The influence of meteorological events on light-trap collecting of insects

J. Puskás [(1)], L. Nowinszky [(2)], Cs. Károssy [(1)] and K. Tar [(3)]

[(1)] Department of Physical Geography, Berzsenyi College, Szombathely, Hungary (e-mail: pjanos@bdf.hu; c.karossy@chello.hu)

[(2)] Department of Engineering. Berzsenyi College, Szombathely, Hungary (e-mail: nlaszlo@bdf.hu)

[(3)] Department of Meteorology, University of Debrecen, Hungary (e-mail: tark@puma.unideb.hu)

Abstract The light-trap collecting results of turnip moth (Scotia segetum Schiff.) were examined connected with different meteorological events as the instability line, the convergence zone, the cyclogenesis, the country-wide rain, the cold- and warm weather fronts, the maritime- and continental moderate, arctic and subtropical air masses used the data published in „Calendar of Weather Phenomena" be-tween 1967 and 1990 by Hungarian National Meteorological Service. There were 29 832 moths caught during 3 232 nights by 64 light-trap stations in the examined period. During one night more light-traps operated, therefore 25 021 observing data were worked up. We mean that the observing data are the same as the catching data at one night, at one observing station. The data of meteorologi-cal events were collected into groups according to their occurrence on one day alone or together with other ones. They were collected into separated groups according to arriving after a day without any meteorological events or if there were any of them on the previous day.

The values of relative catch were calculated daily for each observing stations and generations used the catch data. There was made a comparison between the relative catch values and the meteoro-logical events belonging to the date and also on previous and following 2 - 2 days. Then the relative catch values were summarized and averaged daily. The differences of daily average values of signifi-cance levels were controlled with t-test in all the groups. More than 95 % significance levels were found in 36 groups.

The favourable and unfavourable influences of each event are the strongest at that time, when they have influence not only alone but also with other effects simultaneously or they follow one an-other in a short time.

Our results prove clearly, it is not enough to examine exclusively the modifying influence of each meteorological event on light-trap collecting. The success of light trapping is modified depending on several combinations of each meteorological event and they are not very often the same as the catch-ing result of event to have an influence only.

Key words: *meteorological event, instability line, convergence zone, cyclogenesis, country-wide rain, cold- and warm weather fronts, maritime- and continental moderate, arctic and subtropical air masses, light-trap, turnip moth (Scotia segetum Schiff.)*

1 Introduction and survey of literature

The light-trap collecting results show the mass ratio of each species with deformation because of the influence of environmental factors. If we want to use these collecting data for plant protection purposes, we have to know which factors increase or decrease the number of caught individuals, and the degree of these influences.

The cosmic factors, as the solar activity, moonlight, geomagnetism, inter-planetary magnetic field sector boundaries, gravitational potential generated by heavenly bodies etc. can have their influence simultaneously in large territories, so these influences are the same in the whole country in a moment. It is also favourable in the examinations the phases of moon change in periodic way, so a good prognosis can be easily made for their modifying influence. The solar activity and the caused effects of other cosmic factors take place also in periodic time, although to make a forecast for determined dates can not be done.

It is the largest problem, during the examination of collecting data, to determine the influence of weather always changing in time and space.

In one of our former study [1] (Nowinszky L., Károssy Cs., Ekk I., Tóth Gy. 1994) making use of the fortunate circumstances that a principal weather observation station is located in Szombathely where a light-trap observation site was in operation from 1962 to 1970. We examined the formation of the light-trap catch, in connection with the weather elements that are only regularly measured at principal weather stations (vapour pressure, saturation deficit, wind direction, increasing or decreasing cloudiness, cloud height, fog, thunder and lightning that precede storms).

Sorry to say that new pieces of information can hardly be used by plant protection prognostic. The weather elements, although their modifying influences are well known, influence the current catch with all the other factors simultaneously and in reciprocal effect with them. It is also a problem that most of the light-trap stations are far from the meteorological observation stations and even the most important weather elements, surrounding of light-trap stations, are not measured. It is very difficult to examine connection between the weather and light-trap catch using the data of national light-trap network. That is why we began to study the influences of the upper-air phenomena, the weather events and the macrosynoptic weather types. The territory of Hungary is only 93 000 km^2 therefore the macrosynoptic weather types and air masses can be the same in the whole country, the weather fronts can pass through the territory of Hungary during one night.

