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Light-Trap Catch of Caddisfly (Trichoptera) Species in Connection with the 10.7 cm Solar Radio Flux

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Abstract. The present study deals with the relationship between 10.7 cm solar radio flux and light-trap catches of thirteen caddisfly (Trichoptera) species. Light-trap collections were made from 1980 to 2005. For each caddisfly species, a relationship was found between the 10.7 cm solar radio flux and the number of specimens captured. However, the results were not identical. Four types were identified: ascending, descending, ascending then descending, descending then ascending.

Keywords. caddisfly, 10.7 cm solar radio flux, light-traps, Hungary.

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Összefoglalás. Jelen tanulmány a 10,7 cm-es szoláris rádiófluxus és tizenhárom tegzes (Trichoptera) faj fénycsapdás fogásának kapcsolatával foglalkozik. A gyűjtések 1980 és 2005 között történtek. Minden faj esetében tapasztalható volt összefüggés a 10,7 cm -es szolár rádiófluxus és a befogott tegzesek száma között. Az eredmények azonban nem voltak azonosak. Négy típus volt elkülöníthető: emelkedő, csökkenő, emelkedő majd csökkenő, csökkenő majd emelkedő.

Introduction

The solar activity contains all the information about the surface of the Sun received by different methods. Among them, the most important is the appearance of sunspots, a phenomenon which has been continuously observed since the 18th Century. Sunspots can be seen from the surface of the Earth; their appearance and strength occur in cycles of approximately 11.2 years.

The generally accepted index-number of their observable quantity is the Wolf-type relative number (RW), which is calculated according to the following formula:

$$Rw = \text{constant}\ (10\ g + f)$$

Where: g = the number of observed sunspot groups f = the number of all sunspots

RW's are collected in the Zurich Observatory, the Global Network Centre, and the data are published annually.

Recently, many researchers have developed an index number which takes into consideration the intensity of flares and also their existence period.

An index for chromospheric Hα flare activity was introduced by Örményi (1966). To simplify the calculations, he adopted the proportions 1:2:4 for the characterization of the intensities of various flares. This procedure is expressed by the formula:

$$\mathrm{FAN} = \frac{1}{1440} * \frac{\Sigma}{n} \mathrm{I}_n \Delta t_n$$

Where: FAN = Flare Activity Number

I = intensity of the flare (one of the values 1, 2 or 4)
n = indicates the serial number of a flare occurring on a given day
Δ tn = the duration of the given flare (minutes)

In an earlier study (Nowinszky & Puskás, 2017), numbers of three moth (Lepidoptera) species from the data of Hungarian Light-Trap Network were counted. It was found the light-trap catch of two of the species, *Ostrinia nubilalis* Hübner and *Xestia c-nigrum* Linnaeus, initially increased with the increase of the value of FAN. The third species, *Hyphantria cunea* Drury, differed in showing a decrease. Our results indicated that "Flare activity numbers" can be used in entomological research.

Kleczek (1952) used the first time the Q-index for showing the daily flare activity. This daily flare activity is a specific feature throughout the day.

Q= (ix t)

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

He thought this formula described the whole of the arising from the flares. In the above relation "i" means the intensity on scale of importance and "t" shows the period (in minutes) of the flare.

Turkish astronomers (Özgüç & Ataç, 1989) characterised the daily flare activity for several decades, using the Q-index.

The Sun has low, moderate, and high-activity years during its 11.2-year cycle, in accordance with which the Q-index values change similarly. This presented a difficulty in our investigations. Therefore, we used two solutions in our studies. Previously (Nowinszky & Puskás 2001, 2013) we compared the Q-index value of a given day with the average of the swarming period (Q / Q average). Later (Nowinszky *et al.* 2014, 2015), made separate calculations in the years of low, moderate and high activity. The Q-index data have been available to researchers since 1966. Hither to however, other researchers have not made any studies dealing with the connection between entomology and Q-index data.

In recent years, the present authors have found a connection between sunspot activity and the numbers of different moth species at light traps. (Nowinszky et al. 2017, 2018a, 2018b).

In the present study, we examined the amount of pest moths collected with pheromone traps in the context of a previously unused Sun index (10.7 cm solar radio flux).

Material

The solar radio flux at 10.7 cm (2800 MHz) is an excellent indicator of solar activity. The F10.7 correlates well with the sunspot number as well as a number of ultraviolet (UV) and visible solar irradiance records. The F10.7 has been measured consistently in

Canada since 1947, first at Ottawa, Ontario, then at the Penticton Radio Observatory in British Columbia. Unlike many solar indices, the F10.7 radio flux can easily be measured reliably on a day-to-day basis from the Earth's surface, in all types of weather.

