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Light Trapping of Caught Macrolepidoptera Individuals and Species in Connection with Night Sky Polarization and Gravitational Potential of Sun

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Abstract

The study investigated the light-trap catch of Macrolepidoptera individuals and species in connection with night sky polarization and gravitation of Sun. We calculated the degree of polarization of the clear sky at the Zenith by using the Berry-method. We used the whole Macrolepidoptera data for investigation the number of species and individuals caught in Kámon Botanic Garden between 1962 and 1970 in connection with night sky polarization of Sun and Moon. We established in the study, that the gravitational potential of the Sun and the sky polarization caused influence on the light trap catch.

Keywords: Light-trap; Moths; Sun's polarization and gravity

Introduction

The polarization pattern of the sky in various sky conditions is nowadays well known thanks to the spread of full-sky imaging polar meters. The degree of polarization is maximal along a great circle of the sky being 90 degree from the Sun, and minimal at the Sun and anti-Sun [1]. The degree of polarization also depends on the atmospheric conditions. In cloudy [2] and foggy [3] skies, as well as under canopies [4] the degree of polarisation are much smaller compared to clear skies. However the direction of polarization pattern is very robust, the typical 8-shaped pattern as well as the axis of symmetry is well recognizable. When The Sun is well below the horizon and the moonlights the atmosphere, then the axis of symmetry is the celestial great circle containing the Moon [5]. Barta et al. [6] inspected the transition of characteristics of sky polarization between sunlit and moonlit skies during twilight. Verkhovskaya [7] reported the first time that the arthropods (Arthropoda) are able to distinguish between the polarized light and not polarized one. Insects are able to utilize the sky polarization from the Sun and the Moon for their orientation. This question is dealt with by many researchers and mainly experiments with aquatic insects. It has been well known for almost for half a century that the polarized light of the sky plays an important role in the orientation of certain insects.

Researchers, however, has been as yet concentrated primarily on insects flying in daytime or at dusk and entomologists have paid less attention to species active at night. Horváth & Varjú [8] discovered that some insects are able to use the polarization pattern of the sky in daytime and at dusk. According to Dragonflies & mayflies [9] and *Ephemera danica*, are also deceived by dry asphalt surfaces as these reflect strong horizontally polarized light. Bernáth et al. [10] found oil barrels and sparkling black plastic foils luring dragonflies and insects as if they were traps. Robertson et al. [11] found that the solar panels also operate as ecological traps.

The attraction of night flying insects to the polarized light was primarily investigated by researchers in the context of polarized moonlight. Nowinszky et al. [12]: *Coleoptera: Serica brunnea L., Melolontha melolontha L.*, Lepidoptera: *Operoptera brumata L, Hyphantria cunea* Drury, *Agrotis segetum Den. et Schiff.*), Danthanarayana & Dashper [13]: Certain mosquitoes and moths. Nowinszky et al. [14,15]: *Operophtera brumata L.* and eight Trichoptera species. Nowinszky & Puskás [16]: twenty-four *Microlepidoptera* species. Nowinszky & Puskás [17]. *Lygus* sp. Nowinszky & Puskás [18]: *Ostrinia nubilalis* Hbn. Nowinszky et al. [19]: Pheromone trapping of seven *Microlepidoptera* species. Dacke [20] and Dacke et al. [21] found that the Bogong Moths

(*Agrotis infusa Boisduval*) can use several types of celestial compasses that run along straight tracks. These are the Sun, the Moon, the polarized light pattern, and even the Milky Way, which is far more prominent than a single star.

According to Sotthibandhu & Baker [22] in case of a moonlit night the Moon azimuth is used as a signal as an information for orientation. In starlit night when the Moon is absence the stellar orientation about 95° from the pole star to strongly concerned. Kyba et al. [23] found that in the bright moonlit nights in a highly polarized light bands stretching from the sky at 90 degrees to the Moon, and has recently shown that the nocturnal organisms are able to navigate it. We did not find any study, apart from our own one [24], in the literature which investigate the effectiveness of light trapping in the context of sky polarisation.

Material and Methods

The astronomical data were calculated with a program based on the algorithms and routines of the VSOP87D planetary theory for Solar System ephemeris and written in C by J. Kovács. The additional formatting of data tables and some further calculations were carried out using standard Unix and Linux math and text manipulating commands. For computing the tidal potential generated by the Sun and the Moon we used the expansion of the gravitational potential in Legendre polynomials and expressed the relevant terms as a function of horizontal coordinates of the celestial objects.