The insects' phenomenon of life exerting influence of meteorological events is examined generally with the atmospherical process taking to pieces for elements the authors of publications in literature. It is clear that the joint influences of meteorological events have more importance according to the living creature, but publications dealing with these researches are less known. We could not find fundamental publications connected with this theme in the foreign literature. The modifying influence of collecting connected with 22 kinds of air masses and 20 kinds of weather fronts and discontinuity levels, determined after [2] (Berkes Z. 1961) were examined in our publication [3] (Puskás J., Nowinszky L., Örményi I. 1997).

The air masses, the weather fronts and the discontinuity levels were determined for surrounding of Budapest and regret to say they are not valid for the whole territory of Hungary [4] (Csizsinszky M. 1964). We spread our examinations for the joint influence of meteorological events (weather fronts, air masses, instability line, convergence zone, cyclogenesis and country-wide rain). These pieces of information are part of regular meteorological data and they are simultaneously valid for the whole country or they pass the territory of Hungary at one night.

2 Materials

The "Calendar of Weather Phenomena" published monthly by National Meteorological Service contains cold- and warm weather fronts and 6 kinds of air masses: arctic continental (Ac), arctic maritime (Am), moderate continental (Mc), moderate maritime (Mm), subtropical continental (Tc) and subtropical maritime (Tm) ones.

We mean by air masses the wide - spread mass of the air, although physical characteristics (mainly the temperature and degree of humidity) change horizontally continuously but their changes are very small and their vertical dispersions are almost the same.

The instability lines, the convergence zones, the point of time and the length of time belonging to cyclogenesis and the country-wide rain are found in the above-mentioned "Calendar of Weather Phenomena". The instability line (squall line) is a convective activity which moves in a band or line. The short-term intense strengthening of wind speed is the characteristic of its passing and then comes violent tempest and thunderstorm. The convergence develops if two atmospheric motions come from two different directions in the atmosphere. Generally this process takes place along long line, the air accumulates here and one part of it rises up high. It comes often with weather fronts and cyclons. Cyclogenesis is the developing or strengthening of cyclonic circulation.

The catching results of turnip moth (Scotia segetum Schiff.) were worked up connected with these meteorological events. We used the data of light-trap network in Hungary used uniformly the Jermy type light-traps. The light source is a 100 W normal light bulb at 2 meters above the ground, colour temperature: 2900 K°, the killing material is chloroform. The traps of the plant protection worked from 1st April to 31st October while the forestry ones all the year round, independently of the time of sunrise and sunset, every night from 6 p.m. to 4 a.m. All time data are given in universal time (UT). The insects trapped during one night were stored in one bottle, so the whole catch of one night at one observational site is interpreted as one observational datum.

The collecting data of turnip moth (Scotia segetum Schiff.) were used for examinations receiving from 64 observing stations of national agricultural and forestry network operated between 1967 and 1990. During 3 232 nights 29 832 individuals were caught by the traps. We used 25 021 observing data in our examination. We mean by observing data the catching data at one night, at one observing station independently of the caught moth number.

3 Methods

The number of individuals trapped at different observation sites and times can not be compared to each other even in the case of identical species, as each trap works in different environment factors constantly vary according to time as well. To solve the problem, we calculated relative catch (RC) values for observation sites, species and generations from the catch data. RC is the quotient of the number of individuals caught during the sampling interval (1 night), and the mean values of the number of individuals of one generation counted for the sample interval. In this way, in the case of expected mean number of individuals, the value of relative catch is 1.

The data of meteorological events were collected into groups according to their occurrence on just one day or together with other ones. They were collected into separated groups according to arriving after a day without any meteorological events or if there were any of them on the previous day. We made a comparison between the relative catch calculated from the collecting results and the meteorological events and also the previous and following 2 - 2 days. Then the relative catch values were summarized and averaged daily. The differences of daily average values of significance levels were controlled with t-test in all the groups.

4 Results

The light trapping success of turnip moth (Scotia segetum Schiff.) connected with meteorological events is shown in Table 1. The significance level was more than 95 % in relative catch values in 36 groups.

