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The Influence of Solar Terrestrial Effects on Light-Trap Catch of Night Flying Insects

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ABSTRACT : The study revealed a correlation between the ionospheric storms (?Kf0F2) and light-trap catch of two winter geometrid moth (*Operophthera brumata* L. and *Agriopis aurantiaria* Hbn.). The efficiency of catching the two species by light-trap decreases at the time of negative ionospheric storms and increases during positive ones. The strengthening of atmospheric radio noises (SEA) increases the catch of the Turnip Moth (Agrotis segetum Den. et Schiff).

Keywords : Ionospheric storms, atmospheric radio noises, light-trap, moths.

INTRODUCTION

The solar activity has an important influence on the Earth's atmosphere and life on Earth. As part of the global solar activity, accompanied by intensive X-ray, gamma and corpuscular radiation, outbreaks (flares) appear in the vicinity of the active regions on the surface of the Sun. Reaching the Earth, and getting into interaction with its upper atmosphere, these flares change the existing electromagnetic relations (Smith and Smith, 1963).

The daily activity of the flares is characterized by the so-called Q index that, used by several researchers, considers both the intensity and period of prevalence of the flares. According to a verbal message by Tamer Ataç (Bogazici University, Kandilli Observatory and Earthquake Research Institute, Istanbul) it is calculated with the following formula:

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

In which i = flare intensity, t = period of prevalence.

Q-index data, released with significant delay, are not readily accessible for plant protection prognostics. To overcome this disadvantage, we tried to establish a relationship between the atmospheric radio noises (SEA) that can be measured also by the people operating light-traps and light-trap catch results (Nowinszky and Tóth, 1994).

Solar outbreaks are accompanied by intensive X-ray, gamma and corpuscular radiation that, reaching the Earth, get into interaction with the upper atmosphere and change electromagnetic conditions (Smith and Smith, 1963). In the course of this electromagnetic storms might break out and the ionization relations of the ionosphere might also undergo transformation.

The corpuscular radiation of the Sun leads to the formation of layers (ion concentration) at varying heights of the ionosphere parallel to the surface of the Earth. At the temperate zone latitudes, there are three well discernible ionospheric layers. Layers D and E are in the low regions (60-160 km) of the ionosphere while layer F is classed with the high regions (160-250 km, even 1000 km at the time of big storms). Layer F is split into two (F_1 and F_2) at daytime. At night, layers D, E and F_1 disintegrate, and only layer F_2 remains (Saikó, 1974). The ionospheric disturbances caused by corpuscular radiation appear during solar flares when the Sun emits a vast amount of electrically charged and uncharged particles which entering the atmosphere of the Earth, change the conditions of the ionospheric layers. The changes in layer F_2 appear mainly in fluctuations of ion density and height. Ionospheric layer density is characterized by the boundary frequency of the given layer.

When ionospheric recordings are made, impulses of radio waves of continuously growing frequency are emitted into the atmosphere. The highest frequency reflected by the layer under examination is called boundary frequency (f_0F_2). Influenced by the geomagnetic field, a change takes place in the frequency and polarization of the radio wave emitted (Zeeman effect) which divides into two, sometime three electromagnetic oscillations of different frequencies. The component of a frequency identical to that of the generator is called regular frequency, marked f_0 (Saikó, 1974). We speak of an ionospheric storm when the boundary frequency of layer $F_2(f_0F_2)$ in a given moment digresses at least by 20% from the hourly median value of the given point of time. After Saikó (1966) it is calculated like

$$f_0F_2 \quad \frac{100(\, f_0F_2 \quad f_0F_2 \text{ med})}{f_0F_2 \text{ med}}$$

