DOI: 10.24369/eANP.2017.14.49.
eActa Naturalia Pannonica 14: 49–56.|00.04.2017 | HU ISSN 2061–3911

Light-trap catch of three moth (Lepidoptera) species at different values of the "Flare Activity Numbers"

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Abstract: A Hungarian researcher, Örményi calculated and published the "Flare Activity Numbers" for the period of 1957–1961. The FAN index was devised to indicate the intensity of the flare, the serial number of a flare occurring on a given day and the duration of the given flare. We examined the light trapped three moth (Lepidoptera) species from the data of agricultural observation stations. The chosen species are: European Corn-borer (*Ostrinia nubilalis* Hübner, 1796, Fall (Autumn) Webworm (*Hyphantria cunea* Drury, 1773) and Setaceous Hebrew Character (*Xestia c-nigrum*, Linnaeus, 1758). The relative catch (RC) values were calculated from daily trapping data of these species. The values of relative catch were separated according to the characteristics of each day, after it they were summarised and averaged. We made groups according to the connection between catch and flare activity number pairs, and finally we averaged the results. We calculated regression equations for the relative catch of investigated species and flare activity number data pairs. The light-trap catch of the two examined species (*Ostrinia nubilalis* and *Xestia c-nigrum* initially increased by the increase of the value of the FAN together. The behaviour of one of the species (*Hyphantria cunea*) differs from these; that have an only decreasing character of FAN together. Our results proved that "Flare activity numbers" can be used for entomological researches. They may have significance especially in those years in which the Q-index values are not yet available.

Keywords: "Flare activity numbers", light-trap, moths, Hungary.

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Összefoglalás: Egy magyar kutató, Örményi Imre kidolgozta és megjelentette a "Flare Aktivitási Számok"-at az 1957–1961 közötti évekre. A FAN értékek figyelembe veszik a napkitörések (flerek) számát, intenzitását és időtartamát egy-egy adott napon. A mezőgazdasági fénycsapdák anyagából három lepke (Lepidoptera) faj gyűjtési adatait dolgoztuk fel. A kiválasztott fajok a következők: Kukoricamoly (*Ostrinia nubilalis* Hübner, 1796), amerikai fehér medvelepke (*Hyphantria cunea* Drury, 1773) és c-betűs fűbagoly (*Xestia c-nigrum* Linnaeus, 1758). A napi gyűjtési adatokból fajonként relatív fogás (RF) adatokat számítottunk. Ezeket hozzárendeltük az adott napot jellemző FAN számokhoz. Az összetartozó értékpárokból csoportokat képeztünk. A csoportokon belül átlagokat számítottunk a Fan és a fogási értékekből. Ezeket ábrázoltuk és kiszámítottuk a regressziós egyenleteket és azok paramétereit. Két vizsgált faj, *Ostrinia nubilalis* Hbn. és *Xestia c-nigrum* L. fogása magasabb, ha a FAN értéke nagyobb. A *Xestia c-nigrum* L. különbözik ezektől; a fogása csökken, ha a FAN értéke magasabb. Eredményeink bizonyították, hogy "Flare Aktivitás Szám" használható a rovartani kutatásokban. Jelentősége elsősorban azokban az években lehet, amelyekre vonatkozóan még nem állnak rendelkezésre a Q-index értékek.

Introduction

The solar activity contains all the information about the Sun's surface received with different methods. Among them, the most important is the appearance of sunspots, which has been continuously observed since the 18^{th} century phenomenon. The sunspots can be seen on the sun-facing hemisphere of the Earth. Their appearance and their strength frequency are 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:
R_w = constant (10 g + f)
Where: g = the number of observed sunspot groups
f = the number of all sunspots
The value of constant is determined by features of instruments used in detection. After the selection of instruments sunspot relative number determined in any of the world's solar physics observatory can be reduced onto a uniform scale. The Wolf's relative numbers are collected in the Zurich observatory – as the global network centre – and they publish the data one year later.

