Indian Journal of Agricultural Sciences **81** (2): 154–7, February 2011

Light trapping of *Helicoverpa armigera* in India and Hungary in relation with the moon phases

L NOWINSZKY[1] and J PUSKÁS[2]

University of West-Hungary Savaria University Centre, H 9701 Szombathely Károlyi G Square 4, Hungary

Received: 11 June 2009; Revised accepted: 8 December 2010

ABSTRACT

The scarce bordered straw (*Helicoverpa armigera* Hbn.) was caught by light-trap to ascertain whether the behaviour of European population is the same with Indian ones in connection with moon phases, collecting distance, polarized moonlight and the light pollution. The Indian authors have found that the caught moths were very low at full moon, and high around the new moon. On this contrary, we did not establish difference between the catches of scarce bordered straw (*Helicoverpa armigera* Hbn.) at full moon and new moon in Hungary between 1993 and 2006.

The light pollution in India was lower at that time than this time in Hungary. The collecting distance in India was differing significantly at new moon and full moon. The light pollution equalized the collecting distance all the lunar months in Hungary. Hungarian catch results are modified primarily by polarized moonlight in the period between the first and the last quarters.

Key words: *Helicoverpa armigera*, Hungary, India, Light trapping, Moon phases

The scarce bordered straw (*Helicoverpa armigera* Hbn.) scathes various cultivated plants all over the world except America. Hardwick (1965) recognized three subspecies of H. *armigera* Hbn, ie *H. armigera* in Africa, Europe, continental Asia, Sri Lanka and Japan, *H. armigera conferta* in eastern Indonesia, New Guinea, Guam, Australia, New Caledonia, New Zealand, Fiji, and the Friendly Islands (Tonga) and *Heliothis armigera commoni* from Canton Island (02°50'S 171°40'W) in the central Pacific Ocean. Specimens typical of *H. armigera* and *H. armigera conferta*, as well as intermediates between the two subspecies have been found in Sumatra, eastern Java, and the Philippines.

In 1993, *H. armigera* Hbn. appeared in light-trap catch in Hungary. From that time its catch is regular, the representative number had small fluctuations and it was permanently higher. The peak was in 2003. There are researches all over the world and in Hungary to examine its lifestyle, spreading, migration and gradology. In the recent past, a book was published by Camprag *et al*. (2004) and it contains the results of researches until now.

Both the light-trap and pheromone trap is a useful device for cognition of population changing. Indian researchers determined most specimen fly to the light-trap at new moon, but less ones reach trap at full moon. The catch was successful from new moon until full moon (Sekhar *et al*. 1996, Pedgley *et al*. 1987). On the other hand, Sekhar *et al*. (1995) did not find any difference in pheromone trap success during different moon phases. Vaishampayan and Verma (1982) were collecting *H. armigera* Hbn. in India. They used the common name, gram podborer. Collecting was more successful in the waning than in the waxing period. They presume that the response of moths is weaker to the stimulus of the light trap in the vicinity of a full moon.

In this study, we examined *H. armigera* Hbn. whether the behaviour of European population is the same than Indian ones in connection with moonlight.

MATERIALS AND METHODS

Vaishampayan and Verma (1982) used Pennsylvania-type light-trap, the light-source was 250 W HGL bulb placed in a height of 3 m above the ground.

The trap was in operation near Jabalpur between 1975–76 and 1978–79. They caught a total of 18 732 moths in these years.

The fact that the same subspecies of *H. armigera* Hbn. is flying in India and Hungary (Hardwick 1965) gave us a possibility for and interesting comparison. Using the catching data and results of Vaishampayan and Verma (1982) collecting in the Jabalpur region of India between 1975 and 1979, we could calculate specimen numbers for the different days of the lunar month. We have processed these with our own method and compared the outcome with the results

[1,2]Professor (e mail: lnowinszky@gmail.com)

gained by processing data from Hungary for 1994–2006.

There were used data of Hungarian agricultural light-trap network to the examinations between 1993 and 2006. There are used Jermy-type light-traps in this network (Jermy 1961). The light source of traps was 100 W normal bulb at 2 m height. We used chloroform as killing material. In 1993, there were only 6 traps in operation, but in 2003 only 40 ones collected moths. In this period, there were successful trapping during 1 432 nights and traps caught altogether 21 578 specimens. The number of observation data was 7 845, because more traps were in operation during one night. By observation data, we mean the catch of a species on one night at one observation post, regardless of the number of specimens, but now we did not calculate those nights when trapping was unsuccessful. The moonlight reduces the success of trapping, but it did not make it fully impossible.

