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Light-Trapping of the European Corn Borer (*Ostrinia nubilalis* Hbn.) at Different Values of the Q-index Expressing the Different Intensities of Solar Flares

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The paper deals with connections between solar flare activities and light-trap collection of insects. The authors have worked out the catch data of European corn borer (*Ostrinia nubilalis* Hbn.) adults, as published for the period of 1976–1997 by the Hungarian national light-trap network. The results proved that both the daily and annual catches were significantly modified by the Q-indexes, expressing the different lengths and intensities of the solar flares. On days with high Q-indexes relative to the ones of the average swarming periods, the number of catches are considerably lower. In those years when the Q-index is high, the average individual number and the number of caught moths are lower by 30% as compared to the average number of total cycles (11 years) and the average population density of a given biotope. On the contrary, in years with low Q-indexes an increase as high as 45% can be experienced in the number of individuals collected. Thus, by evaluating the light-trap catches a strong modifying effect of solar flares has to be considered.

Keywords: European corn borer, *Ostrinia nubilalis,* light-trap, solar flares, Q-index.

As part of global solar activity flares, eruptions can be observed in the active regions of the solar surface, that are accompanied by intensive X-ray, gamma- and corpuscular radiations, that reach also the Earth and establish an interaction with its outermost atmosphere, producing thus changes in its electromagnetic conditions (Smith and Smith, 1963).

The Sun eruptions, flares are short (lasting max. 10–20 minutes) shiny spots, temporal areas in the chromosphere of the Sun. Their observation is carried out conventionally in the red (656.3 nanometer wavelength light) of alpha line of hydrogen. At the time of intensive flares the corpuscular emission is thousandfold as compared to a quiet period of Sun. The corpuscles are mostly electrons flying into all directions (also toward the Earth) with a speed of 1500 km^{-1}. These electrically charged corpuscles compose the so-called solar wind that – in contrast to the electromagnetic radiation that reaches the Earth in 8 and a half minutes – reaches our atmosphere in 26–28 hours. On their way to Earth, the flare particles have also to pass the interplanetary space. The magnetic field generated by the galactic cosmic radiation is moderating considerably the effects of flares exerted on the magnetosphere of Earth. Thus, not all flares cause changes in the physical conditions of the upper atmosphere. If, however these changes result from the above-mentioned reasons, the weather becomes temporarily altered and the magnetic field of the corpuscles modifies the undisturbed daily course of the terrestrial magnetic field.

The flares are classified according to the size of their area as compared to the total solar surface. The flares of primary importance (1) do not reach 250 times the half of on millionth part of the total solar surface. If the flare takes 250–600 times this size, it receives an index number of 2; if greater 600 times than that, it has a significance of 3. Because of their significant energy emissions, the cosmic influence of the flares No. 2 and 3 is the most considerable.

Most daily flare activities are characterised by most authors by index Q that expresses the significance of flares also by their duration. Its calculation is made by the following formula:

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

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

Earlier Örményi (1966) calculated and published the flare activity numbers based on similar theoretical principles ("Flare Activity Numbers") for the period of 1957–1965.

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 influence of hydrogen alpha flares No. 2 and 3 (Tóth and Nowinszky, 1983) on light-trap catches.

Material

The Q-index daily data for the period 1976-1997 were provided by Dr. T. Atac (Bogazici University, Kandilli Observatory and Earthquake Research Institute, Istanbul) and by Dr. J. Verő (Research Institute of Geodesy and Geophysics, Hungarian Academy of Sciences, Sopron). Their help is here gratefully acknowledged.

The collection data of European corn borer (*Ostrinia nubilalis* Hbn.) were taken from the collection of the national light-trap network. The data of traps, operated by the Plant Protection Stations were used with the authorization of Dr. I. Eke (Ministry of Agriculture and Country Development), Dr. M. Tóth and Mrs. Gy. Mohai (Station of Plant Health and Soil Protection, Budapest). Many data were received from Professor Z. Mészáros (University of Horticulture and Food Industry, Budapest).

In course of the period studied: in 81 light-trap stations and 3114 nights 133 419 moth individuals were collected in total. As more than one trap operated on each nights the authors disposed over 40 336 observation data in preparing present paper.

Methods

From the collection data of the European corn borer (*Ostrinia nubilalis* Hbn.) 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 or 1 hour) 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. The introduction of RC enables us to carry out a joint evaluation of materials collected in different years and at different points.

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. In the first step 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 mean values have been contracted into groups (classes), then averaged within the classes the relative catches data pertaining to them.

In subsequent studies we have investigated, whether the constantly changing activities of flares had modified the numbers of trapped European corn borer (*Ostrinia nubilalis* Hbn.) individuals? For this study only the data of those observation posts could be used that had worked throughout at least one total solar activity cycle (1976–1986 or 1986–1997). The light-traps operated through both cycles only on two observation posts; additionally, in the first cycle 11 and in the second further 1 light-trap yielded data from a total period. The total catch of the individual years has been compared with the average catch number of 11 years, so essentially yearly relative catch data (RCy) were calculated. These numbers were yearly compared to the average of Q-index, then in years with low (Q-index average 1–3), medium (Q-index average 3–10) and high (Q-index average higher than 10) flare activity the level of significance of relative catch data (RCy) deviation was tried by t-test.

