The beginning of swarming of Beetle (Coleoptera) and moth (Lepidoptera) species depending on the lunar phases, in the material of Becse-type light-trap

A Becse-típusú fénycsapdák által gyűjtött bogár (Coleoptera) és lepke (Lepidoptera) fajok rajzáskezdete a holdfázisokkal összefüggésben

János Puskás, László Nowinszky & Zoltán Mészáros

Abstract: We examined the beginning of swarming of 21 Microlepidoptera species between 1969 and 1973, 73 Macrolepidoptera species between 1970 and 1973 and 93 Coleoptera species of Prilep trap from 1971 in connection with the lunar phases. All the collecting data originated from Becse-type light-traps. The beginning of swarming is in connection with phase of the Moon at least with one part of Macrolepidoptera and Coleoptera species. The most frequent case is the connection with last quarter.

Keywords: Becse-type light-trap, moths, beetles, beginning of swarming, moon phases

Authors' addresses: János Puskás & László Nowinszky | University of West Hungary Savaria University Centre, H-9701 Szombathely Károlyi G. Square 4. | E-mail: pjanos@gmail.com | lnowinszky@gmail.com; – Zoltán Mészáros | Szent István University, Faculty of Agricultural and Environmental Sciences, Institute of Plant Protection, H-2103 Gödöllő, Práter K. Street 1. | E-mail: zoltan.meszaros@t-online.hu

Összefoglalás: [A Becse-típusú fénycsapdák által gyűjtött bogár (Coleoptera) és lepke (Lepidoptera) fajok rajzáskezdete a holdfázisokkal összefüggésben] – Megvizsgáltunk a szerbiai Bečej (Óbecse) községben 1969 és 1973 között működő, szénkéneggel ölő fénycsapda anyagából 21 Microlepidoptera faj rajzáskezdetét a holdfázisokkal összefüggésben. Vizsgáltuk még a macedóniai Prilep területén, 1971-ben üzemelő ugyanilyen fénycsapda által gyűjtött 93 Coleoptera faj rajzáskezdetét is szintén a holdfázisok függvényében. A legtöbb rajzáskezdet az utolsó negyedévben történt

Introduction

The light trapping is the most widespread and efficient method of the collection of flying insects during night. Most of the active insects at night fly onto the artificial light-sources, what anybody may have experienced already, when insects on summer evenings fly in the open window and they fly around the lamps. This phenomenon can be used by the specialists dealing with entomological fundamental researches, insect ethology, plant protection and the spreading of species. Different types of light-traps were

constructed worldwide, although they used different technical solutions, but all of them are equal in two things, they have a light-source and they consist of some kind of killing construction. Based on the information of killed insects it can be cognizable, that which species are in the environment at presence. It is possible to deduce the possibly damage from the number of individuals of the species.
There were in operation the new types of light traps at several settlements in the territory of the former Yugoslavia. These traps could collect the insects with more efficiency than previous models. One of them worked in Bečej (Serbia; geographical coordinates: 45°37'05" N and 20°02'05" E) between 1969 and 1973, the second one was in operation in Prilep (Macedonia; geographical coordinates: 41°20'47" N and 21°33'16" E) in 1971 (Figure 1.).

The light-trap operated by Varga & Mészáros (1973a) between 1969 and 1973 on the territory of the Agricultural and Industrial Combine in Bečej (Yugoslavia) collects many more insects than the Hungarian Jermy-type traps do. The light source of the trap is an IPR WTF 220V, 250W mercury vapour lamp 2 meters above the ground. There is a large collecting cage under the funnel of the trap. The cage contains two perpendicular separation walls made of plastic haircloth dividing the cage into four equal parts. This solution ensured that the tougher bodied and livelier beetles staying at the bottom of the cage couldn't damage the moths and other fragile insects that have climbed up on the separation walls. In the morning the cage was placed in a chest in which a few millilitres of carbon bisulphide had been burnt. The gases thus generated killed the insects quickly and effectively. The light-trap worked every night in the breeding season even in bad weather. Several of this type of traps collecting huge masses of insect material of good quality has been operating in Yugoslavia. Regarded to be dangerous, the use of this type of trap has not been permitted in Hungary (Varga & Mészáros (1973b).