The full moon time data we needed to create our lunar phase classes were downloaded from the Astronomical Applications Department of US Naval Observatory: http:// aa.usno. navy.mil/cgi-bin/aap ap.pl.

For every midnight of the flight periods (UT = 0 h), we have calculated phase angle data of the moon. On the 360 phase angle degrees of the full lunation we established 30 phase angle divisions. The phase angle division including a full moon (0º or 360º) and values 0 ± 6º was named 0. Beginning from this group through the first quarter until a new moon, divisions were marked as -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13 and -14. The next division is ±15, including the new moon. From the full moon through the last quarter in the direction of the new moon divisions, were marked as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14. Each division consists of 12 degrees (Nowinszky 2003). These phase angle divisions can be related to the four quarters of lunation as follows: full moon (-2 – +2), last quarter (3 – 9), new moon (10 – -10) and first quarter (-9 – -3). The nights of the periods under examination were all classed into these phase angle divisions.

Data on the illumination of the environment were calculated with our own software. This software for TI 59 computer had been produced by the late astronomer György Tóth specifically for our joint work at the time (Nowinszky and Tóth 1987). The software calculates the illumination of the sun at dusk, the light of the moon and the illumination of the starry sky – all in lux – for any given geographical place, day and time, separately or summarized. It also calculates with cloudiness.

Cinzano *et al*. (2001) published a world atlas listing the most important data by countries. In this work, the authors consider artificial illumination above 10% of the natural background illumination as light pollution. According to their data, in 1996 and 1997, artificial illumination exceeded 11% of the natural illumination in all areas (100%) of Hungary, and 33% in 81.9% of the country. The same values were 14.9% and 34.7% in India. Two decades before the study by him, it had not been necessary to consider light pollution in India, but it was in the recent years in Hungary.

We also considered light pollution data in calculating collecting distances for the Jermy-type light-trap. Our estimation was based on a study be Cinzano *et al*. (2001). In our study, we calculated both for India and Hungary with average illumination values of a full moon for the time of light trapping.

The collecting distance can be calculated with the help of the following formula (Nowinszky 2006):

$$r_0 = \sqrt{\frac{I}{E_N + E_H + E_{CS} + E_F}}$$

Where: r_0 = collecting distance, I = illumination from the lamp [candela], E = the illumination coming from the environment [lux] the latter consisting of the light of the setting or rising sun (E_N), the moon (EH), the starry sky (E_{CS}) and light pollution (E_F).

For a lunar month chosen as a sample, we calculated collecting distances at 0:00 (local time) of each night. In case of both light traps, cloud cover was taken into consideration and for the Jermy-type light trap we also counted with light pollution (Table 1).

In a former study (Nowinszky *et al*. 1979), we established percentage values for polarized moonlight in connection with the lunar phases, with due consideration to studies by Dollfus (1961) and Pellicori (1971) (Table 2).

Table 1 Theoretical collecting distances (m) of the Jermy-type and the Pennsylvania-type light-trap in connection with the moon phases and cloud cover

Cloud cover	Clear	Intermediate	Cloudy
Moon quarters	Jermy-type light-trap operating with a 100 W normal bulb for first quarter suitable light pollution		
First quarter	41	46	55
Full moon	19	25	45
Last quarter	44	49	55
New moon	57	57	57
Moon quarters	Jermy-type light-trap operating with a 100 W normal bulb for full moon suitable light pollution		
First quarter	19	19	20
Full moon	14	16	19
Last quarter	19	20	20
New moon	20	20	20
Moon quarters	Pennsylvania-type light-trap operating with a 250 W mercury vapour lamp without light pollution		
First quarter	229	313	866
Full moon	92	126	347
Last quarter	274	375	1036
New moon	1023	1399	3456

Table 2 The percentages of the polarized moonlight depending on the phase angle divisions

First quarter	Polarized moonlight (%)	Full moon	Polarized moonlight (%)	Last quarter	Polarized moonlight (%)
–9	6.324	–2	–0.412	3	2.511
–8	6.576	–1	–0.115	4	3.927
–7	6.285	0	0.000	5	5.412
–6	5.788	1	–1.115	6	6.869
–5	4.950	2	–0.412	7	7.941
–4	3.687			8	8.714
–3	2.412			9	8.765

Positive numbers denote the horizontally the negative ones the vertically polarized moonlight. At the time of a full moon the moonlight did not polarized.