The data we use was published by British Geological Survey (http://www.geomag.bgs.ac.uk/data_service/space_weather/solar.html).

A Jermy-type light-trap was used to catch caddisflies. The collecting funnel transfers the insects to the killing bottle with a tail-pice. We used clear chloroform as a killing agent. Modified Jermy type light-traps operated at the Fülöpháza and at Maroslele with compact fluorescent (Philips PL - T 42W / 830 / 4p) bulbs. The Fülöpháza light-trap was equipped with 3 baffles around the bulb to increase the catch. The traps were used continuously throughout the night, from April to the end of October, during the insects' flight period.

Jermy-type light trap

The Jermy-type light-traps were operated in villages as in Table 1. Catch data is displayed in Table 2.

The geographical coordinates of the catching sites and years can be seen in Table 1.

Table 1 The geographical coordinates of the collection sites
and collection years in Hungary, Europe

Collection sites	Years	Geographical Latitude	Longitu
1 Szilvásvárad	1980, 1981	48°64'N	20°23'
2 Eger, Nagy-Eged	1980	47°53'N	20°22'
3 Bükk, Vöröskő Valley	1982, 1983	48°34'N	20°27'
4 Nagyvisnyó	1984	48°08'N	20°25'
5 Dédestapolcsány	1988	48°08'N	20°25'
6 Szarvaskő	1989	47°59'N	20°51'
7 Uppony	1992	48°13'N	20°25'
8 Zemplén	1998	48°45'N	21°48'
9 Duna River at Göd	1999	47°41'N	19°08'
10 Tisza River at Szolnok	2000	47°10'N	20°11'
11 Maroslele	2001	46°16'N	20°21'
12 Fülöpháza	2001, 2002	46°53'N	19°26'
13 Tiszaroff	2002, 2003, 2004,	47°39'N	20°71'
14 Tiszaszőlős	2002, 2003, 2004,	47°55'N	20°25'
15 Csongrád	2002, 2003, 2004, 2005	46°71'N	20°14'
16 Tiszakóród	2002, 2003, 2004, 2005	48°10'N	22°71'

Methods

Basic data were the number of individuals and species caught in one night. In order to compare the differing sampling data, relative values were calculated from the number of individuals and species in each sampling night per year. The relative catch value (RC) was defined as the quotient of the number of specimen caught during a sampling time unit (1 night) per the average nightly catch of individuals and species within the relevant sampling period. For example, when the actual nightly catch was equal to the average nightly catch in the relevant summer, the RC was 1 (Nowinszky 2003).

Table 2. The name of the species caught, the catching sites and years with the numbers of individuals and the nights

Species and light-trap station	*Sites and years from Table 1*	*Number of individuals*	*Number of data*	*Number of nights*
Ecnomidae				
Ecnomus tenellus Rambur, 1842	10, 13, 14, 15,16	26,521	1,149	616
Polycentropodidae				
Neureclipsis bimaculata Linnaeus, 1758	3, 9, 10, 11, 12,13, 14, 15, 16	4,389	943	740
Hydropsychidae				
Hydropsyche instabilis Curtis 1834	2, 3, 5, 6	9,405	507	464
Hydropsyche contubernalis McLachlan, 1865	7, 9, 10, 12,13 ,14, 15, 16	38,402	585	579
Hydropsyche bulgaromanorum Malicky, 1977	9, 10, 12, 13, 14, 15, 16	39,226	574	512
Brachycentridae				
Brachycentrus subnubilus Curtis, 1834	9	3,670	132	132
Limnephilidae				
Eclisopteryx madida McLachlan,1867	4, 7	935	185	185
Halesus digitatus Schrank, 1781	1, 3, 6, 10	5,098	454	454
Potamophylax nigricornis Pictet, 1834	3	9,519	174	174
Goeridae				
Silo pallipes Fabricius, 1781	1, 4, 5, 6, 8	2,753	371	371
Sericostomatidae				
Sericostoma personatum Kirkeby&Spence, 1826	3	2,266	238	238
Odontoceridae				
Odontocerum albicorne Scopoli, 1763	1, 3, 4	2,298	409	509
Leptoceridae				
Setodes punctatum Fabricius, 1793	9, 10	5,937	232	232

In this work, we chose a slightly different solution. Separately, all catch data by species were considered as a single sample and thus relative catch values were calculated. This solution also made it possible to determine the effectiveness of trapping from the relative catch values of each year and to compare the effectiveness of different years. We made divisions using Sturges' method (Odor & Iglói 1987). Finally, we averaged within groups the 10.7 solar radio flux and relative catch data pairs. In the figures are plotted the results and in them are shown the confidence intervals.