There were investigated and published only the moth data of the first two years caught by Becse-type light-trap (Mészáros et al., 1971, Vojnits et al., 1971). However, in 1971, the beetle material, caught in Bečej and Prilep, has been determined and published as well (Mészáros et al., 1976). The Becse-type light trap was also used by other researchers in Serbia (Kereši & Almáši, 2009, Vajgand 2009, 2010).

A reliable prediction of the adult brood emergence of pest insect species is of extreme importance in plant protection. Environmentally sound, effective and economical protection treatments are usually timed to correspond with a special phenological period of the pest species, which can

Figure 1. Localities in Serbia and Macedonia: **1a**) Bečej (=B), Prilep (=P); **1b**) Becse-type light-traps in Prilep (1972)

generally be calculated with acceptable precision from the starting date of the adult brood (Nowinszky, 2008).

In the view of several authors, the life cycle and thus the emergence of the adult brood of insects is possibly also in relation with the lunar phases. Research in this field has mainly concentrated on short-lived species like Ephemeroptera, where the beginning and the culmination of flight occur in quick succession. Hora (1927) compared old records on some Ephemeroptera – the first one from 1744! – with the lunar phases and found that adults emerged most frequently in the vicinity a Full Moon. Pongrácz (1933) experienced several times that the adults of the mayfly *Polymitarcis virgo* Oliv. emerged en mass right after a Full Moon. According to Csongor & Móczár (1954), the swarming of *Palingenia longicaudata* Oliv. (Ephemeroptera) is affected by rising air pressure as well as rising air and water temperatures and the lunar phases. After an examination of the records of the greater swarms of mayflies, Móczár (1957) pointed out that they had all occurred one day after a Full or a New Moon.

Earlier we already published two studies. We published the beginning of swarming of Macrolepidoptera species in connection with the moon phases used the Hungarian light trap data (Nowinszky & Ekk 1988, Nowinszky 2008) and the data of North Carolina and Nebraska States of USA (Nowinszky & Puskás 2012). We established in both study that the swarming of species begins in different periods of the moon phases. We worked up the data of light trap catch in Bečej and Prilep in our present study. Although we know that the number of caught individuals and beginning of some species can depend on several factors. Some of these factors have an impact in conjunction with each other. We investigated only the influence of Moon in this study and we ignored the influence of all the other factors. Similarly makes almost every insect ecology researcher who examines the impact of a single environmental factor.

Material and Method

Two light-traps were in operation in Bečej and Prilep. One of them worked in Bečej at Agricultural and Industrial Combine. We examined 21 Microlepidoptera species between 1969 and 1973. 73 Macrolepidoptera species were investigated between 1970 and 1973. The moth data originated from Bečej-type light-trap. We had the Coleoptera data of Prilep trap only from 1971, so we could worked up 93 Coleoptera species. List of all examined species, of course, is not possible. However, they are listed the moth and beetle species, which caught most of the individuals in the light-trap (Table1.). The processing ignored those species which only one specimen was caught by light-traps.The values of a phase angle of the Moon were calculated with the help of our own computer program. This program was made by Tóth György astronomer for our earlier works.

We have divided the 360° phase angle of the full lunar month (lunation) into 30 divisions. The division in the ±6° phase angle value vicinity of a Full Moon (0°, or 360°) was named: 0. Starting from here, divisions in the direction of the first quarter until the New Moon were named: -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13, -14. Also starting from the Full Moon, divisions in the direction of the last quarter until a New Moon were named: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14. The division including the New Moon was named: ±15. All divisions include 12 phase angle values. We have arranged all nights of the observation period into one of these phase angle divisions. Consequently, we have assigned the day of the catch of the first specimen of all adult broods of all species to a phase angle division of the Moon, summarized the results, and finally we plotted in percentage the frequency of adult brood emergences falling into the different divisions.