The use of Wolf's relative numbers has been significant progress in the meteorological researches in the second half of the 20^{th} century. Similarly, significant results were obtained in studies of Wolf's relative numbers and the relationship between plant pathogens. Details of these could not be our goal, but we refer to a previous study of ours (Nowinszky & Tóth 1987), in which we have a detailed overview about this. Some researchers found a contact between some pests and the solar activity.

Martinek (1972) concluded that in a large number of appearance of European Pine Sawfly (*Neodiprion sertifer* Geoffroy) can be found in every 11 year when there is maximum of sunspots. Manninger (1975) had observations during several decades about the gradation of harmful insects. He found relationship between the gradation and the periods with dry and inland water, which have connection to solar activity. He proved that in the second half of the dry periods the drought-loving species, but in the second part of the periods with inland water moisture-loving species had gradation. Klimetzek (1976) examined several pest gradations between 1810 and 1970. He found that strong gradation occurs mainly during minimums and maximums of sunspot. In later years, many researchers developed an index number which takes into consideration the intensity of flares and also their existence period.

Kleczek (1952) used the first time the Q-index for showing the daily flare activity. This daily flare activity is specific characteristic during the whole day.

Q = (i x t)
where i = flare intensity, t = the time length of its existence.

He thought this connection show about the whole energy which arises 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. Some researchers used the method of Kleczek in connection with flare activity which is determined for every day (Kleczek 1952, Knoška & Petrásek 1984).

Turkish astronomers (Özgüç & Ataç 1989) characterised the daily flare activity for more decades. They used for this characteristic the Q-index. This index shows the significance of flares also by their duration Ataç (1987), Ataç & Özgüç (1998).

The Q-index data are available to researchers from 1966. In addition to our own studies (Nowinszky & Puskás 2001, 2013a, 2013b, Puskás et al. 2010, Nowinszky et al. 2014, 2015) other researchers did not make any examinations dealing with the connection between entomology and Q-index data.
A Hungarian researcher, Örményi (1966) also calculated and published the "Flare Activity Numbers" based on similar theoretical principles as the Q-index for the period of 1957-1961.

Waldmeier (1940) has been executing studies on the frequency, extent ad intensity of flares. He proposed a new method for the definition of the intensity of chromospheric flares. This was based on brightness measurements, taking into account the average intensity of the flares. As a result of these investigations, a new scale of intensities has been established namely classification by Waldmeier: 0.6, 1.0 and 2.0.

For the scale of simplifying the calculations, Örményi (1966) has adopted the proportions 1.0 : 2.0 : 4.0 for the characterization of the intensities of various flares.

An index for chromospheric Hα flare activity is introduced by Örményi (1966). This procedure is expressed by the formula:

$$\text{FAN} = \frac{1}{1440} \frac{\Sigma}{n} 1_n \Delta t_n$$

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
Δt_n = the duration of the given flare (minutes)

There were established two light trap networks (agricultural and the other at research institutes) till 1958 which were in operation uniformly with Jermy-type light -traps. From 1961 some light-traps of forestry already were in operation.

Material

We selected trapping data of three species to our investigations in years 1959, 1960 and 1961. These species can be trapped in large number by national light-trap network. The whole material of the selected species has been processed origi-

Ostrinia nubilalis *Hyphantria cunea* *Xestia c-nigrum*
Photos: © I. Fazekas

nated from 31 light-trap station from the territory of Hungary.

We got the trapped examined moth (Lepidoptera) species from the data of agricultural observation stations.

The chosen species are: European Corn-borer (*Ostrinia nubilalis* Hübner, 1796) – data from 28 traps. Fall (Autumn) Webworm (*Hyphantria cunea* Drury, 1773) – data from 31 traps. Setaceous Hebrew Character (*Xestia c-nigrum* Linnaeus, 1758) – data from 22 traps.

All three species fly in large number to the light and they are massively important pests except Setaceous Hebrew Character, which caused serious damage to alfalfa (Mészáros 1972) and grapes (Kadocsa 1938).