Results and Discussion

Our results are shown in Figures 1 – 13.

The results of light-trap catches of caddisfly species were recorded daily. The data obtained were compared with the 10.7 cm solar radio flux values characteristic of solar activity. We found that different species did not respond in the same way to the strength of solar activity, and that catch peaks were associated with different 10.7 cm solar flux values.

Four types of behaviour were identified:

Descending:
Hydropsyche instabilis Curtis, 1834, *Eclisopteryx madida* McLachlan, 1867, *Silo pallipes* Fabricius, 1871, *Sericostoma personatum* Kirby & Spence 1862,
Ascending:
Neureclipsis bimaculata Linnaeus, 1758, *Hydropsyche contubernalis* McLachlan, 1865, *Hydropsyche bulgaromanorum* Malicky, 1977, *Brachycentrus subnubilus* Curtis, 1834,
Ascending then descending:
Ecnomus tenellus Rambur, 1834, *Potamophylax nigricornis* Pictet, 1834, *Odontocerum albicorne* Scopoli, 1763
Descending then ascending:
Halesus digitatus Schrank, 1781, *Setodes punctatum* Fabricius, 1793

It is notable that these categories are independent of the taxonomic classification of the species.

We found that the 10.7 cm radio flux value of the Sun on a particular day influenced the light-trap catch results of that day. The Sun's electromagnetic radiation reaches the Earth's surface in 8 minutes. This modifies the weather, which affects light-trap catch results.

According to our hypothesis, the explanation of our results can be the following: Low relative catch values are always associated with weather conditions unfavourable to insect flight activity, but high values are more difficult to interpret. Major environmental changes bring about physiological adjustments in the activity of insects. The imago is short-lived, and unfavourable weather 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 function of its normal activity. It may either become more lively, increasing the intensity of its flight, copulation and egg-laying activity, or take refuge in passivity to weather an unfavourable situation. Hence, in the present state of our knowledge we might say that favourable and unfavourable weather situations might equally be accompanied by a high catch Nowinszky (2003).


Halesus digitatus Schrank, 1781, male
https://www.biolib.cz/en/image/id262647/

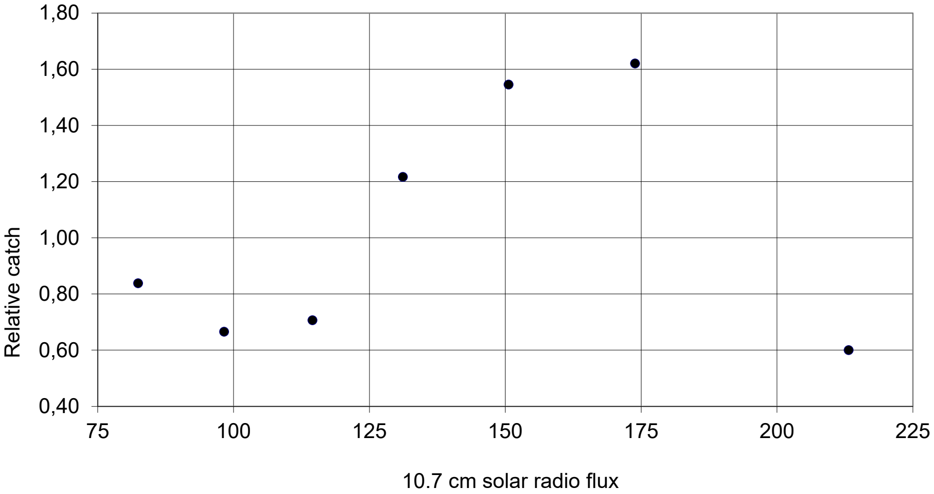

Figure 1 Light-trap catch of *Ecnomus tenellus* Rambur, 1834 in connection with the 10.7 cm solar radio flux