According to Saikó's account (1969), Δf_0F_2 value trends were examined simultaneously at six ionosphere observation stations. They were: Freiburg (48°03' N, 07°35' E), Pruhonice (49°59' N, 14°33' E), Belgrade (44°48' N, 20°31' E), Békéscsaba (46°40' N, 21°11' E), Dourbes (50°06' N, 04° 36' E), Juliusruh (54°38' N, 13°23' E). The examinations have clearly shown a sud-den increase of the Δf_0F_2 value after the effect occurred at all six stations. This fact has lead to the conclusion that radiation from the flares can bring about ion condensation also in the F_2 layers over larger areas. Of the impacts of ionospheric storms on the Earth, those influencing the weather have been subjected to closer investigation. In Hungarian literature, Saikó's works (1963 and 1979) provide information on these. Research into disturbances that suddenly make their presence felt in the lower ionosphere is of significance. Investigation is carried out first of all with absorption measuring, as radio waves are greatly absorbed in this layer.

The X-ray radiation of the flare at a wavelength of less than 1nm enhances the ionization of layer *D* positioned at a height of some 70-80 kilometres. This has two simultaneous clear consequences. One is short wave fadeout (SWF). The other increased reflection of the extra long radio waves. As a consequence, extra long wavelength radio noise can be observed permanently, caused by uninterrupted thunderstorms in the tropical zone. At times of ionospheric disturbances the radio noise is of essentially greater intensity. About 8 minutes after the appearance of a solar flare, atmospheric radio noise at 27 kHz (11 km wavelength) suddenly increases (Sudden Enhancement of Atmospherics = SEA). SWF and SEA both occur after every major flare proportionately with the growth of X-ray radiation. The first one kills short wave radio communication for a few hours. At the same time, radio waves in the VHF band that under normal conditions find their way into cosmic space without running into any obstacle may now get reflected as a result of increased ionization of the upper layers of the ionosphere, creating a situation in which will be temporarily possible to receive the signals of distant TV transmitters. Even when the sky is clouded, increased atmospheric radio noise provides a clear indication of a major flare taking place on the surface of the Sun.

Flares of importance one (they are relatively frequent) are followed by SEA in about 10% of all cases, this proportion is 50% in the case of flares of importance two, while the proportion is 90% in the case of the strongest flares, those of importance three. SEA can be observed by very simple radio-technological equipment, even in cloudy weather, provides information easy to handle and is also suitable for an indirect detection of flares (Del Vecchio, 1959). Yet, easy as it is to perform, no SEA observation has so far been carried out in Hungary.

We do not know of publications in either Hungarian or international literature examining the efficiency of collecting insects by light-trap in relationship with ionospheric disturbances or atmospheric radio noise. However, Becker (1964) and Damaschke and Becker (1964) established a negative correlation between atmospheric radio noises and the oxygen intake of termites. Later on, Becker and Gerisch (1977) could prove their effect also on the feeding activ-ity of termites.

MATERIAL AND METHODS

The data we have needed for our calculations (border frequency of the F_2 layer of the iono-sphere (f_0F_2) and the atmospheric radio noise at 27 kHz (SEA) were provided by publications released by the Panská Ves Observatory of the Geophysics Research Institute of the Czechoslovak Academy of Sciences. This observatory is about 25-30 kilometres from Prague. In the view of Béla Szudár (Main Metorological Station, Békéscsaba), it is scientifically justified to cross-check the values measured there with those of the light-trap catches in Hungary (per-sonal communication).

From the material of the national light-trap network we compared the border frequency (f_0F_2) of layer F_2 with the catch data for Winter Moth (*Operophthera brumata* L.) and Scarce Umber (*Agriopis aurantiaria* Hbn.) (Nowinszky *et al.*,1995). Data related to the former species come from the period between 1961 and 1976. We had at our disposal 3 712 observation data of 46290 individuals from 18 observation sites over 837 nights. Regarding the latter species, we processed 1322 observation data of 8614 individuals collected at 44 observation stations over 403 nights in the years 1962-1970.

To examine the effect of SEA we used data pertaining to turnip moth (Agrotis segetum Den. et Schiff.) from the material of the Kecskemét fractionating light-trap and the national light-trap network (Nowinszky *et al.*, 1995). The national light-trap network provided us with 20508 observation data on 32100 individuals collected by 61 light-traps over 2647 nights between 1957 and 1976.