We calculated the degree of polarization of clear sky lit by the Sun and by the Moon separately at the Zenith for every half hour between 1st January 1967 and 31st December 1969. For this we first determined the celestial position of the Sun and the Moon for every point in time of the above interval for a geographic position of 46° 54' 26.64"N and 19° 41' 30.12"E in Kecskemét, Hungary with the atmospheric refraction taken into account [25]. We then calculated the degree of polarization of the clear sky at the Zenith by using the Berry-method [26]. For this calculation we assumed a neutral point distance of 27.5° and for the sake of simplicity a maximum of degree of polarization of 100%. Note, that during this paper we did not use the absolute degree of polarization, instead only their relative ratios, so assuming 100% maximum degree of polarization does not influence our end results, despite being a non real scenario. We had only one collection data from a whole night, so we worked with the gravity and polarization data calculated for 23 hours (UT).

The Forest Research Institute operated a Jermy-type light-trap in Kámon Botanic Garden (Szombathely, Hungary) between 1962 and 1970. The geographical coordinates of this Botanic Garden are 47°25′66″N and 16°60′36″E. The light-trap consists of a frame, a truss, a cover, a light source, a funnel and a killing device. All the components are painted black, except for the funnel, which is white. The frame is fixed to a pile dug into the ground. A metal ring holding the funnel and a flattened conical cover made of zinc-plated tin joins the steel frame. The cover is 100cm in diameter. The distance between the lower edge of the cover and the higher edge of the funnel is 20-30cm. The light source is a 100W normal electric bulb [27]. This light-trap operated continuously in all the years, except on snowy winter days and a few malfunctioning nights.

All Macrolepidoptera species and individuals were identified from the catch of this period. There were caught altogether the specimen of 549 different Macrolepidoptera species by light-trap during 9 years in following families: *Drepanidae, Lasiocampidae, Saturniidae, Sphingidae, Geometridae, Notodontidae, Arctiidae, Noctuidae, Nolidae*. We used the whole Macrolepidoptera data for investigation the number of species and individuals in connection with night sky polarization of Sun and Moon.

The caught individuals and species were investigated with combined data for 9 years. They were examined separately according to each aspect: spring, early- and late summer, autumn and winter [28]. We only processed the material of the early and late summer jointly because of the few details of the other aspects. The number of individuals of the respective species was not considered on a daily basis, it was only examined whether certain species was present on a particular day. Data on more-generation species were processed separately according to generations. On the other hand if between the swarming times of two generations vagabond or migrating individuals between the swarming periods of two generations could be easily observed, these were considered as independent generation. And if the two generations were not to be separated unambiguously from each other, the procedure used with one-generation species was followed [29].

We have calculated the relative catch values (RV) of the number of caught individuals and species by summer aspects. Basic data were the number of individuals and species caught by one night. In order to compare the differing sampling data, relative values were calculated from the number of individuals and species for each sampling night per year. The RV was defined as the quotient of the number of specimen caught during a sampling time unit (1 night) per the average catch of individuals and species within the same aspect relating to the same time unit. For example when the actual catch was equal to the average individual number captured in the same aspect, the RV was 1 [30]. Of course, each species appears and disappears naturally, so each aspect cannot be separated from each other with a sharp borderline. It is necessary to take natural periods as a starting point [31] when we determine an examination period. Therefore, the estimate of the boundary limits is as follows: We depicted the number of every day captured species separately in every year and we marked the points separating the borders of each aspect on the received curves. Our own program, necessary to depiction, printed the dates for the marked points.

We have examined the effectiveness of gravitational potential and night sky polarization of Sun and Moon for the catch of individuals and species. We did not receive significant

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values neither the gravitational potential of Moon nor its sky polarization, so these results are not published. We depicted these and also the results coming from the different factors and the connection with catch. Since our catch data have Poisson distribution, the spreads are roughly the same as averages. Figures also show the confidence intervals.