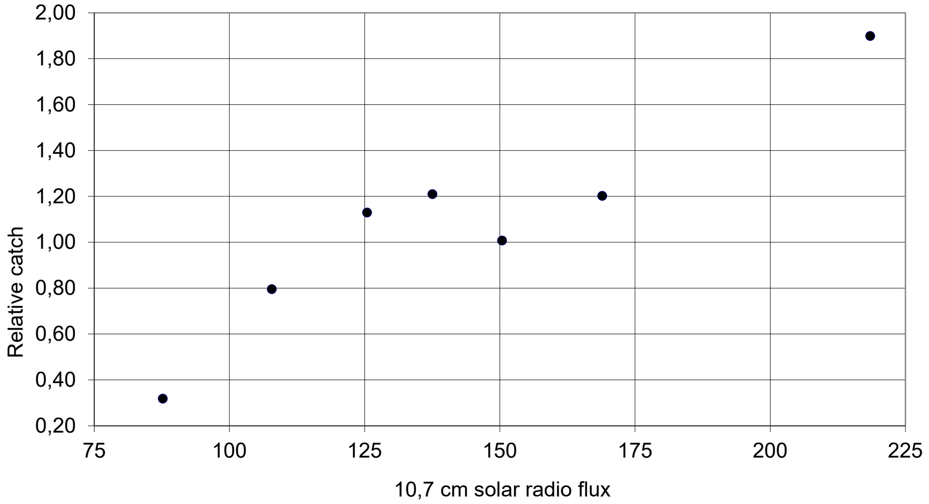

Figure 2 Light-trap catch of *Neureclipsis bimaculata* Linnaeus, 1758 in connection with the 10.7 cm solar radio flux

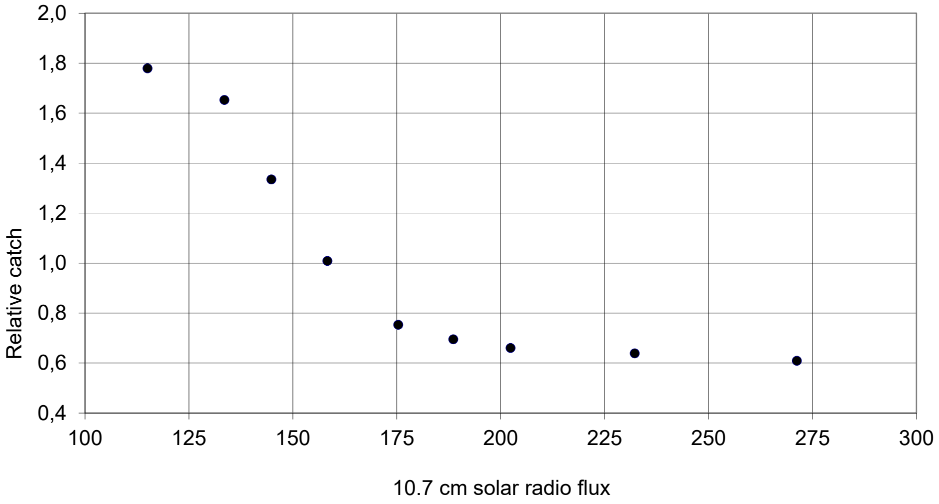

Figure 3 Light-trap catch of *Hydropsyche instabilis* Curtis, 1834 in connection with the 10.7 cm solar radio flux

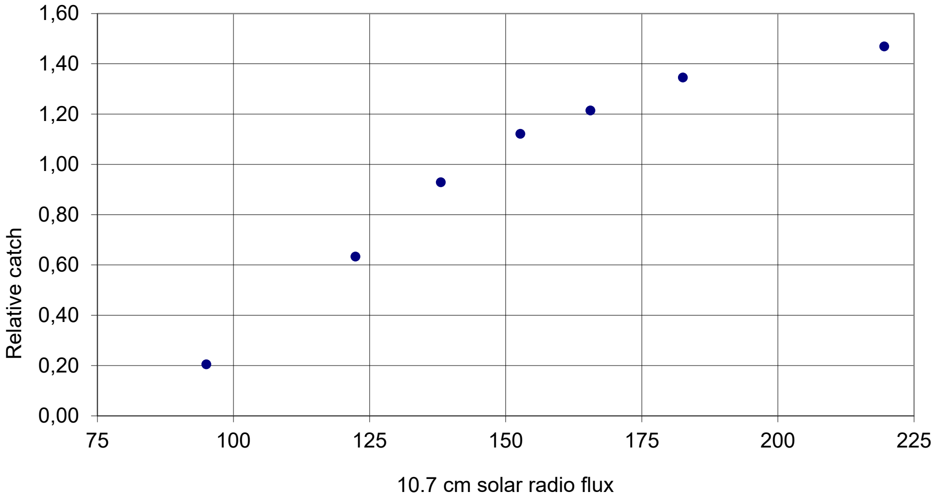

Figure 4 Light-trap catch of *Hydropsyche contubernalis* McLachlan, 1865 in connection with the 10.7 cm solar radio flux