All three species have extremely extensive foreign and Hungarian literature. Such review could not be our goal, therefore, only refer to some very important author from the Hungarian researchers.

European Corn-borer (O*strinia nubilalis* Hübner: Jablonowski (1897), Manninger (1949), Nagy (1958), B. Balázs (1965), Mészáros, Z. (1965, 1969), Sáringer (1976), Keszthelyi (2004, 2010), Keszthelyi & Lengyel (2003), Keszthelyi & Sáringer (2003), Keszthelyi & Ács (2005), Pal-Fam et al. (2010).

Fall Webworm (*Hyphantria cunea* Drury): Nagy et al. (1953), Jermy (1957), Kovács & Delyné-Draskovits (1967), Járfás & Viola (1985).

Setaceous Hebrew Character (*Xestia c-nigrum* Linnaeus): Kadocsa (1938), Reichart (1968), Mészáros (1972).

All the Flare Activity Number (FAN) was written off from the study of Örményi (1966).

Methods

The individual number is not the same in the different years and regions concerning to the same species. Because of this relative catch (RC) values were calculated. RC value means the sampling time unit (generally it is one night) and the average individual number in unit time of sampling, the number of generations categorised by the influence of individuals. The values of relative catch were separated according to the characteristics of each day, after it they were summarised and averaged. We made groups according to the connection between catch and flare activity number pairs, and finally we averaged the results. We calculated regression equations for the relative catch of investigated species and flare activity number data pairs (Nowinszky 2003).

We made groups using Sturges' method (Odor & Iglói 1987) for flare activity number data. The RC values were categorised according to the FAN belonging to each day and after it they were summarised and averaged.

Results and Discussion

Our results are shown in Figures 1-3.

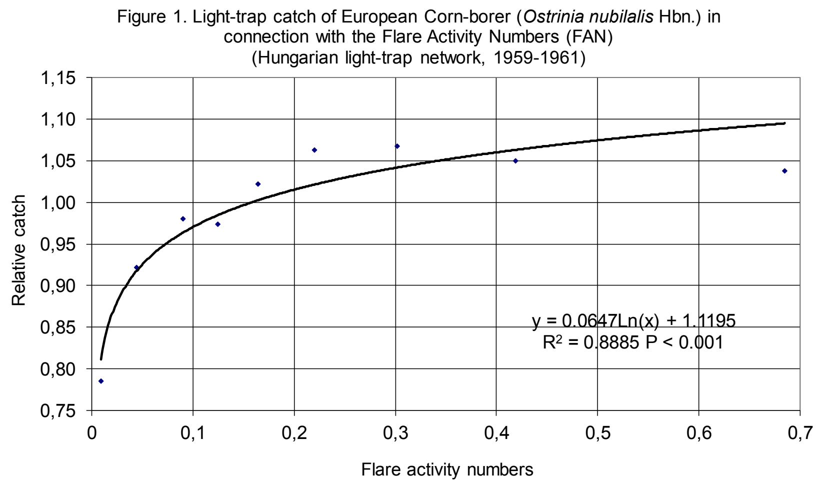
The light-trap catch of the two examined species (*Ostrinia nubilalis* Hbn. and *Xestia c-nigrum* L.) initially increased by the increase of the value of the FAN together. The behaviour of one species (*Hyphantria cunea* Drury) differs from these; that have an only decreasing character of FAN together. In what follows, we present the resulted special nonlinear models and figures for the different behavioural types.

We used logarithmic, second- or third-degree polynomials to show our results, which proved that the FAN could significantly change the daily trapping of insects. We think these results are related to the different lengths and intensities of the solar flares. We could see that the activity change of insects is not in connection with the taxonomic category.