Results and Discussion

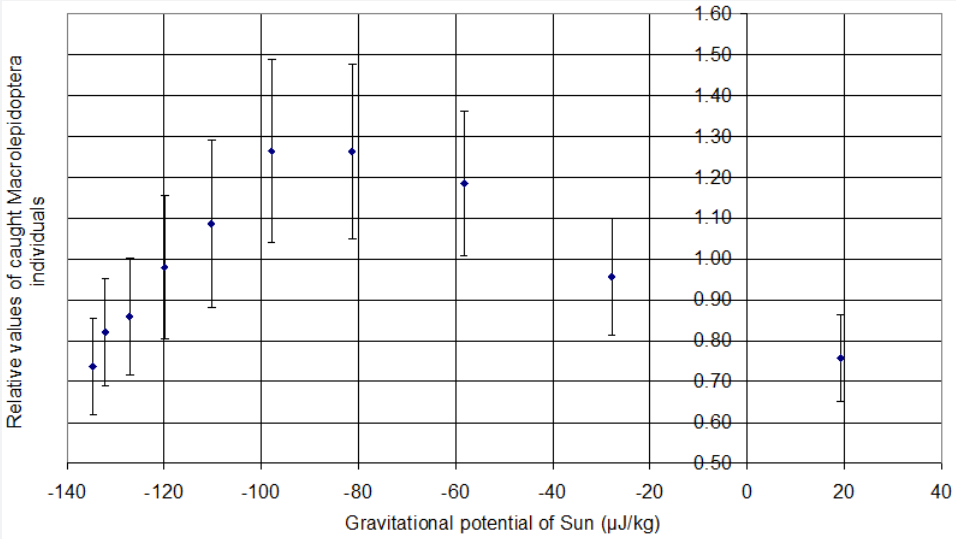

Figure 1 Light-trap catch of all Macrolepidoptera individuals in connection with gravitational potential of Sun

Figure 1: Light-trap catch of all macrolepidoptera individuals in connection with gravitational potential of sun.

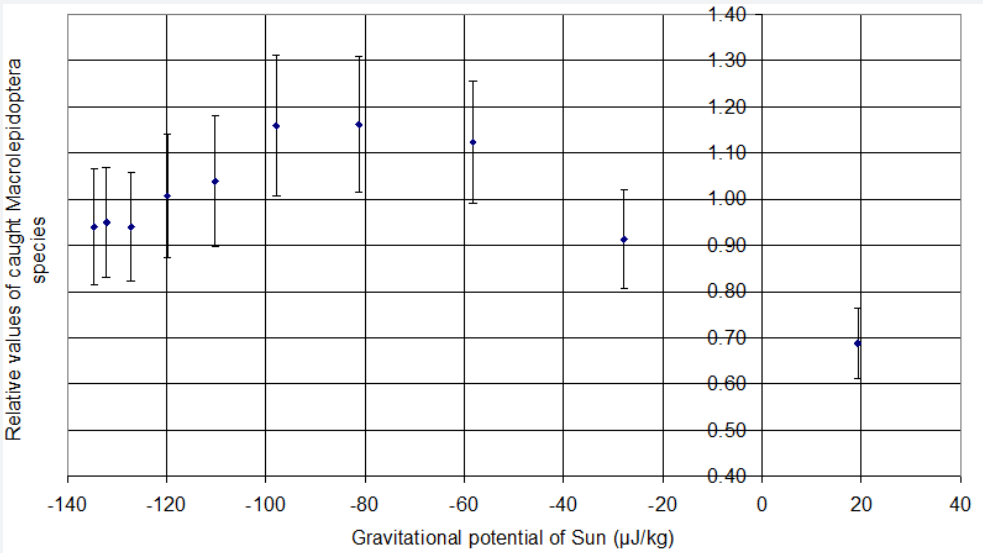

Figure 2 Light-trap catch of all Macrolepidoptera species in connection with gravitational potential of Sun

Figure 2: Light-trap catch of all macrolepidoptera pecies in connection with gravitational potential of sun.

The efficiency of gravitation potential of Sun for the catching results of caught individuals and species can be seen in Figure 1 & 2. The Sun is over the horizon only in the first and last collection hours, so it is there at dusk and dawn. Nevertheless, both its effects of the sky polarization and gravitation on the Macrolepidoptera individuals and species are larger than the Moon's influence. Our current result partially confirms and partially refutes our previous results. In our previous study [24], we processed the catch data of only one species (Turnip moth, *Agrotis segetum Denis et Schiffermüller*), but there we

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had only hourly catch data. We established in the study, that the gravitational potential of the Sun and the sky polarization caused by the Sun have an influence only in the period of dusk and dawn. The efficiency of night sky polarization originated by Sun for the catching results of caught individuals and species can be seen in Figure 3 & 4.

