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Research Article

Additions to Williams' Dilemma: Can Moonlight Impede Insect Activity? (Effectiveness of the Catch in the Vicinity of Moonrise and Moonset)

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Abstract

The study deals with the effectiveness of light-trap catch of insects in relation to moonrise and moonset. It was found that the catching results are better during the hour of moonrise or the hour after it, than in the hour before moonrise for all five species. However, the catch decreases during the hour of moonset or the hour following it. The results confirm that the moonlight did not decrease, but rather increased the effectiveness of the light-trap catch.

Introduction

The first simple light-trap working with electric light was developed more than and hundred years ago. Collectors found that the catch decreases during the hour of moonset or the hour following it. The results confirm that the moonlight did not decrease, but rather increased the effectiveness of the collection. Many studies in professional literature are devoted to the role of the Moon in modifying light trapping catch. The conclusions have been contradictory and up to this day a good many questions remain unclarified. Researchers soon noticed that fewer insects fly into the light around the Full Moon. Williams [1] first dealt with this question in depth. He thought it possible that the light of the Moon reduced the distance from which the insects responded to the light of the lamp. Another possibility, according to him, is that the moonlight inhibits the activity of insects. In the following decades, many studies were published on this topic with mixed results. Some authors considered the reduction of the collection area as a plausible explanation. Others believed that the activity-inhibiting effect of moonlight was proven. In this introduction, we can only refer to a few important studies, but we dealt with these possibilities in detail in our previous studies.

Partly on the basis of other authors in the literature, and partly on the basis of our own results, we only briefly summarize what we can currently say about Williams's dilemma. In previous decades, the influence of the collection distance was significant. However, there were species that were unable or unwilling to fly the long collection distance to the light source. The influence of the collection distance on the collection may have varied depending on the species. However, as light pollution increased in many countries around the world, the influence of the collection distance increasingly lost its importance. Today, the collection distance is only relevant in places that can be said to be free of light pollution. We refer to some important studies that report the activity-inhibiting effect of moonlight and some that report results that refute this. [2] Collected once in every hour in Andhra Pradesh, India. They recorded moonlight hourly at the zenith. High moonlight values resulted in a drop of the light-trap catch. Using a Robinson-type trap in Upper Egypt (Sa'id Misr), [3] studied the influence of the Moon by collecting moths in desert and agricultural areas. The catch was usually higher during nights without moonlight in both desert and agricultural habitats. Yela and Holyoak [4] detected a decrease in the catch in growing moonlight by using a modified Heaty-type UV trap in Southern Spain. Nemec [5] collected Corn Earworm (*Heliothis zea* Boddie) in highest numbers during a New Moon and in lowest numbers during a Full Moon. He was of the view that moths have an inactive period at a Full Moon. [6] discovered that the catch of most taxa changes in a 2:1 or 3:1 ratio between New Moon and Full Moon. [7] Sotthibandhu and Baker [8] argued that moonlight cannot have an influence on the collecting distance. Thus, in their point of view, increased light intensity moderates flight activity.

Dufay [9] most convincingly summarized the objections. The following observations by Dufay [9] 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 collecting decreases but does not stop,
- During lunar eclipses, the catch is high when the Moon is obscured, although closely before and after it is low. This observation is quite demonstrative, as the eyes of nocturnal insects adapt to darkness only 5-9 minutes after it sets in.

Our own research also proved that the moonlight does not inhibit the flight activity of insects. These conclusions were discussed in detail in our book dealing with the Moon and light trapping of insects [10]. In our current work, we examine this topic from a completely different perspective: We take a stand on this much-discussed issue based on the collection results of the moonrise and moonset clocks. Earlier, Agee [11] addressed this issue. He reported that few Corn Earworm (*Heliothis zea* Boddie) and other noctuids were active at a Full Moon, but many were active before the rise of the Moon and after its set. We have not published a study on such a topic previously.

Material

The data of the Moon's rise and Moon's set were taken from the Astronomical Applications Department U. S. Naval Observatory data for the years 1967, 1968, 1969 and 1976, 1977, 1978 and 1979. Light-trap collection with fractionating light-traps was carried out at two locations in Hungary. Prof. József Járfás operated a light-trap of his own design in Kecskemét (45°54′44″E and 19°41′50″N). The captured insects fell into different containers every hour. This fractionating light-trap system was operated between 1967 and 1969 from the beginning of May until the end of September in all three years. Collecting took place from 6 p. m. to 4 a. m. (UT) for ten hours every day, regardless of the time of sunset and sunrise.

