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Research Article

Light-Trap Catch of *Lygus* sp. (Heteroptera: Miridae) in Connection with the Polarized Moonlight, the Collecting Distance and the Staying of the Moon above the Horizon

Nowinszky L.* and Puskás J.

University of West Hungary, H-9701-Szombathely, Károlyi Gáspár Square 4. Hungary, Europe.

Abstract: The paper deals with connections between light trapping of *Lygus* sp. and the polarized moonlight, the collecting distance and the staying of the Moon above the horizon.

Keywords: *Lygus* sp., light-trap, Moon.

1. Introduction and Review of literature

The influence of the moonlight on the catches of light-traps has been examined for decades. Williams (1936) has published fundamental studies in this field. Williams found that much fewer insects were collected at Full Moon compared to New Moon. He established two reasons, which may be responsible for lower catch levels at Full Moon periods:

(1) Increased moonlight reduces the flying activity of insects, consequently, a smaller rate of active population will be accessible for the light-trap, or
(2) The artificial light of the trap collects moths from a smaller area in the concurrent moonlit environment.

The past few decades did not come up with a satisfactory answer to that dilemma. The conclusions are contradictory and up to this day, a good many questions have remained unclarified.

We refer to the most important studies only from the international literature, but we summarized our results until now, in detail in our two previous books (Nowinszky, 2003 and 2008).

Moonlight reduces the number of insects trapped. This view is shared by Mazochin-Porshnyakov (1954), Agee (1972), Bowden (1973b), Southwood (1978), Vaishampayan and Verma (1982), Nag and Nath (1991). The collecting distance as a function of changing moonlight has been calculated by a number of researchers (Dufay, 1964; Bowden, 1973a), Bowden and Church (1973). Bowden (1982) determined, by identical illumination, the collecting radius of three different lamps. Bowden and Morris (1975) always calculated for an identical area the volume of their catch made in the course of the lunar month in areas reduced by the effect of moonlight. The highs of the standardized data occurring in the proximity of the full moon also contradict the theory on the hindering effect of moonlight.

It is important to define and distinguish the concepts of a theoretical and a true collecting distance based on a study of Nowinszky (2008). By theoretical collecting distance, we mean the radius of the circle in the centre of which the trap is located and along the perimeter of which the illumination caused by the artificial light source equals the illumination of the environment (Nowinszky *et al*., 1979). The size of the theoretical collecting distance depends on the luminous intensity of the artificial light source (Candela). It depends on the different days and during the night of the year continuously changing illumination of the environment (time and span of twilights, the periodical changes of the Moon, light pollution) that may be different depending on geographical position, the season of the year or during one night (Nowinszky, 2008; Nowinszky and Puskás, 2013).

The length of a real collecting distance is influenced by the shielding effect of the configuration of the terrain, objects, buildings and vegetation and the presence of disturbing lights within the theoretical collecting distance.

Recently Cinzano and his colleagues discussed the nocturnal state of the sky in several studies. They even

*Corresponding author:
E-mail: lnowinszky@gmail.com, pjanos@gmail.com.

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. Intensive light pollution can be noticed in Europe (Cinzano, 2001). Nowinszky (2006) published a summarizing study about the inhibitory effects of light pollution on light trapping. He noted that the collecting distance, belonging to New Moon and Full Moon, will moderate or totally disappear because of the light pollution. Other researchers are of the view that moonlight slackens the flight activity of insects.

By reason of their studies, Baker and his colleagues (Baker, 1979; Sotthibandhu and Baker, 1979; Baker and Sadovy, 1878) believe that moonlight cannot have an influence on the collecting distance. The following observations by Dufay (1964) contradict the theory of moonlight inhibiting activity: Nocturnal moths can be seen in the light of car lights also on moonlit nights; at a Full Moon is collecting decreases, but does not stop; in case of lunar eclipses the catch is high when the Moon is obscured, although closely before and after it is low.
According to Edwards (1961), an estimate of the activity depends on two factors. One is the proportion of the population in an active phase and the other the amount of time spent in flight by these specimens.