Table 1

Relative catches of turnip moth (Scotia segetum Schiff.) connected with meteorological events used the data of light-trap network in Hungary operated between 1967 and 1990

Name of event			*Values of relative catches at the days around events*					
N	*-1*	*On the day of event*	*-2*	*-1*	*0*	*→0*	*1*	*2*
1.	∅	Ins.	1.17 (232)	1.01 (254)	*1.17* (317)	***0.55*** (39)	*0.95* (143)	1.01 (110)
2.	∅	CV	1.04 (236)	0.98 (297)	1.05 (391)	1.06 (457)	1.16 (284)	1.02 (189)
3.	∅	C	*1.00* (142)	***0.86*** (166)	*0.99* (395)	***0.86*** (222)	0.93 (367)	0.93 (264)
4.	∅	CF	**1.29** (81)	***1.36*** (81)	***0.89*** (279)	***0.56*** (53)	*1.07* (243)	1.09 (180)
5.	∅	CR	**1.76** (52)	***1.78*** (72)	***1.22*** (76)	1.04 (28)	*1.13* (58)	***1.47*** (56)
6.	∅	Mc	*1.05* (91)	***0.66*** (90)	***1.34*** (90)		**1.32** (47)	**1.51** (44)
7.	∅	Mm	0.61 (20)	0.50 (16)	**0.64** (96)		***1.31*** (82)	***0.76*** (71)
8.	∅	Sc	***0.64*** (79)	*1.03* (87)	*0.95* (108)		***0.50*** (39)	**0.56** (31)
9.	∅	Sm	**1.54** (55)	***1.36*** (68)	*0.97* (99)	***0.80*** (59)	***1.24*** (47)	**1.32** (47)
10.	∅	Ins. Sm	1.11 (148)	1.02 (155)	0.97 (155)		0.96 (43)	0.87 (34)
11.	∅	Ins. Mm	*1.05* (74)	***1.22*** (79)	***0.94*** (96)	1.10 (28)	1.17 (17)	1.42 (16)
12.	∅	Ins. CF Sm	1.11 (25)	***1.53*** (25)	***0.86*** (27)		***1.57*** (30)	**1.35** (27)
13.	∅	Ins. CF Mm	1.02 (209)	1.03 (368)	**0.96** (304)		***0.92*** (306)	***1.14*** (252)
14.	∅	Ins. CF Sm Am	*1.12* (29)	*0.77* (29)	*0.97* (28)		***1.78*** (29)	*1.24* (27)
15.	∅	Ins. CF Mm Sm	***1.23*** (22)	***1.51*** (51)	*1.03* (50)		***0.74*** (36)	*1.19* (34)
16.	∅	Ins. CF Mm CR	*1.06* (30)	***0.78*** (32)	***0.73*** (35)		***0.59*** (34)	*1.07* (35)
17.	∅	CV C Sm	***1.43*** (25)	***0.85*** (28)	*1.04* (21)			
18.	∅	CV C Sm CR	***1.20*** (22)	***0.81*** (22)	*0.94* (21)			
19.	∅	CV Mm	***1.46*** (35)	***0.82*** (38)	***0.72*** (52)		***0.44*** (29)	***0.93*** (27)
20.	∅	C CR	*1.05* (94)	***0.93*** (134)	**0.91** (202)	0.98 (75)	*1.01* (180)	***1.35*** (94)
21.	∅	C Mm	1.07 (62)	*1.04* (69)	***0.79*** (95)	1.03 (14)	*1.03* (103)	1.06 (90)
22.	∅	C Mm CR	***1.25*** (49)	***0.66*** (71)	**0.62** (104)		***0.80*** (60)	0.96 (57)

Table 1

Relative catches of turnip moth (Scotia segetum Schiff.) connected with meteorological events used the data of light-trap network in Hungary operated between 1967 and 1990

Name of event			*Values of relative catches at the days around events*					
N	*-1*	*On the day of event*	*-2*	*-1*	*0*	*→0*	*1*	*2*
23.	∅	C Am CR		1.06 (25)	**0.90** (42)		***0.87*** (38)	***1.49*** (41)
24.	∅	CF Mc	***0.75*** (218)	*1.05* (245)	*1.09* (318)		*0.97* (266)	***0.76*** (199)
25.	∅	CF Mm	1.02 (993)	*1.03* (1201)	**0.92** (1630)	**0.88** (156)	**0.94** (1463)	**0.94** (1392)
26.	∅	CF Mm CR	1.02 (34)	*1.07* (56)	**0.75** (72)	**0.71** (21)	**0.83** (73)	**0.66** (58)
27.	∅	CF Ac	*0.98* (45)	***1.21*** (59)	***1.16*** (73)		***0.46*** (63)	*0.99* (36)
28.	∅	CF Am	0.94 (156)	*1.01* (208)	***1.22*** (228)		***0.92*** (203)	0.98 (173)
29.	∅	CF Am CR		*0.97* (46)	***0.70*** (48)		***0.90*** (23)	
30.	∅	WF Sm	**1.38** (50)	**1.54** (60)	**1.66** (73)		1.18 (16)	
31.	∅	WF Mm	0.96 (33)	***0.81*** (50)	***0.48*** (68)		*0.96* (39)	***1.35*** (30)
32.	∅	WF Mc	*0.91* (22)	***0.42*** (45)	***1.27*** (45)			
33.	Inst.	CF Mc	1.11 (58)	**1.15** (60)	***1.12*** (62)		***0.95*** (60)	0.97 (33)
34.	Inst.	CF Mm	0.99 (54)	*1.00* (69)	***0.42*** (68)		*1.00* (51)	**1.30** (46)
35.	Inst.	CF Mm CR	*1.11* (44)	***0.83*** (39)	***0.53*** (36)		*1.19* (25)	
36.	CV	CF Mm	0.92 (45)	*1.02* (49)	***1.48*** (54)		*1.08* (33)	1.05 (20)