Based on the number of specimens caught in India and Hungary, we calculated relative catch values for each brood. Relative catch (RC) is the ratio of the number of specimen caught in a given sample unit of time (1 hr or 1 night) and the average number of specimen caught in the same time unit calculated for the whole brood. If the number of the specimen trapped equals the average, the value of relative catch is: 1. Only nights and hours with some catch were included in the calculations, as our earlier works (Nowinszky 2003), had convinced us that although the moon has an influence on the efficiency of trapping, it never makes collecting impossible.

Examining the influence of lunar phases, we compared the catch of Pennsylvania-type and Jermy-type light traps in different phase angle divisions. We analyzed the correlation between collecting distances and relative catches in the case of the Pennsylvania-type light trap and between polarized moonlight and relative catches for the Jermy-type light trap. We did not distinguish horizontally or vertically (oscillating) polarized moonlight, as in one of our earlier studies (Nowinszky 2008) we found no significant difference between the catch of traps set up in environments characterized by different kinds of polarization. Our results, including regression equations and significance levels, are displayed in Figures.

RESULTS AND DISCUSSION

The results are shown in Figs 1, 2.

Our results are not the same as statements of Indian researchers. This fact is amazing, because both populations (in India and Central Europe) belong to the same subspecies (Hardwick 1965). The wave length of light sources used in India and Hungary are not the same, but we did not make comparison between the number of caught moths. We wanted to investigate where can be found catching minimum and maximum in lunar month.

There is a very intensive decrease around full moon in India, but we can see maximum catch at new moon. The success of catch is almost the same around new moon and full moon in Hungary, but there are two little catch peaks near the first and last quarter, when the polarized proportion of moonlight is the highest. In our previous study (Nowinszky *et al*. 1979), we also found the highest catch at the same quarters monitoring consolidated light-trap catch results of seven species.

Perhaps the cause of difference between results in India and Hungary is not because of the variance of light-trap types. Researchers use several light-trap types all over the world. Generally, the observations show intensive decrease around full moon. Recently, intensive light pollution can be noticed

The regression equation: $y = 0.008x^2 - 0.2531x^2 + 2.4113$ $R = 0.8221$ $P < 0.001$ Significance level between First Quarter and Full Moon $P < 0.001$, First Quarter and New Moon $P < 0.001$ Full Moon and Last Quarter $P < 0.05$, Full Moon and New Moon $P < 0.001$, Last Quarter and New Moon $P < 0.01$ The correlation between collecting distance and relative catch $R = 0.8924$ $P < 0.001$

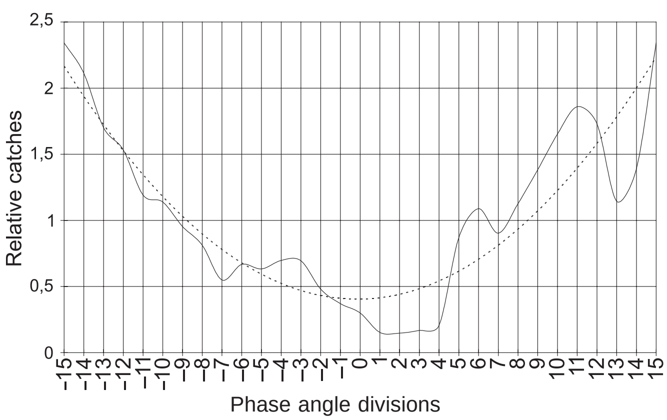

Fig 1 Light-trap catch of the scarce bordered straw (*Heicoverpa armigera* Hbn.) In India (Jabalpur) between 1974 and 1979 depending on the phase angle divisions from the data of Vaishampayan and Verma (1982)

The regression equation

$y = 2E{-}07x^6 - 2E{-}05x^5 + 0{,}0006x^4 - 0{,}011x^3 + 0{,}0914x^2 - 0{,}2955x + 1{,}1671$

$R^2 = 0{,}5989$ $P < 0{,}001$

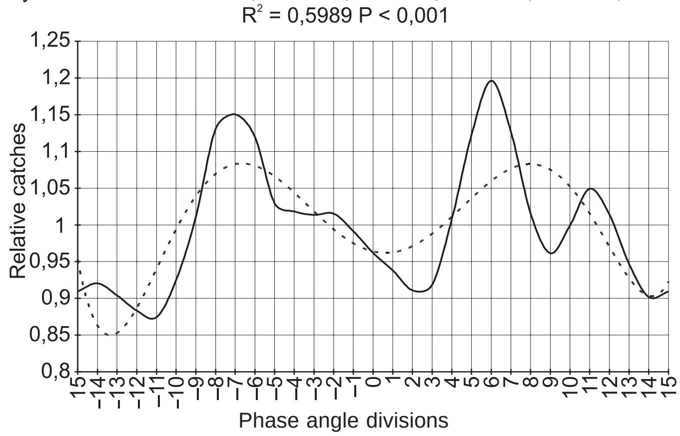

Fig 2 Light-trap catch of the scarce bordered straw (*Heicoverpa armigera* Hbn.) in Hungary between 1993 and 2006 depending on the phase angle divisions

