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ORIGINAL ARTICLE

Effects of the Night Sky Polarization Originated by Sun on the Light-Trap Catch of 21 Caddisfly (Trichoptera) Species in Hungary

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ABSTRACT

Our present study deals with the relationship between the night sky polarization originated by Sun and the light-trap catch of 21 caddisfly (Trichoptera) species. Our Jermy-type light-traps operated eleven years between 1980 and 2000 and around ten townships. Our recent work calls attention of researchers to new and perhaps even more influential environmental factor. It is the night sky polarization phenomena originated by Sun.

Key words: *caddisflies, Sun, sky polarization, light-trap*

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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 degrees from the Sun, and minimal at the Sun and anti-Sun (Horváth, *et al*. (1998). The degree of polarization also depends on the atmospheric conditions. In cloudy (Horváth, *et al*. (2002) and foggy skies, as well as under canopies (Hegedűs, *et al*. (2007) 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.

Insects can detect polarized light and night sky polarization originated from the Sun and it can be seen throughout the night, although its degree varies. The night sky polarization is particularly important for aquatic insects because they find their habitats on this basis.

The caddisflies (Trichoptera) an important group of aquatic insects that are active at night and en masse fly to the artificial light sources so they can be caught in bulk with light-traps (Malicky 1980, 1987), Usseglio-Polatera 1(987), Waringer (1991), Ujvárosi (1999, 2002), Graf, *et al*. (2008, Dicken & Boyaci (2008), Müller-Peddinghaus (2011), Rychla & Buczyńska (2013), Buczyńska, *et al*. (2014, 2016), Nowinszky, *et al*. (2016).

Horváth & Varjú (2004) discovered that some insects are able to use the polarization pattern of the sky in daytime and at dusk. According to Dragonflies & mayflies (Kriska, *et al*. (2008) and *Ephemera danica*, are also deceived by dry asphalt surfaces as these reflect strong horizontally polarized light. Bernáth, *et al*. (2001) found oil barrels and sparkling black plastic foils luring dragonflies and insects as if they were traps.

The attraction of night flying insects to the polarized light was primarily investigated by researchers in the context of polarized moonlight. Nowinszky & Tóth (1987), Nowinszky, *et al*. (1979, 2012a, 2012b) and Nowinszky & Puskás (2014, 2015), Danthanarayana & Dashper (1986) Dacke, *et al*. (2013), Dacke (2014) 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 (1979) in case of a moonlight 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*. (2011) 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 (Nowinszky, *et al*. 2017) in the literature which investigate the effectiveness of light trapping in the context of night sky polarization.

Many researchers dealt with the connection between the night sky polarization and the orientation of dissimilar aquatic insects, but they did not work on light-trap catch data (Gál, *et al*. 2001, Csabai, *et al*. 2006). Our recently published book (Nowinszky,) has been dealing with the results of light trapping of four Trichoptera species (*Hydropsyhe contubernalis* McLachlan, *Hydropsyche bulgaromanorum* Malicky, *Neureclipsis bimaculata* Linnaeus and *Halesus digitatus* Schrank) in connection with the night sky polarization.

MATERIAL AND METHODS

We made our own light-trap collections at ten sites in counties during the summer month's period (May to Sept.) of years between 1980 and 2000 on all nights (Table 1).

Table 1: The geographical coordinates of the own catching sites and years in Hungary, Europe

Collection sites	Years	Geographical	
		Latitude	Longitude
Nagy-Eged, Csomós farm-streamlet, Eger,	1980	47°54'N	20°22'E
Szilvásvárad, Szalajka stream,	1980	48°64'N	20°23'E
Nagyvisnyó, Nagy brook,	1981, 1984	48°08'N	20°25'E
Bükk, Vöröskő Valley	1982, 1983	48°34'N	20°27'E
Dédestapolcsány, Bán stream	1988	48°08'N	20°25'E
Szarvaskő, Eger stream	1989	47°59'N	20°51'E
Uppony, Csermely stream	1992	48°13'N	20°25'E
Zemplén Mountains, Kemence brook	1998	48°45'N	21°48'E
Göd, Danube River	1999	47°41'N	19°08'E
Szolnok, Tisza River	2000	47°10'N	20°11'E

Established Otto Kiss (2003) made the light-traps and identification of the specimens. In this study we used the data from the most frequently captured 21 species (Table 2).

We calculated the degree of polarization of clear sky lit by the Sun at the Zenith for every half hour between 1st January 1980 and 31st December 2000. For this we first determined the celestial position of the Sun 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 (this city is approximate in the middle of Hungary) with the atmospheric refraction taken into account (Meeus, 1998). András Barta calculated the degree of polarization of the clear sky at the Zenith by using the Berry-method (Berry, *et al*. 2004).