We have defined the concept of flight activity as follows. Flight activity is the ratio of the proportion of specimens actually flying in the real collecting distance and thus available for the trap and the length of time the insects spend flying as compared to the duration of trapping. However, it is clear that the proportion of the total population, which currently flying in the air, and they spent time not measured (Nowinszky, 2008).

We published several new results regarding the effect of the Moon based on our own research (Nowinszky 2008; Nowinszky and Puskás, 2010, 2011, 2012 and 2013; Nowinszky *et al*., 2012a; Nowinszky *et al*., 2012b). Due to light pollution, the difference between the theoretical and actual collecting distance has become basically balanced out. Consequently, the catch of certain species is practically equal at a Full Moon and at a New Moon. The actual collecting distance – just like the theoretical one – varies by light-trap types and taxa.

Due to light pollution, the difference between the theoretical and actual collecting distance has become basically balanced out. Consequently, the catch of certain species is practically equal at a Full Moon and at a New Moon.

Generally, illumination by the Moon does not hamper the flight activity of insects. Besides the points made by Dufay (1964), the following facts prove this theory. It is a justified fact, that certain insects use polarized moonlight for their orientation. It is unthinkable that the activity of these insects would decrease when polarized moonlight is present in a high ratio. Our investigations have also proved the catch to be higher in case of higher polarization. In moonlit hours we observed a higher catch on more occasions than in hours without moonlight.

The relatively strong illumination by the Moon cannot be the reason for a catch minimum recorded on a Full Moon. Most insects start to fly in some kind of twilight and illumination at twilight is stronger by orders of magnitude than illuminated by moonlight.

Suction trap studies by Danthanarayana (1986) have not justified the decrease observable with light traps at a Full Moon. Observation is claiming that insects spend less time in flight during a Full Moon should be completed with similar observations for a New Moon. High standard scientific investigation is needed to study both periods.

Not even on the basis of the relative brightness of the Moon do we find a correction of the catch data acceptable, as this method does not consider the role of polarized moonlight and it is not effective throughout the whole lunar month (Nowinszky, 2008).

Our hypothesis is the following: In the absence of major light pollution, the reason for the low level of catch at a Full Moon might be the collecting distance that would be the shortest at this time, the fact that the insects rely on other sources of orientation because of the low polarization ration of moonlight, changed flight altitude [3] and, in the case of some species, the timing role of the Moon.

We examined in the current study how affect Moon the light trap catch of the *Lygus* species (Heteroptera: Miridae). Earlier we made similar examination with butterflies (Lepidoptera) and caddisflies (Trichoptera).

The majority of bug (Heteroptera) species can fly well onto the light (Kondorosy, 1997). However, several harmful species cannot be collected with light.

In Hungary till now from the light trap catch of bugs (Benedek and Jászainé, 1968; Jászainé 1964; Jászainé 1964-1966; Jászainé 1998; Rácz and Bernáth, 1993) published results, but these authors selected their topics only according to ecological and faunal viewpoints.

The species richness and abundance of the field bugs (Miridae), collected by the light traps, are important. Among these the most considerable ones are *Lygus rugulipennis* Poppius and *Lygus pratensis* Linnaeus, the individual number is high in both cases (Kondorosy, 1997).

Duviard (1974) investigated the effects of the moonlight among the foreign authors, but not in conjunction with our examined species. He collected the 79% of Belostomatidae species during two weeks around the full moon.

We mention the paper of Önder *et al.*, (1984) from the new studies. They collected in large number the *Exolygus pratensis* (L.), *Lygus rugulipennis* (Popp.), *Adelphocoris lineolatus* (Gz.) és a *Trigonotylus ruficornis* (G.) species of Miridae in Turkey.

2. Material and Methods

The light source of the applied Jermy-type light-traps was a 100W normal white light electric bulb hanged under a metal cover (Ø: 1m) at 200cm height above the ground. Most traps were operated without baffles and the insect material was led by a funnel under the bulb into a collecting jar. In each case, chloroform was used as a killing agent. The traps were operated through every night during the season from April until October. An automatic on/off switching technique guaranteed the capture of both crepuscular and nocturnal insects. Turning on the light trap was 18 O'clock every night and off at 4 am (UT) (Nowinszky, 2003).