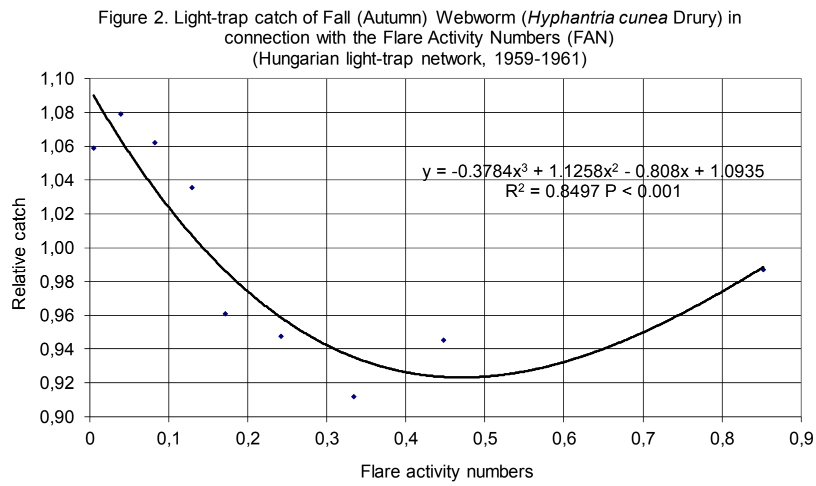
A similar phenomenon has been observed in the relationship between Q-index and various Macrolepidoptera and Microlepidoptera species (Nowinszky et al. 2015). We experienced different behavioural types in examination of different environmental factors and other insect species. The height of the tropopause has different reactions in case of different caddisflies (Trichoptera) species (Nowinszky et al. 2016) and two moth species (*Ostrinia nubilalis* Hbn. and *Xestia c-nigrum* L.) (Nowinszky & Puskás 2013b). The same phenomena was found at the time of pheromone trapping of different Microlepidoptera species (Nowinszky & Puskás 2016).

According to our hypothesis this phenomenon plays a most important role in the undisturbed function in the life of communities. If every species, within all taxon, behave equivalently towards a positive or negative impact on the environment, serious disturbances can be caused in the food networks' function. They could be gradations or significant decreases in the individual number of species. In both cases the relative stability of the life community can change, which is always at the expense of smaller and bigger changes, but there is still balanced.

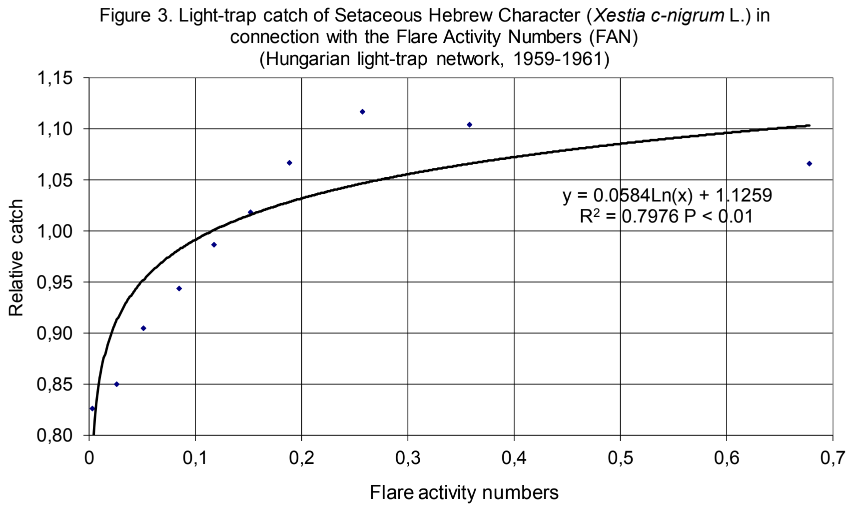
Our results proved that "Flare activity numbers" can be used for entomological researches. They may have significance in those years primarily, in which is not yet available the Q-index values.



1. ábra. Az *Ostrinia nubilalis* fénycsapdás fogása a Fler Aktivitási Számok függvényében (1959-1961)



2. ábra. A *Hyphantria cunea* fénycsapdás fogása a Fler Aktivitási Számok függvényében (1959-1961)



3. ábra. A *Xestia c-nigrum* L.) fénycsapdás fogása a Fler Aktivitási Számok függvényében (1959-1961).

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