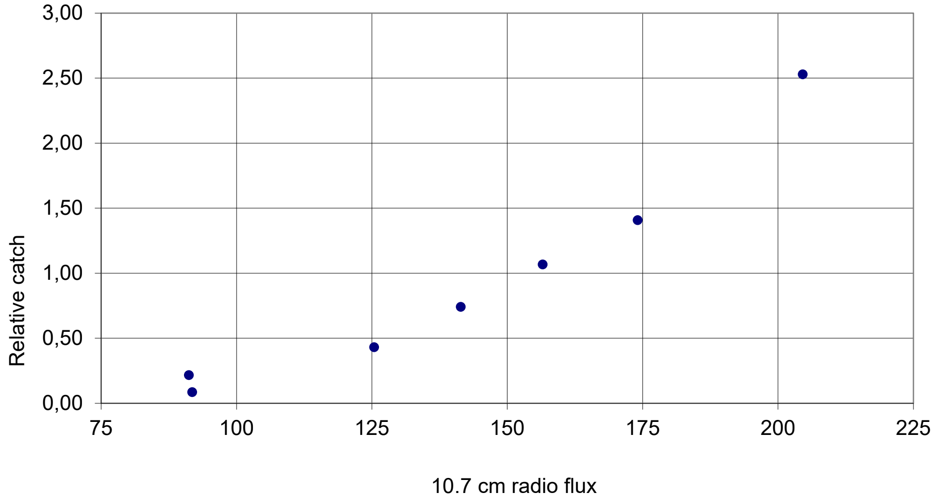

Figure 5 Light-trap catch of *Hydropsyche bulgaromanorum* Malicky, 1977 in connection with the 10.7 cm solar radio flux

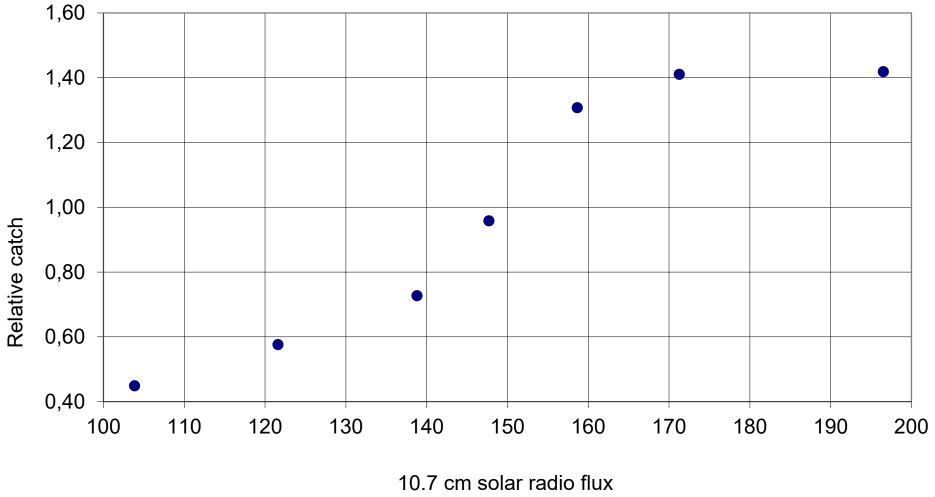

Figure 6 Light-trap catch of *Brachycentrus subnubilus* Curtis, 1834 in connection with the 10.7 cm solar radio flux