Results and Discussion

The beginnings of swarming of insects captured by the Becse-type light-trap are shown in Figures 2–4. The number of moths (Microlepidoptera), is in Figure 2., the Macrolepidoptera species are in Figure 3. The Coleoptera species, caught in Bečej and Prilep, are illustrated in Figure 4.

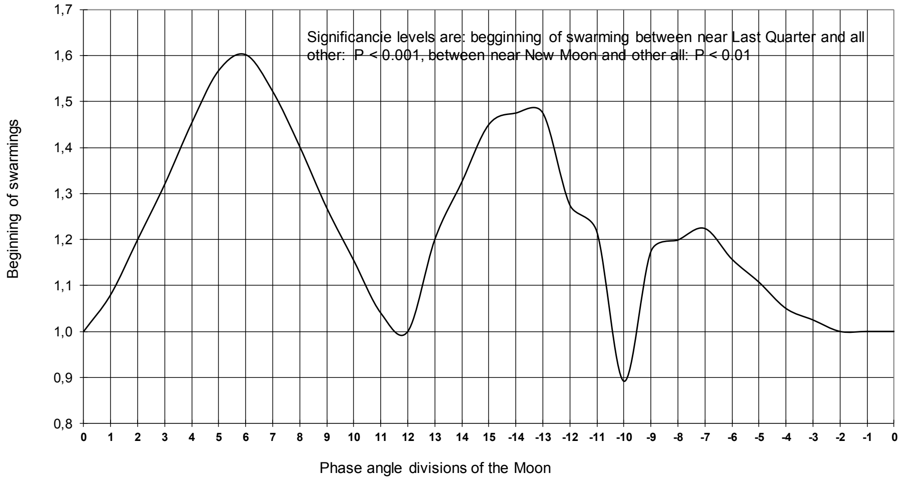
We see that the beginning of swarming is in connection with phase of the Moon at least with one part of Macrolepidoptera and Coleoptera species. The most frequent case is the connection with last quarter. The life of the moths generally is short, may exist so some kind of timer factor, which insures the reproduction ready individuals finding each other out. The regularly changing moon phases appear to be suitable for this. It is striking, that the beginning of swarming rarely occurs at the time of a full moon and in first quarter of the moon at the examined taxons.

We have assigned the day of the catch of the first specimen of all adult generations of all species to a phase angle division of the Moon, summarized the results, and finally we plotted in percentage the frequency of adult generation emergences falling into the different divisions.

Nemec (1971) presumes that the generation cycles of *Heliothis zea* Boddie are synchronized with the moon phases. The results of Agee et al. (1972) also suggest the activity and life cycle of *Heliothis zea* Boddie to be synchronized with the lunar phases. Possibly, several other physical phenomena - like the maturity of the foodplant, temperature or other factors - might also be responsible for this lunar rhythm. Bowden & Gibbs (1973) find it worth considering whether the lunar phases synchronize flight activity in some stage of development. According to Bowden (1973), lunation determines an important biological rhythm for the different insect species. The conclusion of Danthanarayana (1986) that Moon periodicity is unrelated to the time of the appearance of the Moon above the horizon is of great importance. This precludes the possibility that the observed flight behaviour would be a direct visual response to the Moon or to moonlight. In his view, the periodicity of the Moon may have the advantage of making survival possible via migration and contributing to the synchronization of emergence and flight in favour of mating and reproduction. Using pheromone traps for *Cydia pomonella* L. (*) in South-California, Conlee (1995) found that the emergence of the first generation was guided by lunation for 10 years, while the second generation followed the first one after one and a half lunar month.

This fact, that the difference of beginning of swarming in first and in the last quarters of the moon may give an explanation according to our assumption, that the polarisation of the moonlight is significantly higher around the last quarter of the moon, than in the environment of a first quarter. The polarized moonlight is in a positive contact with the flying activity of the insects (Nowinszky & Puskás, 2010 and 2012).