Using Saikó's method (1966), we calculated the difference in the value of the boundary frequency (f_0F_2) of layer F_2 expressed in the percentage of the hour-median (Δf_0F_2) for each hour of each night of the collecting period. Differences over 20% were considered as iono-spheric storms. These were given, also after Saikó (1966), character numbers (*K*) as follows: an observed storm of a negative or positive sign between 20-30% is listed in the 1st, between 30-40% in the 2nd and above 40% in the 3rd class of intensity. The character numbers were summed up by nights ($\Sigma K f_0F_2$) and were then considered as independent variables.

From the catching data of the examined 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 average individual number, the RC value is 1 (Nowinszky, 2003).

We averaged by nights the relative catch values (RC) from the various observation sites then correlated these to the sum-totals of the character numbers. We arranged the pairs of values in classes, and then averaged them. To reveal the assumed connection we made correlation calculations.

SEA nightly averages showed significant differences in the years between 1957-1976, therefore we expressed them in the percentage of the average of the swarming periods. We arranged in classes the values gained in this way together with the related catch values, then averaged them and made correlation calculations. We correlated the hourly catch data received from Kecskemét with the percentage values of the changes in SEA as compared to the previous hour, and then applied the procedure outlined above.

RESULTS AND DISCUSSION

The relationship between the $\Sigma K f_0 F_2$ and the light-trap catch of the Winter Moth (*Opero-phthera brumata* L.) and the Scarce Umber (*Agriopis aurantiaria* Hbn.) content the Fig. 1 and Fig. 2. Fig. 3 shows the catching results of Turnip Moth (*Agrotis segetum* Den. et Schiff.) from the data of national light-trap network depending on the SEA. The same results seem from the data of Kecskemét fractionating light-trap in Fig. 4. Each figure also includes the results of the calculations of significance.

Fig. 1
Light-trap catch of the Winter Moth (*Operophthera brumata* L.) depending on the $\Sigma K f_0 F_2$

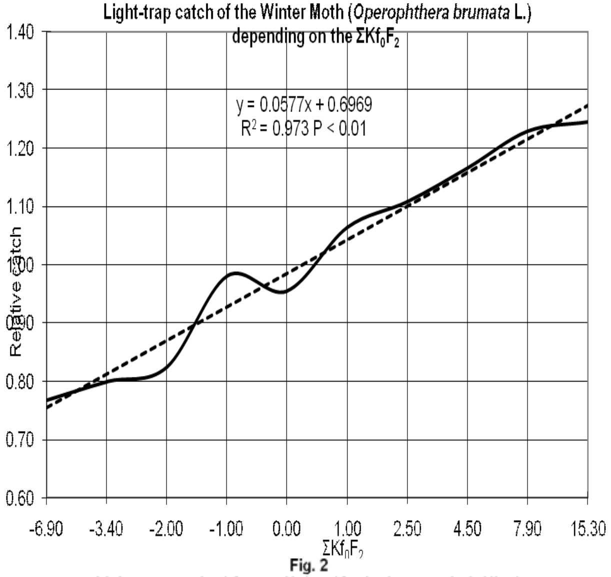


Fig. 2
Light-trap catch of Scarce Unber (*Agriopis aurantiaria* Hbn.) depending on the $\Sigma K f_0 F_2$

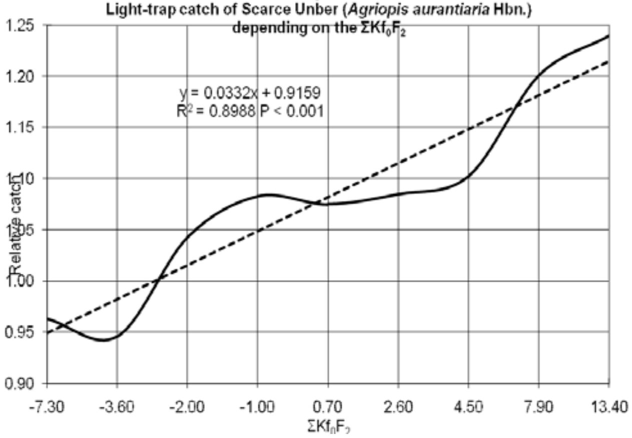


Fig. 3
Light-trap catch of Turnip moth (*Agrotis segetum* Den. et Schiff.) depending on the SEA (National light-trap network, 1961-1976)