Data on the illumination of the environment were calculated using our own software. This software for TI 59 computers was developed by the late astronomer G. Tóth specifically for our joint work at that time (Nowinszky and Tóth, 1987). The software was transcribed for modern computers by M. Kiss. The software calculates the illumination in terms of lux of the Sun at dusk, the light of the Moon and the illumination of a starry sky for any given geographical location, day and time, separately or summarized. It also considers cloudiness.

The data of Moonrise and set were got from astronomical yearbooks. From these, we counted the period of Moon stays above the horizon during all the investigated nights. The ratio of the percentage polarization of moonlight was taken over from our earlier work (Nowinszky and Tóth, 1987).

All our data on cloud cover were taken from the Annals of the Hungarian Meteorological Service. The data in these books are oktas of cloud cover (eighth part) recorded every 3 h (Nowinszky and Puskás, 2013).

The light trap collection data of *Lygus* Genus, caught in Fejér County (Hungary, Europe) between 1980 and 1995, were processed in conjunction with the collection distance, the polarized moonlight and the length of stay over the horizon of the Moon.

The material of caught species has not been determined, but its deciding majority belonged to individuals of *Lygus rugulipennis* Poppius, 1911 (European Tarnished Plant Bug) and *Lygus pratensis* Linnaeus, 1758 (Tarnished Plant Bug). Altogether 43758 individuals and 2793 monitoring data were available for the investigation.

The names of light trap catch stations, their geographical coordinates and the years of collecting are shown in Table 1.

We have calculated the relative catch values of the number of specimens trapped by years. Basic data were the number of individuals caught by one trap in one night. The number of basic data exceeded the number of sampling nights because in most collecting years more light-traps operated synchronously. In order to compare the differing sampling data of the Genus, relative catching values were calculated from the number of individuals. For examined Genus the relative catch (RC) data were calculated for each sampling day per site per year. The RC was defined as the quotient of the number of individuals caught during a sampling time unit (1 night) per the average catch (number of individuals) within the same generation relating to the same time unit. For example, when the actual catch was equal to the average individual number captured in the same generation/swarming, the RC value was 1 (Nowinszky, 2003).

Table 1. Years of trapping and geographical coordinates of light-trap stations.

Towns and villages	Years	Geographical coordinates	
		Latitudes	Longitudes
Dunaföldvár	1980	46°47'29"N	18°55'45"E
Dunaújváros	1980	46°58'03"N	18°56'13"E
Gánt	1982	47°23'47"N	18°23'26"E
Nadap	1981-1990	47°15'44"N	18°56'13"E
Pusztaegres	1981-1995	46°53'16"N	18°37'01"E
Rácalmás	1984-1985	47°01'51"N	18°56'60"E
Ráckeresztúr	1991	47°16'60"N	18°49'76"E
Sárosd	1982 and 1989	47°02'50"N	18°39'12"E
Seregélyes	1986	47°06'77"N	18°34'80"E
Sukoró	1986	47°14'40"N	18°39'99"E
Székesfehérvár	1980 and 1981	47°17'45"N	18°19'59"E
Velence	1980	47°14'32"N	18°39'28"E
Zámoly	1983-1990	47°19'00"N	18°24'64"E

Following we arranged the data on the catching distance, polarized moonlight and the duration of the Moon staying above the horizon in classes.

The data are plotted and regression equations were calculated for a relative catch of examining Genus and the parameters of the Moon data pairs.

3. Results and Discussion

Our results are shown in Fig. 1-6.

Our results proved that in the examined years, when the light pollution was not high yet, the increase of the collection distance increased the efficiency of the collection from New Moon to Full Moon and also from Full Moon to New Moon. In recent years, we demonstrated in our several studies the collection distance has minimal role, because of the light pollution in the latter decade.

The duration of the Moon staying above the horizon unambiguously causes the increase of the catch from New Moon to Full Moon and also from Full Moon to New Moon.

The proportion of polarized moonlight also leads to the increase in the catch both in the first quarter of the Moon and the last quarter of the Moon. These latter two results justify that the moonlight does not reduce the efficiency of the light trapping again together with the result of our earlier works.