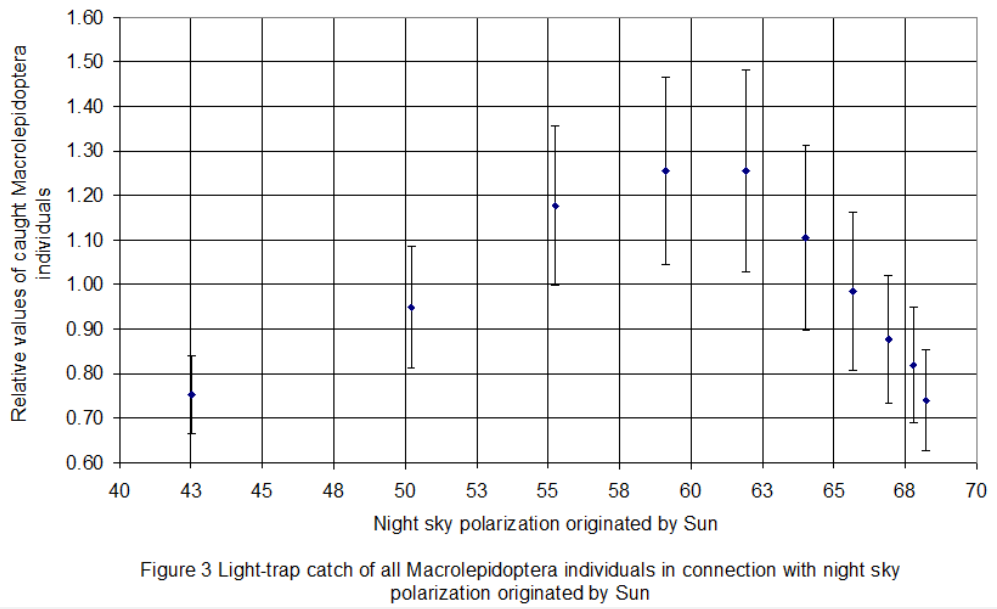

Figure 3: Light-trap catch of all macrolepidoptera individuals in connection with night sky polarization originated by sun.

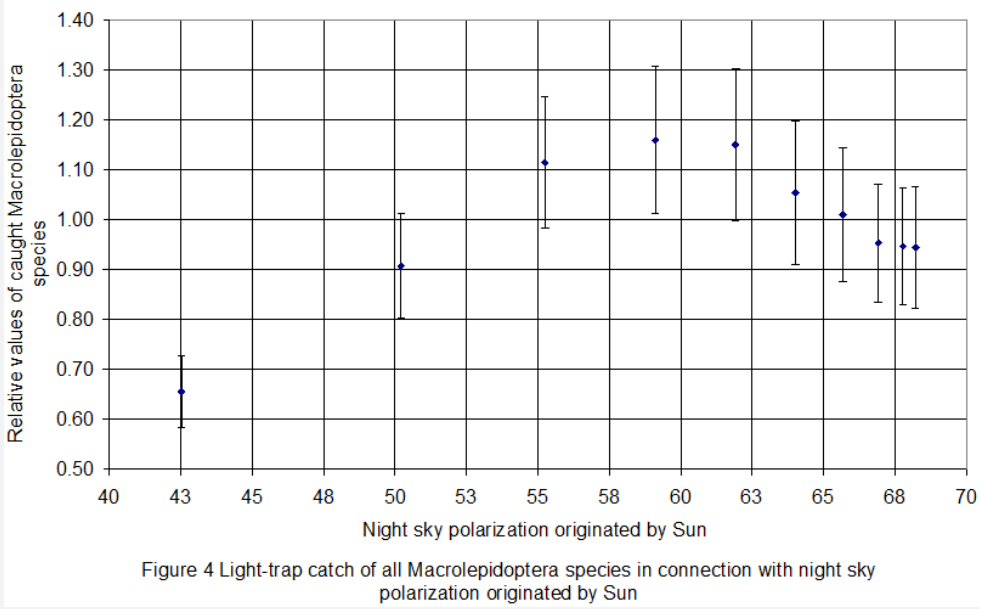

Figure 4: Light-trap catch of all macrolepidoptera pieces in connection with night sky polarization originated by sun.

In the largest part of the night the Moon has a greater influence on the light trap catch. However, our both studies proved that the gravitation of celestial bodies and the polarization of the sky have an influence on the collection. This is a new result and we did not find any precedent in the literature. Therefore, these should be taken into account when assessing the light trap catch results.

Conclusion

Our recent work calls attention of researchers to new and perhaps even more influential environmental factors. These are the gravitational potential of the Sun and the sky polarization originated by the Sun.

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of the low rate of formation of the crystallohydrate of Darunavir and proves the high probability of the fact that the water contained in PRE¬ZISTA and KEMERUVIR tablets is hygroscopic.

Based on the evidence found, we may assert that as API the crystalline Darunavir Ethanolate and Darunavir Amorphous have no substantial advantages over each other.

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