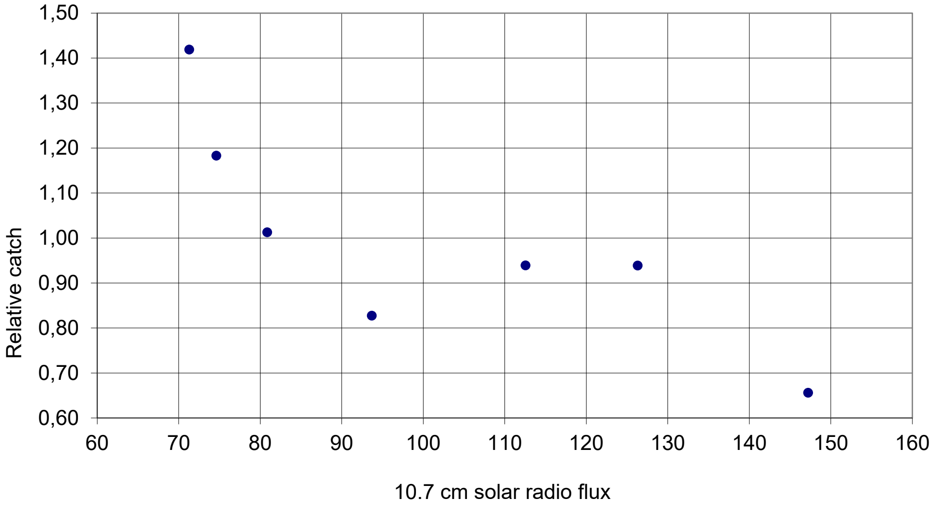

Figure 7 Light-trap catch of *Eclisopteryx madida* McLachlan, 1867 in connection with the 10.7 cm solar radio flux

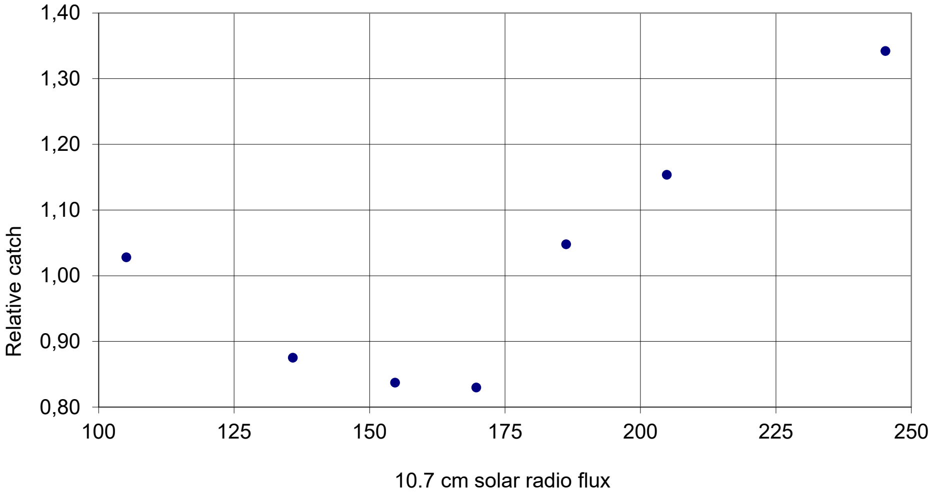

Figure 8 Light-trap catch of *Halesus digitatus* Schrank, 1781 in connection with the 10.7 cm solar radio flux

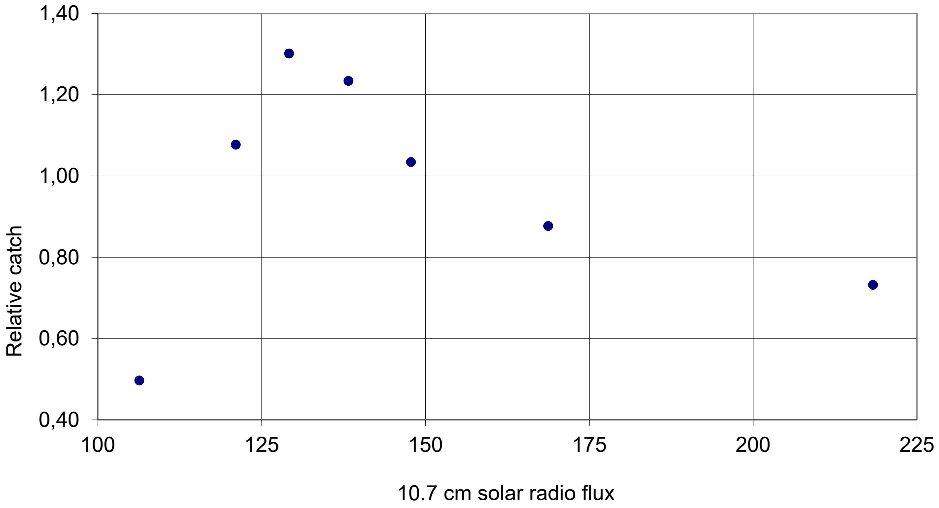

Figure 9 Light-trap catch of *Potamophylax nigricornis* Pictet, 1834 in connection with the 10.7 cm solar radio flux