Among the light trapped insects, Járfás provided us with the data of four moth species for our previous joint studies. We also used these data in this work (Table 1). The other location was Nagykovácsi (47°57′60″E and 19°88′38″N) near Budapest. This light-trap was designed by Prof. Zoltán Mészáros. A fractional type mercury vapour (125 W) light-trap was in work at Julianna-farm of the Plant Protection Institute between 1976 August and 1979 July work during 57 nights. The working period was 12 hours in spring, summer and the beginning of autumn from 5 p.m. until 5 a.m., but from the second part of October between 4 p.m. and 4 a.m. (UT). We used the data for a composite taxon of many species (Microlepidoptera species indeterminate) from the catching material of this light-trap. This included the largest number of captured individuals (Table 1).

Table 1: Catching data of examined species

Species	Number of		Number of	
	Moonrise	Moths	Moonset	Moths
Kecskemét, Járfás-type light-trap				
Crambidae, Pyraustinae				
European Corn-borer *Ostrinia nubilalis* Hübner, 1796	25	135	19	44
Arctiidae, Arctiinae				
Autumn Webworm *Hyphantria cunea* Drury, 1773	26	188	27	166
Noctuidae, Noctuinae				
Heart & Dart *Agrotis exclamationis* Linnaeus, 1758	27	209	24	121
Turnip Moth *Agrotis segetum* Denis & Schiffermüller, 1775	28	536	26	459
Nagykovácsi, Mészáros-type light-trap				
Microlepidoptera spec. indet	657	9	352	6

Methods

On all nights of the catching periods, we determined the time of the moonrise or moonset. We collected the catch data for both these hours and the previous and next hours and then summarized them by species. As the light-trap in Kecskemét operated on all nights of the catching periods, it tracked the swarming of the captured insects. Therefore, in our previous studies, we calculated the relative catch (RC) values from the number of moths caught [12]. The relative catch is the quotient of individuals caught in a given hour and the average number of individuals per sampling time unit (one hour). Its application enables the comparison of results obtained at different places or times. We used these relative catch data for this work.

Since the light-trap in Nagykovácsi only operated intermittently, its catch data did not follow the swarming of each species. Therefore, we could not calculate relative catch values from these. Therefore, we expressed the data of each night as a percentage. After that, we summarized and averaged the catching data for the hours of moonrise and moonset. In the same way, we summarized and averaged the data of the previous and next hours. The results are presented in figures.

Results and Discussion

The results are presented in **Figure 1a-5b**.

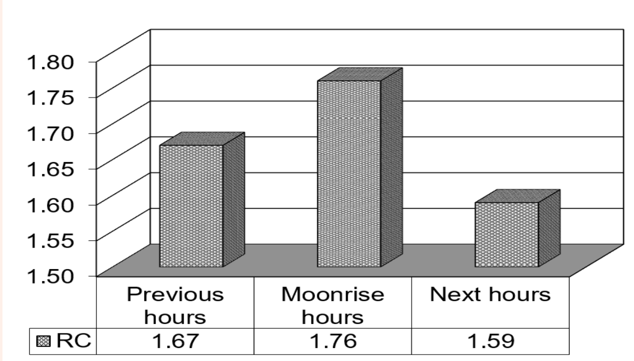

Figure 1a: Light-trap catch of European Corn-borer (*Ostrinia nubilalis* Hübner, 1796) in moonrise hours, previous- and next hours

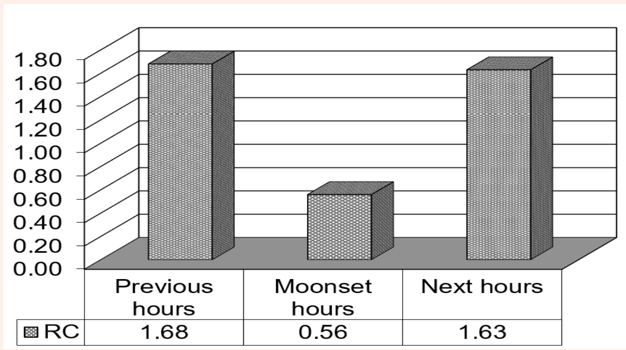

Figure 1b: Light-trap catch of European Corn-borer (*Ostrinia nubilalis* Hübner, 1796) in moonset hours, previous- and next hours