Figure 2. The beginning of swarming of moth (Microlepidoptera) species depending on the lunar phases, in the material of Becse-type light-trap



Cydia pomonella (*)

Figure 3. The beginning of swarming of moth (Macrolepidoptera) species depending on the lunar phases, in the material of Becse-type light-trap

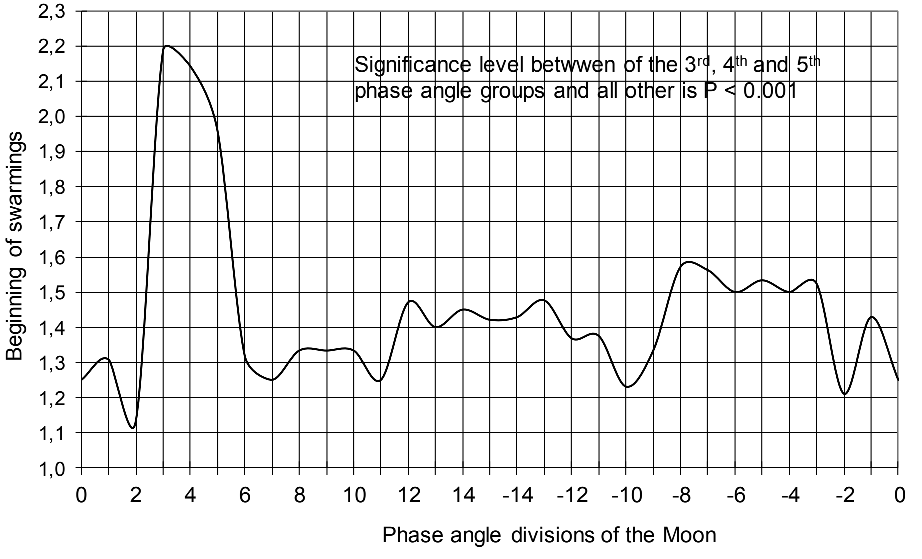


Figure 4. The beginning of swarming of beetle (Coleoptera) species depending on the lunar phases, in the material of Becse-type light-trap

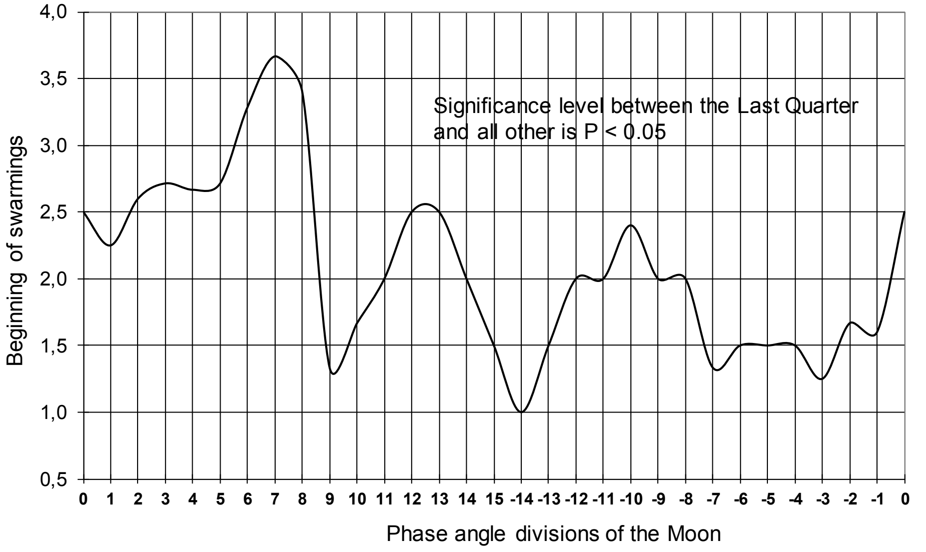


Figure 5. Becse-type light trap in Bečej (Serbia, in 1972)