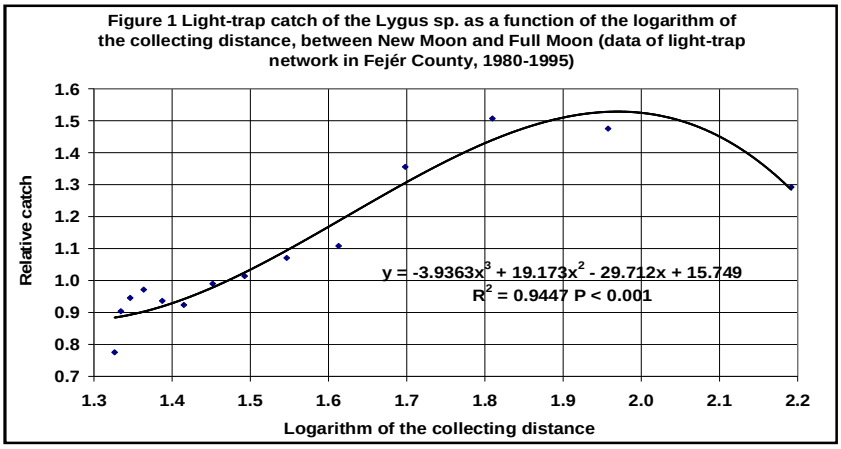


Figure 1 Light-trap catch of the Lygus sp. as a function of the logarithm of the collecting distance, between New Moon and Full Moon (data of light-trap network in Fejér County, 1980-1995)

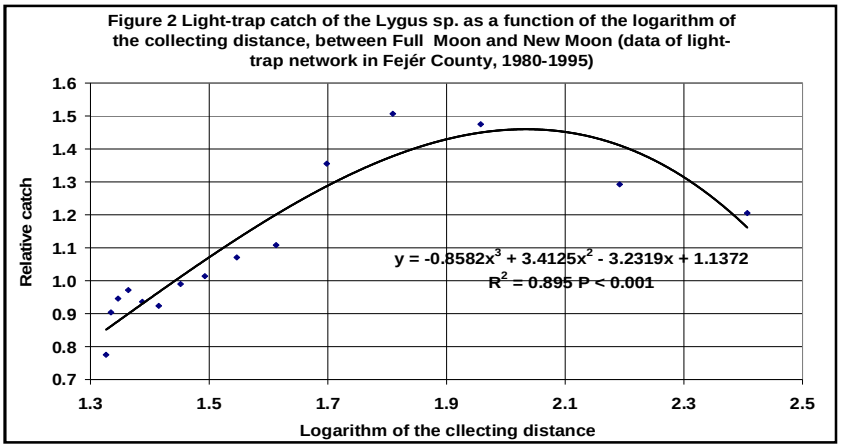


Figure 2 Light-trap catch of the Lygus sp. as a function of the logarithm of the collecting distance, between Full Moon and New Moon (data of light-trap network in Fejér County, 1980-1995)

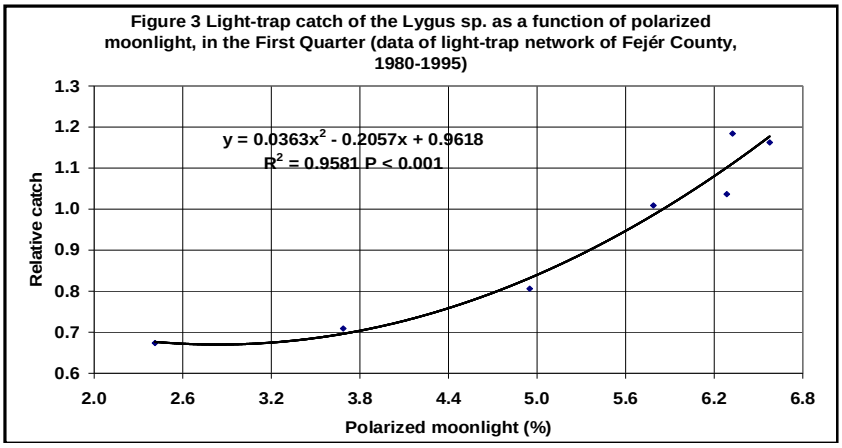


Figure 3 Light-trap catch of the Lygus sp. as a function of polarized moonlight, in the First Quarter (data of light-trap network of Fejér County, 1980-1995)

