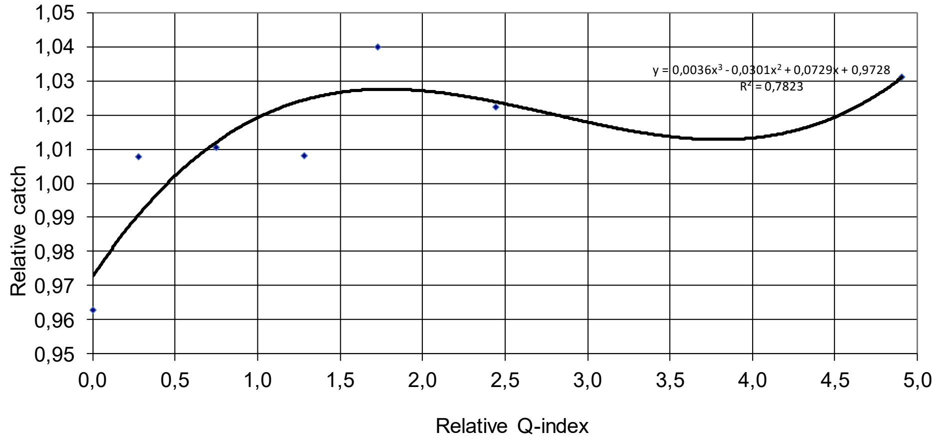

Figure 3. Light-trap catch of *Serica brunnea* Linnaeus in connection with the relative Q-index, 1967-1974
3. ábra. A *Serica brunnea* Linnaeus fénycsapdás fogása és a relatív Q-index összefüggése, 1967-1974

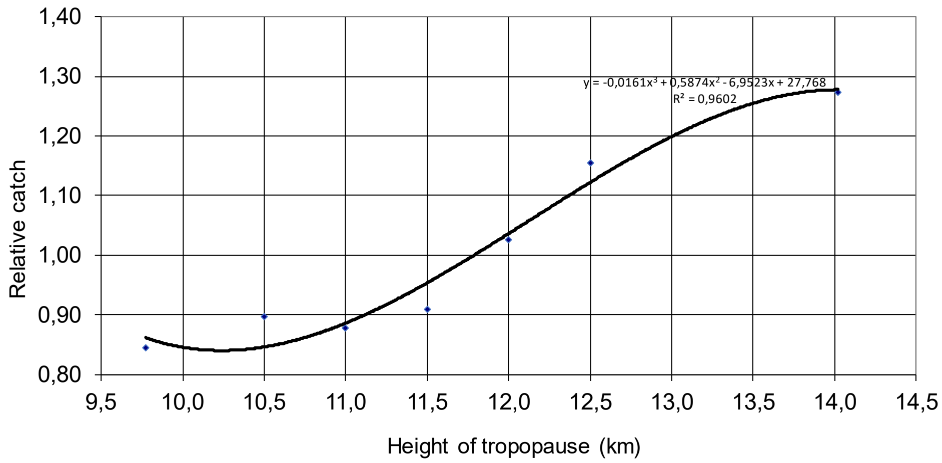

Figure 4. Light-trap catch of *Hymenalia rufipes* Fabricius in connection with the height of tropopause 1969-1974
4. ábra. A *Hymenalia rufipes* Fabricius fénycsapdás fogása a tropopauza magasságával összefüggésben, 1969-1974

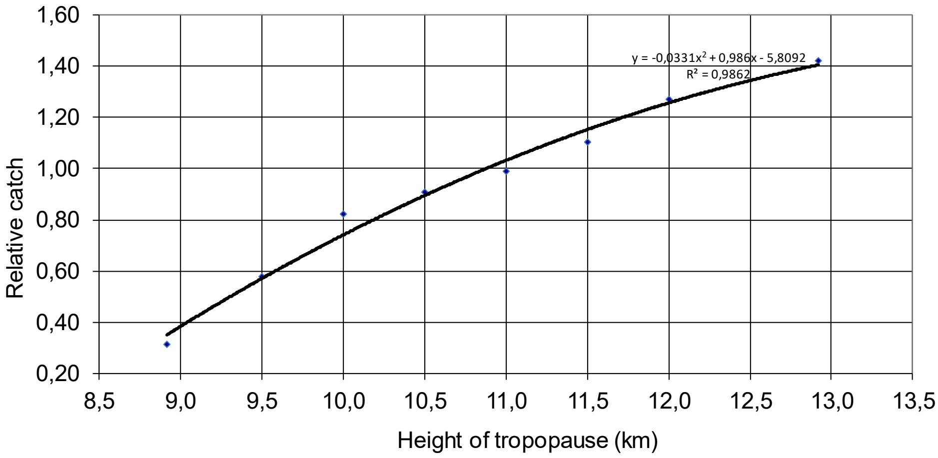

Figure 5. Light-trap catch of *Rhizotrogus aestivus* Olivier in connection with the height of tropopause,1967-1974
5. ábra. A *Rhizotrogus aestivus* Olivier fénycsapdás fogása a tropopauza magasságával összefüggésben, 1967-1974