Table 1. Collection data of the examined Lepidoptera species

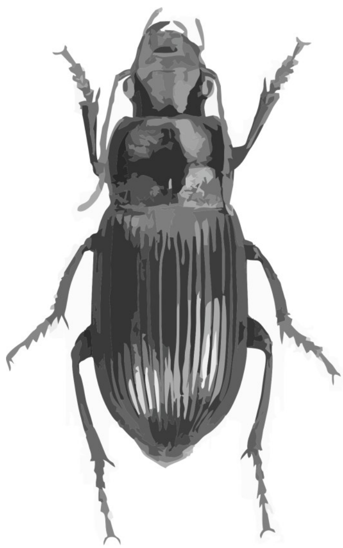
Families and scientific names	**Common names**	**Moths**
TORTRICIDAE		
Aleimma loeflingiana Linnaeus, 1758	Yellow Oak Button	2824
CRAMBIDAE		
Evergestis extimalis Scopoli, 1763	Marbled Yellow Pearl	1149
Loxostege sticticalis Linnaeus, 1761	Beat Webworm Moth	1196
Sitochroa verticalis Linnaeus, 1758	Lesser Pearl	3002
Ostrinia nubilalis Hübner, 1796	European Corn-borer	38120
Nomophila noctuella Den. et Schiff.,1775	Rush Veneer	14374
PYRALIDAE		
Etiella zinckenella Treitschke, 1822	Lima Bean Pod Borer	3141
Homeosoma nebulella Den. et Schiff.,1775	European Sunflower Moth	6263
GEOMETRIDAE		
Timandra comae Schmidt, 1931	Blood-vein	4263
Chiasmia clathrata Linnaeus, 1758	Latticed Heath	3478
Ascotis selenaria Den. et Schiff.,1775	Luna Beauty	2159
LYMANTRIIDAE		
Leucoma salicis Linnaeus, 1758	White Satin Moth	3255
ARCTIIDAE		
Hxphantria cunea Drury, 1773	Fall Webworm	4447
Spilosoma lubricipeda Linnaeus, 1758	White Ermine	2644
Spilosoma urticae Esper, 1789	Water Ermine	4634
Phagmatobia fuliginosa L.	Ruby Tiger	14374
NOCTUIDAE		
Agrotis segetum Den. et Schiff.,1775	Turnip Moth	9895
Agrotis exclamationis Linnaeus, 1758	Heart & dart	2348
Axylia putria Linnaeus, 1761	The Flamme	2914
Noctua pronuba Linnaeus, 1758	Large Yellow Underwing	1755
Xestia c-nigrum Linnaeus, 1758	Setaceous Hebrew Ch	28999
Discestra trifolii Hufnagel, 1766	The Nutmeg	11381
Mamestra brassicae Linnaeus, 1758.	Cabbage Moth	4187
Laconobia suasa Den. et Schiff., 1775	Dog's Tooth	4434
Laconobia oleracea Linnaeus, 1758	Bright-line Brown-eye	7512
Mythimna turca Linnaeus, 1761	Double Line	1324
Mythimna vitellina Hübner, 1808	The Delicate	3583
Mythimna pallens Linnaeus, 1758	Common Vainscot	3689
Heliothis maritima Graslin, 1855	Shoulder-striped Clover	3563
Emmelia trabealis Scopoli, 1763	Spotted Sulphur	18678
Macdunnoughia confusa Stephens, 1850	Dewick's Plusia	1236
Autograha gamma Linnaeus, 1758	Silver Y	6868
Autographa pulchrina Haworth, 1809	Beautiful Golden Y	1163
Tephrina arenacearia Den. et Schiff.,1775	Lucerne Moth	4457

Table 1. Collection data of the examined Coleoptera species (continuation)

Families and scientific names	Common names	Beetles
SCARABIDAE	—	
Aphodius lugens Creutzer, 1799		105
SCARABEIDAE		
Anomala solida Erichson 1847	—	491
CARABIDAE		
Amara consularis Duftschmid, 1812 *	—	1074
Dolichus halensis Schaller, 1783	—	778
Harpalus tardus Panzer, 1797	European Ground Beetle	172
Harpalus calceatus Duftschmid, 1812 **		1336
Harpalus griseus Panzer, 1796	Strawberry Seed Beetle	541
Harpalus rufipes De Geer, 1774	—	995
Acupalpus dorsalis Fabricius, 1787	—	299
Acupalpus discophorus Fischer, 1824	—	765
Stenolophus mixtus Herbst, 1784	—	337

Graphic: by Imre Fazekas, 2015

Amara consularis *



Harpalus calceatus **

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