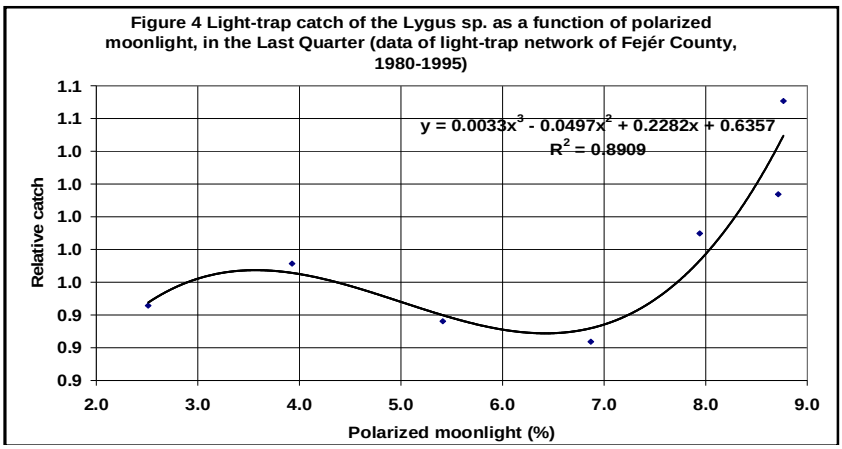
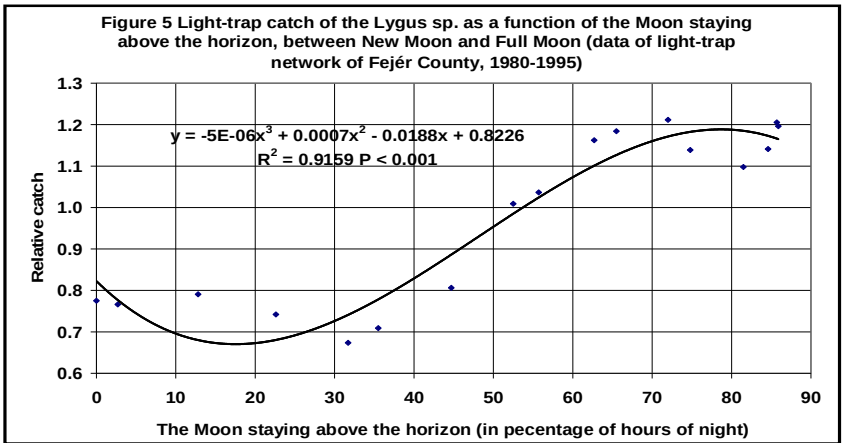
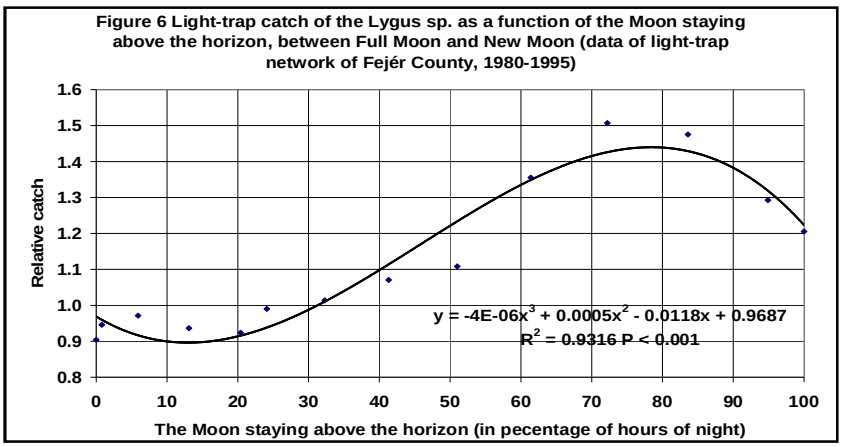


Figure 4 Light-trap catch of the Lygus sp. as a function of polarized moonlight, in the Last Quarter (data of light-trap network of Fejér County, 1980-1995)





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