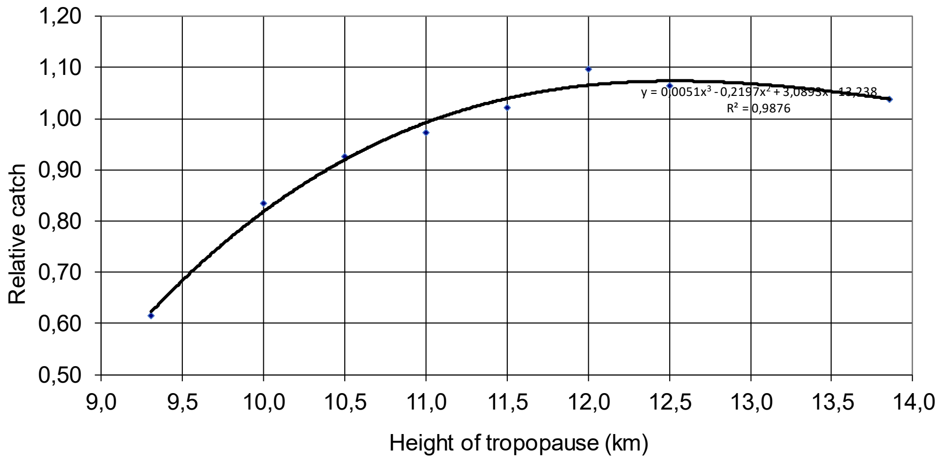

Figure 6. Light-trap catch of *Serica brunnea* Linnaeus in connection with the height of tropopause,1969-1974
6. ábra. A *Serica brunnea* Linnaeus fénycsapdás fogása a tropopauza magasságával összefüggésben, 1969-1974

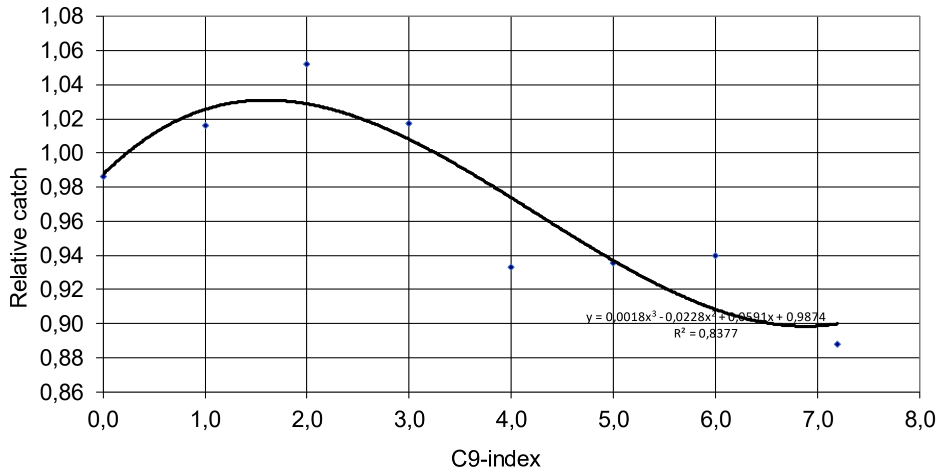

Figure 7. Light-trap catch of *Hymenalia rufipes* Fabricius in connection with the geomagnetic C9-index, 1969-1974
7. ábra. A *Hymenalia rufipes* fénycsapdás fogása és a földmágneses C9-index összefüggése