Notes: -2 and -1 = previous days of event, 0 = the day of meteorological event, →0 = following days with the same event, 1 and 2 = first and second days following the event, ∅ = a day without meteorological event, Ins. = instability line, CV = convergence zone, C = cyclogenesis, CR = country-wide rain, CF = cold weather fronts, WF = warm weather fronts, Mm = moderate maritime air mass, Mc = moderate continental air mass, Am = arctic maritime air mass, Ac = arctic continental air mass, Sm = subtropical maritime air mass, Sc = subtropical continental air mass. If the significant difference of value of relative catch is more than 95 % level on two following days it is shown with italic numbers. If the value of relative catch differs more than 95 % significance level from the relative catch average of summarized all the other data it is shown with bold numbers. The number of observing data is given in parentheses. There are not given those meteorological events in the table, when there are less than 20 observing data, and probably this is the reason they do not have significant differences neither to the previous day's catching nor the average of summarized all the other data.

5 Discussion

The instability line decreases alone the number of caught specimen only at that case, when it repeats during some days. If cold weather front comes after it still the same day, the unfavourable influence can be shown yet the same day. If it comes with other meteorological events the influence is unfavourable or ineffective for catching result. On the following day the quantity of collecting increases only if subtropical air mass also arrives. The convergence zone is ineffective alone but if it comes together with cyclogenesis the number of collected moths decreases on the previous day. There is an unfavourable influence if it comes with moderate maritime air mass from the previous day till following day. The collecting results are low on previous day if cyclogenesis can be found only. On the day of arriving it is also low when it comes with any other meteorological events. If it comes with country-wide rain the catching is low even on the following day. It is remarkable the country-wide rain alone is favourable before and after the event for success of catching but if it comes with any other meteorological events, the catching is unfavourable for it. The cold weather front arrived alone is favourable on previous days for collecting, but it is unfavourable on the day of arriving and following one. It is also unfavourable arrived together with moderate air mass, and collecting is increased by the coming with arctic air mass but it is decreased on next day. The warm weather front arrived with subtropical air mass is favourable for catching already on previous day and day of arriving but it is unfavourable if warm front comes with moderate maritime air mass. The number of caught moths is low on day of arriving and following one at coming of moderate maritime air mass and it is independent of combination with any other meteorological events. The catching is not very high, except if it comes with other meteorological event, on previous day of arriving the moderate continental air mass but it is high on following days. If the instability line on previous day is followed by moderate continental air mass with cold front on day of arriving, the catching of previous night is high but it is low on following one. If the instability line on previous day is followed by moderate maritime air mass with cold front on day of arriving, the low collecting can be observed on that day will change for high on following one. The subtropical maritime air masses, arrived alone, with instability line and cold front, are unfavourable but they are favourable on previous and following days. If these kinds of air masses come with convergence zone and cyclogenesis the collecting is small on previous night. The subtropical maritime air masses, arrived with warm weather front, are favourable for success of collecting on previous day and also on day of arriving. The number of caught moths shows decrease on arriving day of subtropical continental air mass and it is the same on next day. The number of collected moths is lower on arriving and following days of subtropical continental air masses. The catching is high on previous and arriving days belonging to the arctic air mass coming with cold weather front, but there is a decrease on following day.

Our results prove clearly: it is not enough to examine alone the modifying influence of each meteorological event on light-trap collecting. The success of light trapping is modified depending on several combinations of each meteorological event and they are not very often the same as the catching result of event to have an influence alone.

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