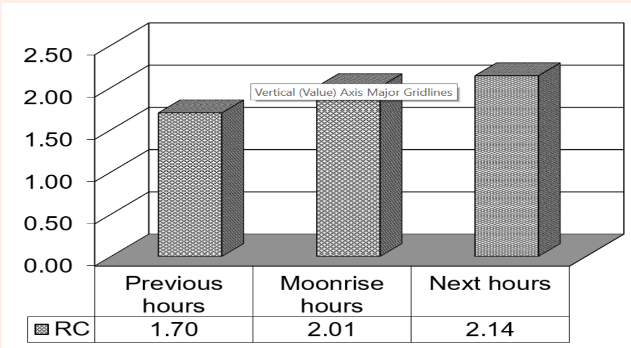

Figure 2a: Light-trap catch of Autumn Webworm (*Hypantria cunea* Drury, 1773) in moonrise hours, previous- and next hours

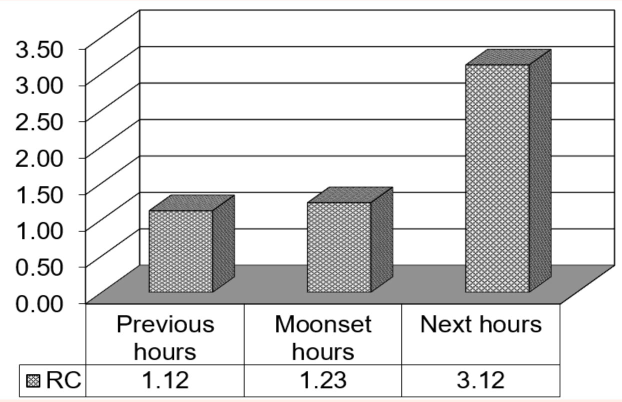

Figure 2b: Light-trap catch of Autumn Webworm (*Hypantria cunea* Drury, 1773) in moonset hours, previous- and next hours

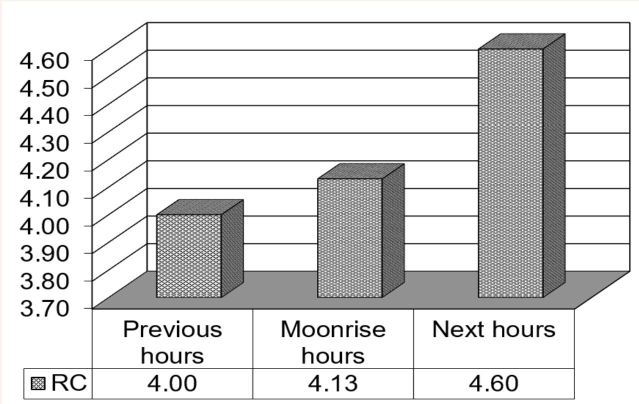

Figure 4a: Light-trap catch of Turnip Moth (*Agrotis segetum* Denis & Schiffermüller, 1775) in moonrise hours, previous- and next hours

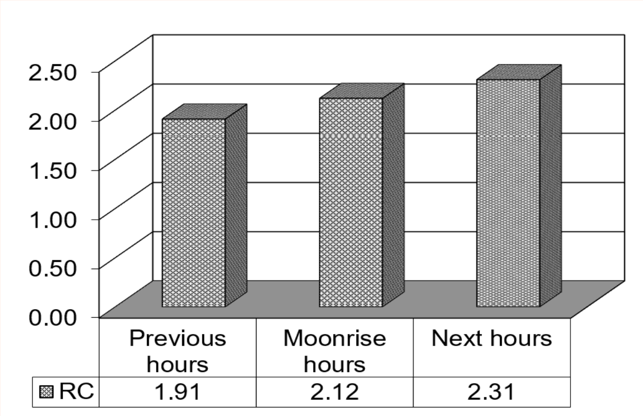

Figure 3a: Light-trap catch of Heart & Dart (*Agrotis exclamationis* Linnaeus, 1758) in moonrise hours, previous- and next hours

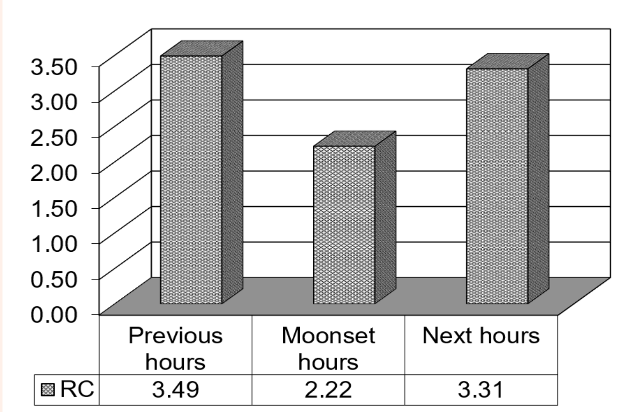

Figure 4b: Light-trap catch of Turnip Moth (*Agrotis segetum* Denis & Schiffermüller, 1775) in moonset hours, previous- and next hours