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 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).

Table 2: The name of families, species, years, number of individuals and nights

Families Species	Years	Number of individuals	Number of nights
Rhyacophilidae			
Rhyacophila tristis Pictet 1834	1998	566	100
Rhyacophyla fasciata Hagen, 1859	1980, 1981, 1989	655	257
Glossosomatidae			
Glossosoma conformis Neboiss 1963	1998	504	90
Hydroptilidae			
Agraylea sexmaculata Curtis, 1834	2000	1,725	127
Ecnomidae			
Ecnomus tenellus Rambur, 1834	2000	2,193	103
Hydropsychidae			
Hydropsyche contubernalis McLaclan, 1865	1992, 1999, 2000	37,876	459
Hydropsyche bulgaromanorum Malicky, 1977 Brachycentridae *Brachycentrus subnubilus* Curtis, 1834	1999	4,030	132
Lepidostomatidae			
Lepidostoma hirtum Fabricius, 1775	1999	2,434	107
Polycentropodidae			
Neureclipsis bimaculata Linnaeus, 1758	1982, 1983, 2000	30,579	283
Limnephilidae			
Ecclisopteryx madida Mc Lachlan 1867	1984, 1992	935	184
Potamophylax nigricornis Pictet, 1834	1982, 1983	9,519	174
Halesus digitatus Schrank, 1781	1982,1983, 1989, 2000	4,288	390
Limnephilus rhombicus Linnaeus 1758	1980, 1982	3,959	191
Goeridae			
Silo pallipes Fabricius, 1781	1988, 1998	1,646	131
Sericostomatidae			
Sericostoma personatum Kirby & Spence 1862	1982, 1983	2,266	238
Odontoceridae			
Odontocerum albicorne Scopoli 1763	1980, 1982-1983	1,816	311
Leptoceridae			
Oecetis ochracea Curtis, 1925	2000	385	103
Athripsodes albifrons Linnaeus, 1758	2000	814	115
Stodes punctatus Fabricius, 1759	2000	6,553	232
Ceracle dissimilis Stephens, 1836	2000	928	100

The size of the populations of different observers are in different places, and the modifying factors are not the same all the time and location of the trapping, it is easy to see that the same number of items you can capture an entirely different proportion of two different observers place or time, the population studied. To solve this problem, the application offers to the relative catch values (Nowinszky, 2003). The relative catch (RC) is for a given sampling unit time (one night) and number average equivalent time sampling unit relative to the number of generations before bassoon individuals divided. If the number of specimens is equal to the average, value of the relative catch is 1.

The relative catch data were classified into the appropriate night sky polarization divisions. The polarization divisions and the corresponding catch data were organized into classes. Their number was determined according to Sturges' method (Odor & Iglői 1987) using the following formula:

$$k=1+3.3 * 1g\ n$$

Where: k=the number of groups, n=the number of observation data.
The relative catch values were sorted according to the respective diurnal values of polarization values and then averaged and depicted. The figures also show the confidence intervals

RESULTS AND DISCUSSION

Our results can be seen in Figures 1–21.

Figure 1 Light-trap catch of *Rhyacophila tristis* Pictet in connection with night sky polarization originated by Sun