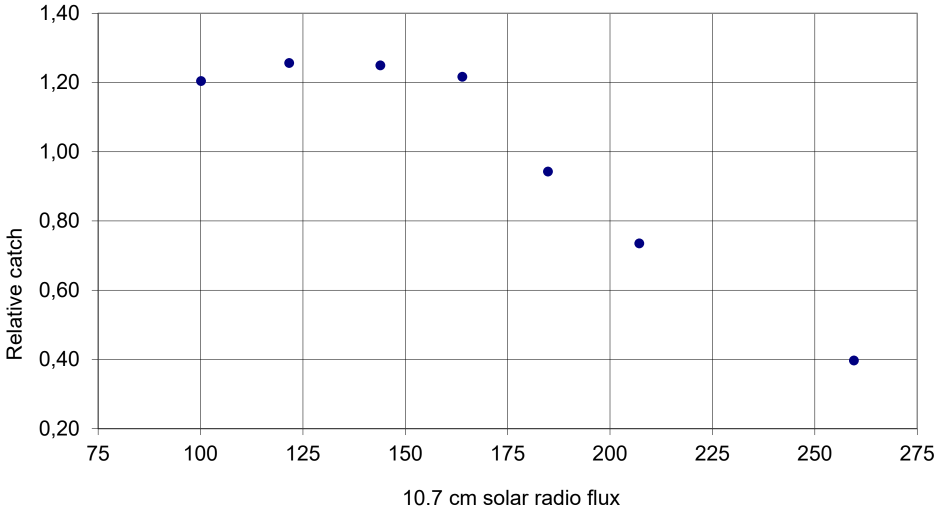

Figure 10 Light-trap catch of *Silo pallipes* Fabricius, 1871 in connection with the 10.7 cm solar radio flux

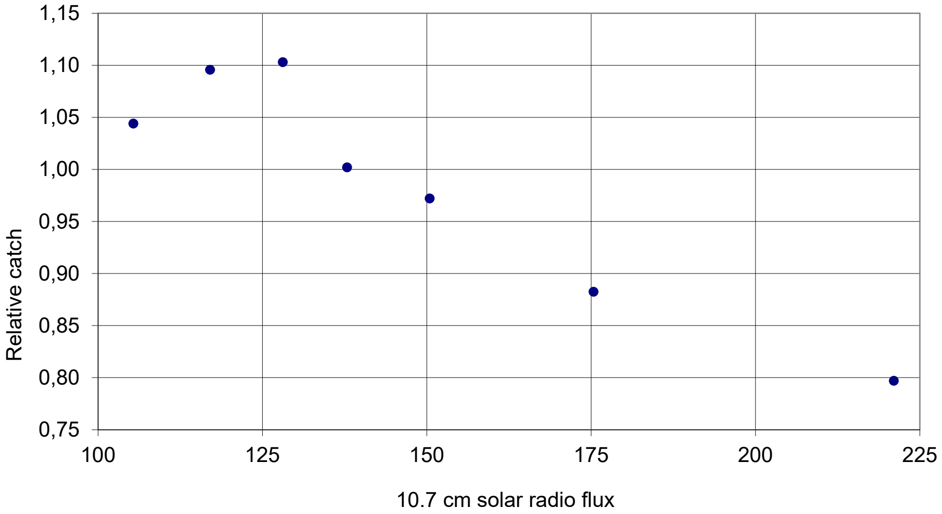

Figure 11 Light-trap catch of *Sericostoma personatum* Kirby & Spence 1862 in connection with the 10.7 cm solar radio flux

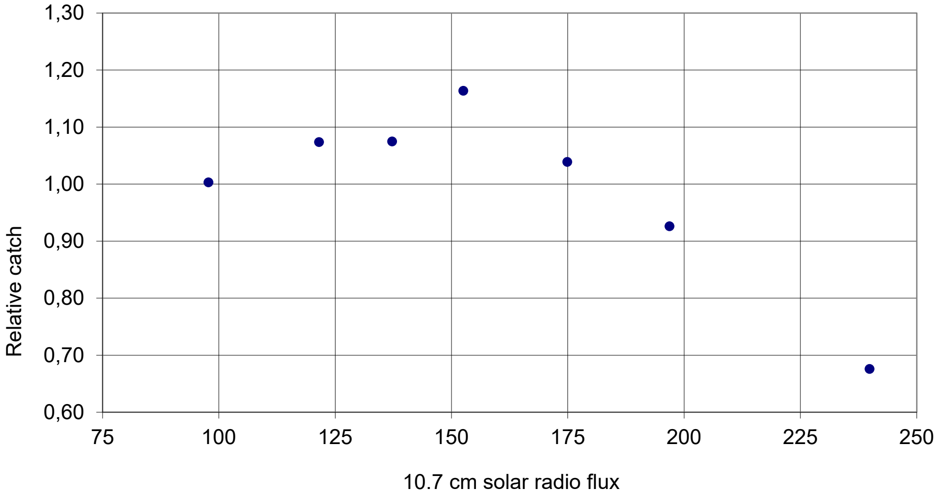

Figure 12 Light-trap catch of *Odontocerum albicorne* Scopoli, 1763 in connection with the 10.7 cm solar radio flux