Results

The connections between Q/Q averages and daily catches of European corn borer (*Ostrinia nubilalis* Hbn.) are presented in *Table 1.* The values of Q-index characteristic for each year are shown in *Table 2.* In the latter the yearly relative catch data (RCy) of the studied species are also presented.

Discussion

From the results several important consequences could be drawn. Between the Q-indexes and maximal values of Q/Q average a negative correlation (r = – 0.715) could be found, that is significant at 99.9 % level.

As proven by the data of *Table 1,* on those days when the value of Q/Q average surpasses 3, the catch number of European corn borer (*Ostrinia nubilalis* Hbn.) adults significantly regresses. Such high values occur mainly in years in which the Q-index averages are lower than 10. This means that in those years when the flare activity is mostly moderate the rarely occurring high Q-indexes surpass considerably the average. In those years, however, where the average Q-index is higher than 10, the highest Q-index

Table 1

Daily catches of European corn borer (*Ostrinia nubilalis* Hbn.) adults in 1976–1997 at different values of Q/Q average

Q/Q average 1	Average of relative catch 2	Number of data 3
0.00	0.964	9541
0.12	1.051	3144
0.31	1.054	3626
0.51	0.988	4112
0.71	1.048	3673
0.91	0.985	2695
1.43	1.008	8488
2.41	0.987	2666
3.42	1.102	911
4.97	0.870	825
6.82	0.821	321
12.21	0.783	334

Notes: Correlation between Q/Q average and the relative catch:
r = –0,8146 (significant on levels higher than 99%)

values surpass much less the average. The unfavourable influence of flare activity, which exceeds considerably the average, is reflected in the decreasing number of daily light-trap catches. Because decreasing catches may be experienced on the first day of strong flare activity, we assume that the success of light-trapping is significantly and negatively influenced by the electromagnetic radiation arriving from the Sun. The decrease of catch numbers cannot be felt at Q/Q average values lower than 4. To these values generally high Q-indexes are attached, at the same time the deviation from the average is lower.

One can suppose that the high flare activity generally decreases the number of caught individuals. The method used by us so far, i.e. the relative daily catches, calculated separately for each year per swarming period of the Lepidopteran is inadequate. By introducing and using the relative yearly catch (RCy) we succeeded to confirm the fact that in the case of high flare activity when the Q-index average was higher than 10 (the average catch number calculated for a period of 11 years, a Sun cycle and characteristic for the given observation point, does barely amount to 70% of the expected individual number collected. In years with low flare activity, however, the catch number exceeds the average at least by 44%.

So, according to our results, changes in Sun flare activity considerably modify both the daily catch of European corn borer (*Ostrinia nubilalis* Hbn.) individuals and the number of individuals present. Both statements are important for plant protection prognostics.

Table 2

Yearly relative catch (RCy) of European corn borer (*Ostrinia nubilalis* Hbn.) adults calculated as functions of Q-index yearly averages

Years	Q-index maximum	Q-index average	Q/Q average maximum	Number of data	RCy average
1986	5.36	0.406	13.20	13	2.079
1996	11.48	0.478	24.02	3	1.052
1976	4.98	0.632	7.88	13	1.294
1997	12.28	0.642	19.13	3	0.443
1995	12.00	0.734	16.35	3	1.423
1994	12.08	0.973	12.42	3	0.734
1985	21.31	1.459	14.61	13	1.467
1987	16.21	2.917	5.56	3	1.289
a		*0.920*		*54*	*1.440*
1977	32.27	3.059	10.55	13	0.788
1983	37.29	3.360	4.03	13	1.163
1984	42.09	3.573	11.78	13	0.863
1988	36.90	6.880	4.37	3	1.280
1992	33.56	8.453	4.88	3	1.642
1993	36.92	9.243	10.99	3	0.634
b		*5.468*		*48*	*0.984*
1978	65.23	10.719	6.09	13	0.653
1979	56.40	12.151	3.46	13	0.536
1980	53.38	15.350	3.39	13	0.330
1981	51.29	15.757	3.12	13	0.737
1982	112.31	16.313	5.77	13	1.088
1989	55.10	16.461	3.33	3	0.766
1990	43.40	16.556	3.57	3	0.620
1991	68.22	19.464	4.44	3	1.115
c		*15.614*		*74*	*0.689*

Notes: Levels of significance:
Between Q-index average and maximum of Q/Q average 99.9%
Between *a–b* lines of RCy values 95.0%
Between *b–c* lines of RCy values 95.0%
Between *a–c* lines of RCy values 99.9%

Literature

Örményi, I. (1966): The relationship between geomagnetic activity and chromospheric Hα-flares. Acta Geodaet., Geophys. et Montanist. Acad. Sci. Hung. 1, 121–136.

Smith, H. J. and Smith, E. V. P. (1963): Solar flares. Macmillan Co., New York. 426.

Tóth, Gy. and Nowinszky, L. (1983): Influence of solar activity on the outbreaks and daily light-trap catches of Scotia segetum Schiff. Z. ang. Ent. 95, 83–92.