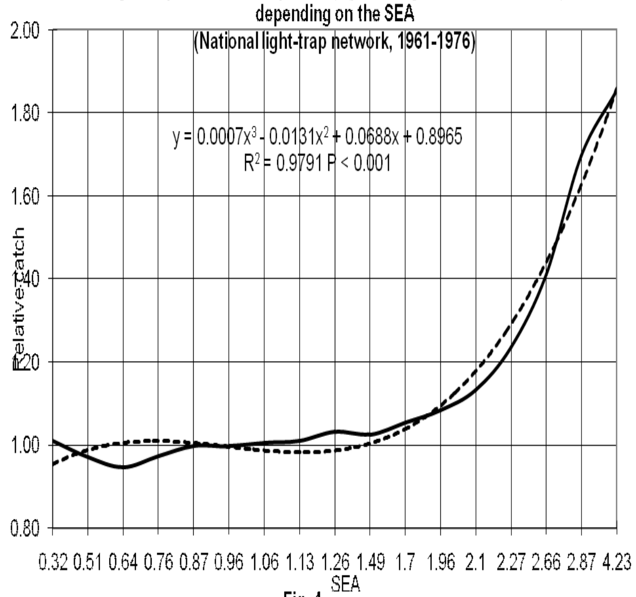
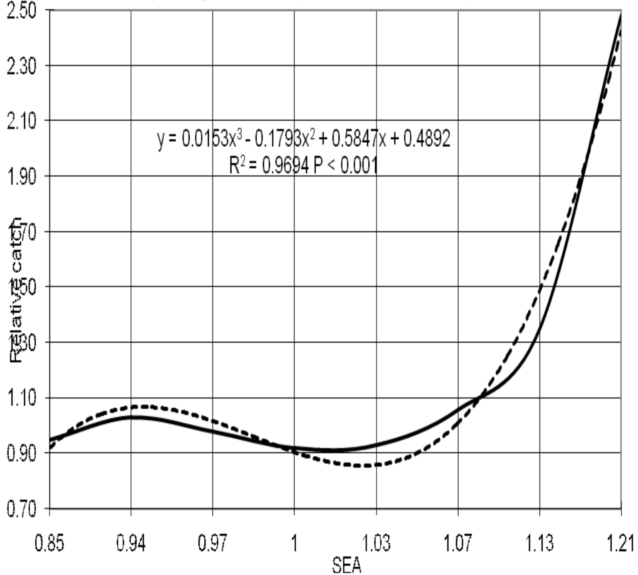


Fig. 4
Light-trap catch of Turnip Moth (*Agrotis segetum* Den. et Schiff.) depending on the SEA (Kecskemét, 1967-1969)



The efficiency of catching the two species of winter geometrid moth by light-trap decreases at the time of negative ionspheric storms and increases during positive ones. Surprisingly, the strengthening of atmospheric radio noises suitable for the indirect detection of solar outbreaks is accompanied by an almost instantly discernible intensification of the flying activity of insects. The same thing can be observed in the course of a night, namely, the catch will rise whenever the intensity of radio noises strengthens from one hour to the other, and will become more moderate when it weakens. There is also a positive correlation between the SEA maximum for the night.

In the case of strong solar outbreaks the catch by light-trap can reflect even if with great distortions the size of the different populations. And with solar activity increasing and de-creasing in a periodicity of 11 years, in the evaluation of catch data it might be worth while to consider the relationship we have revealed. The simple and moderately expensive task of collecting the SEA data required for further investigation could also be organized by the institu-tions running the light-traps.

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