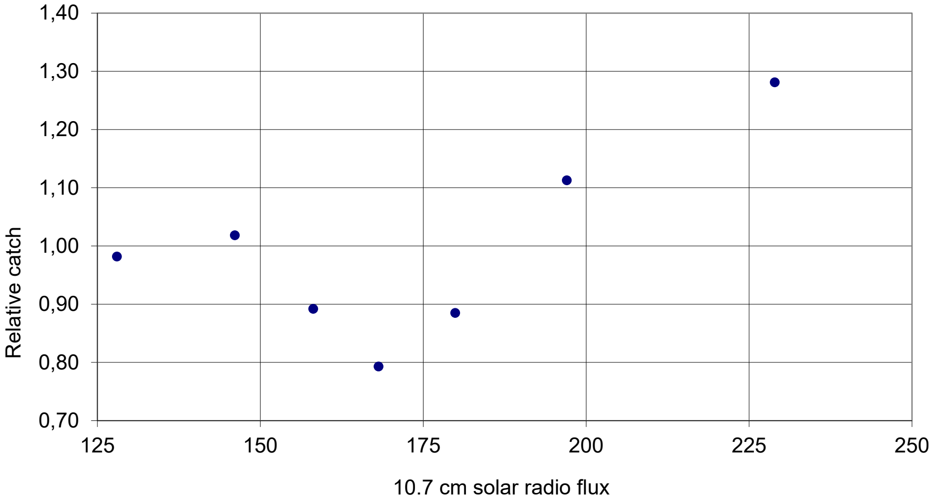

Figure 13 Light-trap catch of *Setodes punctatum* Fabricius, 1793 in connection with the 10.7 cm solar radio flux

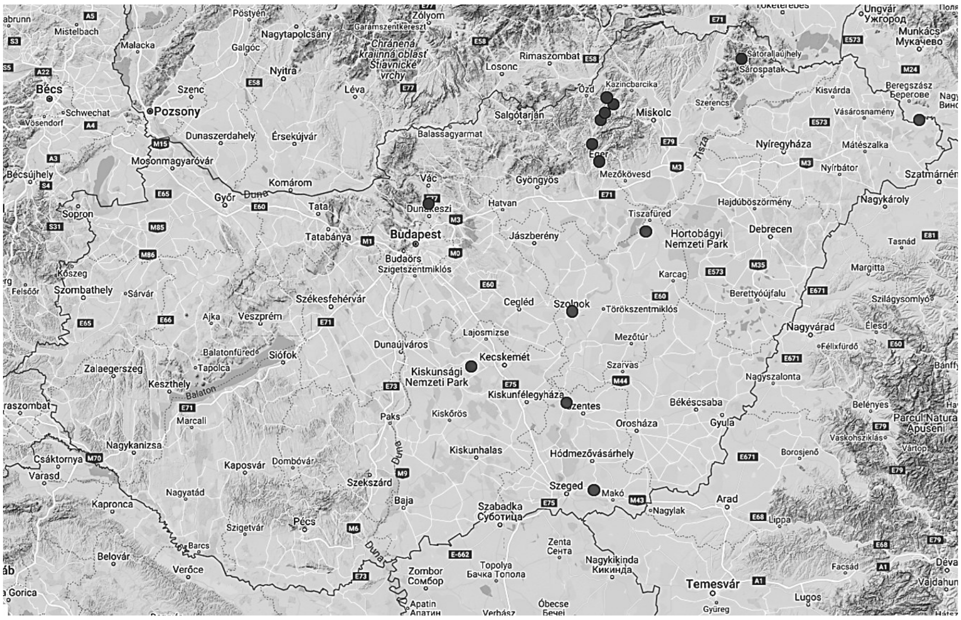

Figure 14. Geographical location of research sites and light traps in Hungary (black dots) | © Fazekas I. 2021

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