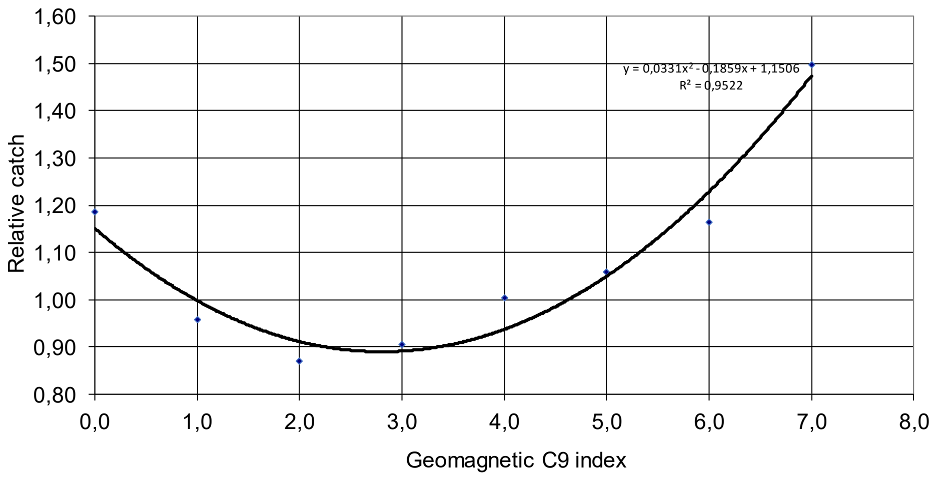

Figure 8. Light-trap catch of *Rhizotrogus aestivus* Olivier in connection with the geomagnetic C9 index,1967-1974
8. ábra. A *Rhizotrogus aestivus* Olivier fénycsapdás fogása és a földmágneses C9-index összefüggése

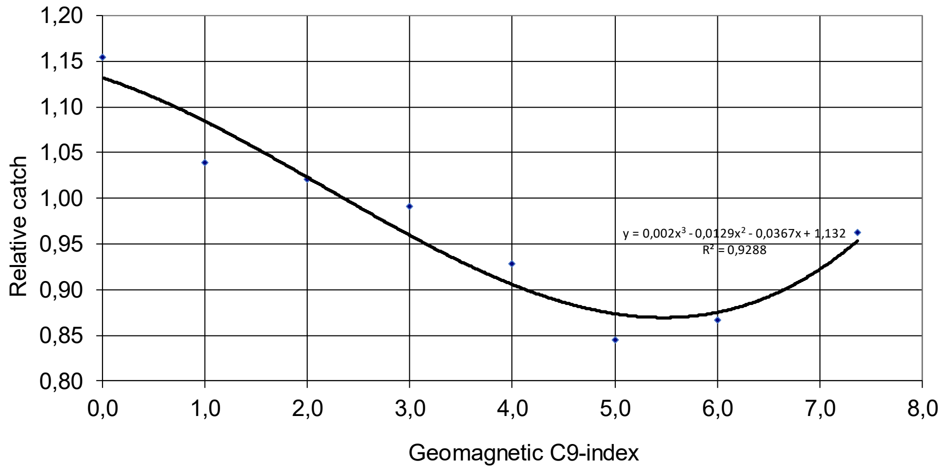

Figure 9. Light-trap catch of *Serica brunnea* Linnaeus in connection with the geomagnetic C9-index,1969-1974
9. ábra. A *Serica brunnea* Linnaeus fénycsapdás fogása és a földmágneses C9-index összefüggése

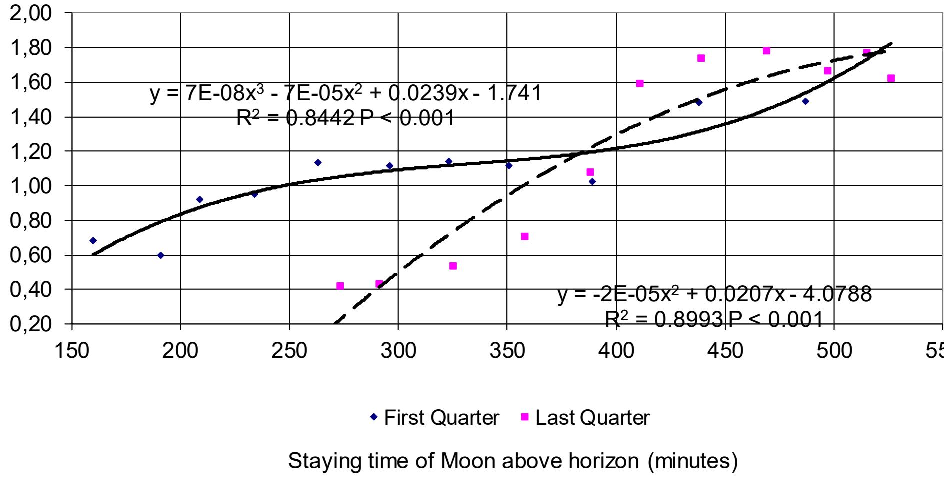

Figure 10. Light-trap of *Hymenalia rufipes* Fabricius in connection with the staying time of Moon above horizon, First-and Last Quarter, 1969-1974
10. ábra A *Hymenalia rufipes* Fabr. fénycsapdás fogása a Hold horizont fölötti tartózkodásával összefüggésben