in Europe (Cinzano *et al.* 2001). Therefore, we rather think it is likely that the collecting distance, belonging to new moon and full moon will moderate or totally disappear because of the light pollution (Nowinszky 2006).

Data provided by Vaishampayan and Verma (1982) make it clear that there was a catch maximum at a new moon and a minimum at a full moon. In Hungary, however, one can observe no maximum at a new moon or minimum at a full moon, only smaller, still significant maxima in the first and the last quarter. We found that the degree of light pollution was smaller in India 30 years ago, than in Hungary in recent years.

Here, the difference between the catch at a full moon and a new moon practically disappeared. Consequently, there is no difference between the catch in this two quarters, but there is maximum in the first and the last quarter.

Examining the relationship between polarized moonlight and collecting has gained special significance since studies by Dacke *et al*. (2003) had proved that certain insects can find their bearing with the help of polarized moonlight. Our current findings also show a growth of light trap catch when the polarized part of moonlight is higher.

REFERENCES

Camprag D, Sekulic R, Kereši T and Baea F. 2004. Kukuruzna Sovica (*Helicoverpa armigera* Hübner) i Integralne Mere Suzbijanja. Poljoprivredni Fakultet Departman za Zastitu Bilja i Zivotne Sredine *Dr Oavle Vukosovic Novi Sad*. **183**. Summary 161–7.

Cinzano P, Falchi F and Elvidge C D. 2001. The first world atlas of the artificial night sky brightness. *Mon. Not. R. Astron. Soc*. **328**: 689–707.

Dacke M, Nilsson D E, Scholtz C H, Byrne N and Warrant E J. 2003. Insect orientation to polarized moonlight. *Nature* **424**. 33. July 03.

Dollfus A. 1961. Polarization studies of planets. (*in*) *The Solar System* 3. University Chicago Press.

Hardwick D F. 1965. The corn earworm complex. *Memoirs of the Entomological Society of Canada* **40**: 1–217

Jermy T. 1961. Monitoring insects' flight activity by light-traps (in Hungarian). A növényvédelem idõszerû kérdései – *Recent Problems of Plant Protection* **2**: 53–61.

Nowinszky L. 2003. 7. The factors modifying the degree of light-trap efficiency: The Moon (*in*) *Handbook of Light Trapping*, pp 108-125. Nowinszky L [Ed.]. Savaria University Press.

Nowinszky L. 2006. The light pollution and the light trapping of insects (in Hungarian). *Dissertationes Savarienses* **36**: 1–34.

Nowinszky L, Szabó S, Tóth Gy, Ekk I and Kiss M. 1979. The effect of the moon phases and the intensity of polarized moonlight on the light-trap catches. *Z. ang. Ent.* **88**: 337–53.

Nowinszky L and Tóth Gy. 1987. 'Influence of cosmic factors on the light-trap catches of harmful insects (in Hungarian)'. PhD dessertation, Szombathely. 123.

Pedgley D E, Tucker M R and Pawar C S. 1987. Windborne migration of *Heliothis armigera* (Hübner) (Lepidoptera: Noctuidae) in India. *Insect Sci. Applic*. **8**. 4/5/6: 599–604.

Pellicori S F. 1971. Polarizing properties of pulverized materials with special reference to the lunar surface. *Applied Optics* **10**. **2**: 270–85.

Sekhar P R, Venkataiah M and Rao N V. 1995. Effect of moon light and lunar periodicity on the pheromone trap catches of *Helicoverpa armigera* (Hubner) moths. Research Note. *Journal of Research APAU* 23. **3**: 38.

Sekhar P R, Venkataiah M and Rao N V. 1996. Effect of moon light and its periodicity on the light trap catches of *Helicoverpa armigera* (Hubner) moths. *Annals of Agricultural Research* **17**. **1**: 53–5.

Vaishampayan S M and Verma R. 1982. Influence of moon light and lunar periodicity on the light trap catches of gram podborer, *Heliothis armigera* (Hubner) moths. *Indian Journal of Entomology* **44**. **3**: 206–12.