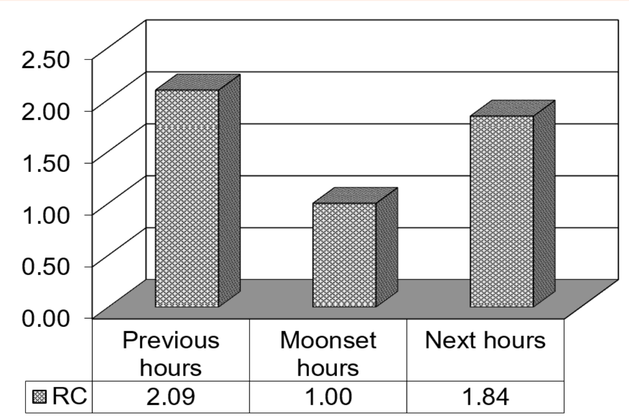

Figure 3b: Light-trap catch of Heart & Dart (*Agrotis exclamationis* Linnaeus, 1758) in moonset hours, previous- and next hours

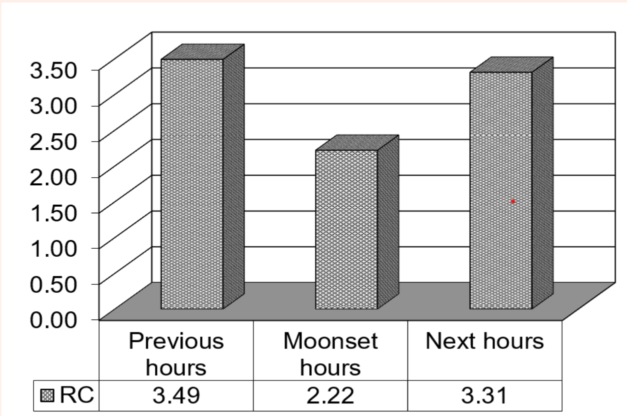

Figure 5a: Light-trap catch of *Microlepidoptera* spec. Indet. in moonrise hours, previous- and next hours

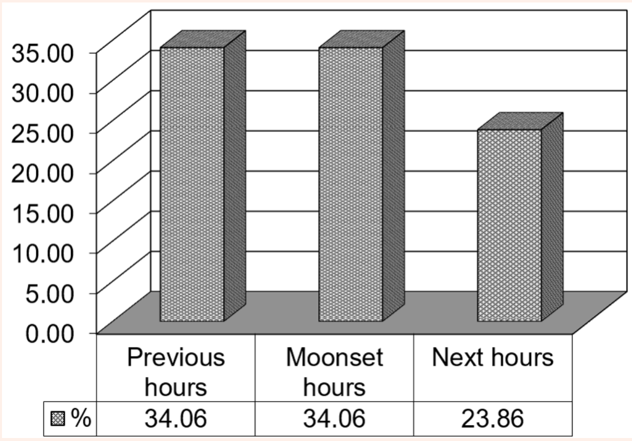

Figure 5a: Light-trap catch of *Microlepidoptera* spec. Indet. in moonset hours, previous- and next hours

Our results clearly prove that in the hour of moonrise, or in the following hour, when the whole hour is full of moonlight, the catch increases compared to the previous hour. This finding is true for all four species (Figures 1a-4a) and also for the microlepidopteran species group (Figure 5a). In three cases (Figures 2a-4a), the catch of the hour following the moonset is higher than the catch of the moonrise. This may be explained by the fact that there is no moonlight in the initial part of the moonrise hour. In the hour of moonset, the catch drops significantly compared to the catch of the previous hour, with two exceptions. In the case of *Hyphantria cunea*, the catch does not decrease, and even increases in the following hour. This result is therefore contrary to the results of the other species. The catch of Microlepidoptera spec. indet. during the hour of moonset does not decrease yet, but it does in the following hour. Despite the fact that we could process relatively little data, our results are remarkable. We examined the question of whether the moonlight reduces the activity of insects from a completely new perspective. Our results also prove that moonlight does not reduce, but rather increases, the activity of insects.

Conflicts of interest: None

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