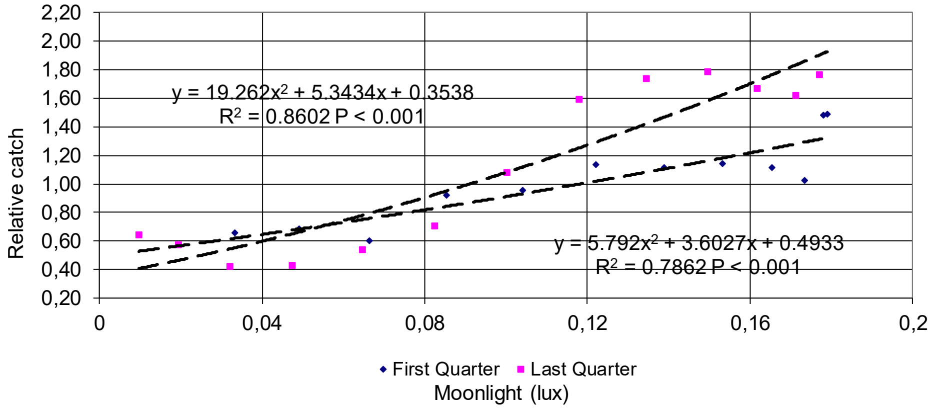

Figure 11. Light-trap of *Hymenalia rufipes* Fabricius in connection with the moonlight, First- and Last Quarter,1969-1974

11. ábra A *Hymenalia rufipes* Fabricius fénycsapdás fogása a holdfénnyel összefüggésben, első-és utolsó negyedben

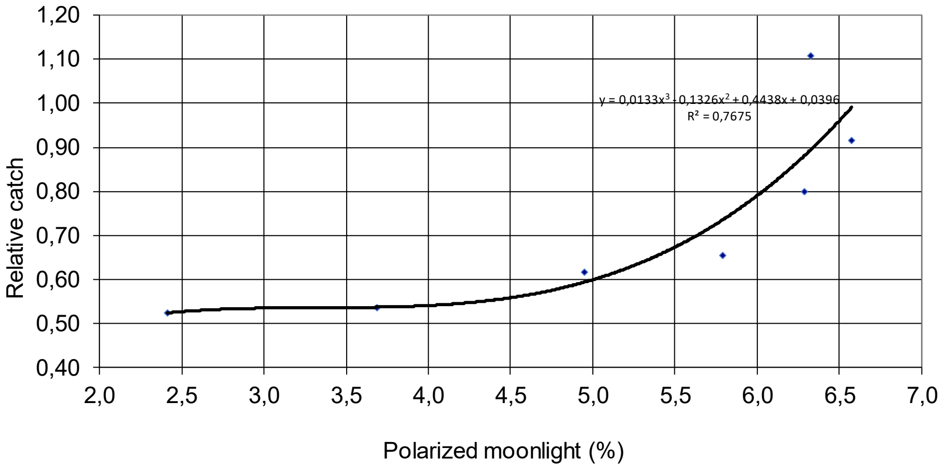

Figure 12. Light-trap catch of *Rhizotrogus aestivus* Olivier in connection with polarized moonlight in First Quarter, 1967-1974

12. ábra. A *Rhizotrogus aestivus* Olivier fénycsapdás fogása a polarizált holdfénnyel összefüggésben, első- és utolsó negyedben

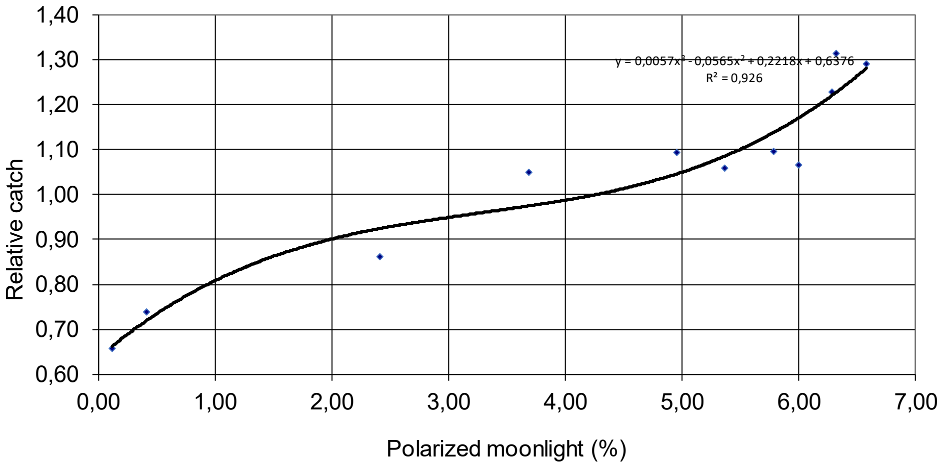

Figure 13. Light-trap catch of *Serica brunnea* Linnaeus in connection with the polarized moonlight in First Quarter, 1969-1974
13. ábra. A *Serica brunnea* Linnaeus fénycsapdás fogása a polarizált holdfénnyel összefüggésben, első negyedben

Serica brunna (Fabricius, 1758)
(= *brunnea* Linnaeus 1758
(https://www.kaefer-der-welt.de/)

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