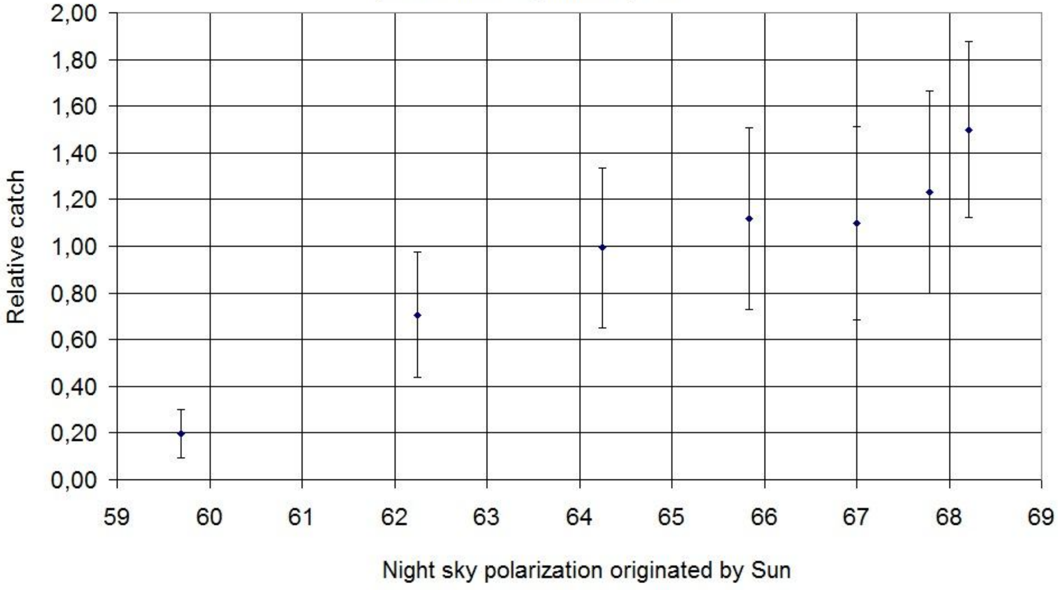


Figure 2 Light-trap catch of *Rhyacophila fasciata* Hagen in connection with night sky polarization originated by Sun

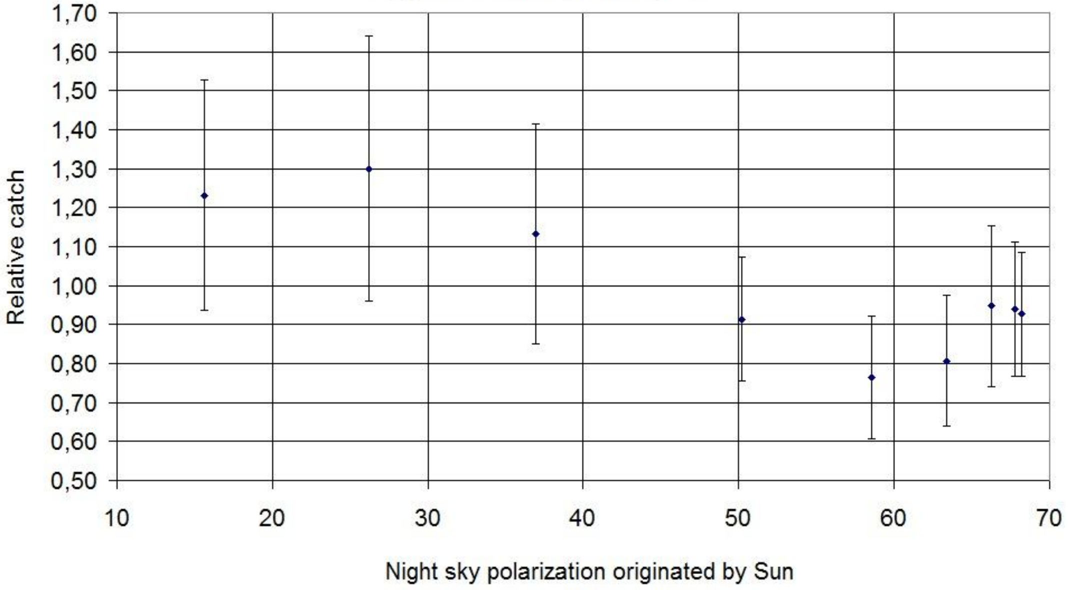


Figure 3 Light-trap catch of *Glossosoma conformis* Neboiss in connection with the night sky polarization originated by Sun

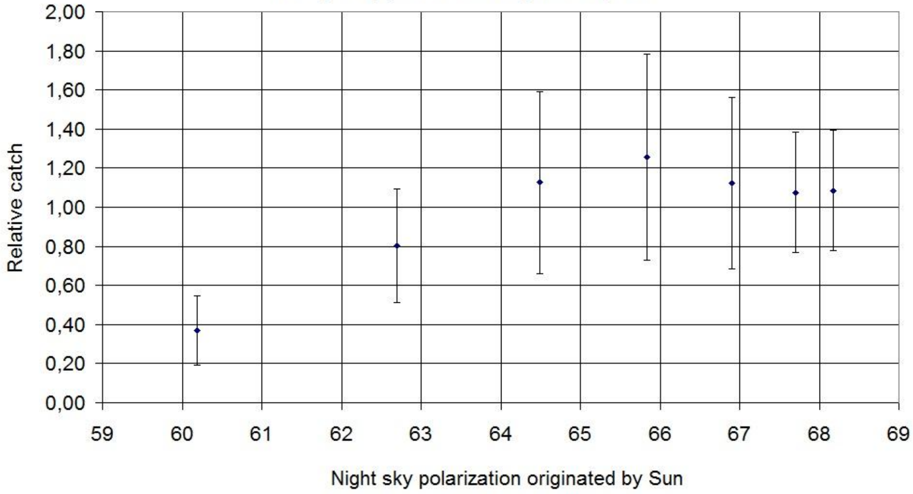


Figure 4 Light-trap catch of *Agraylea sexmaculata* Curtis in connection with night sky polarization originated by Sun

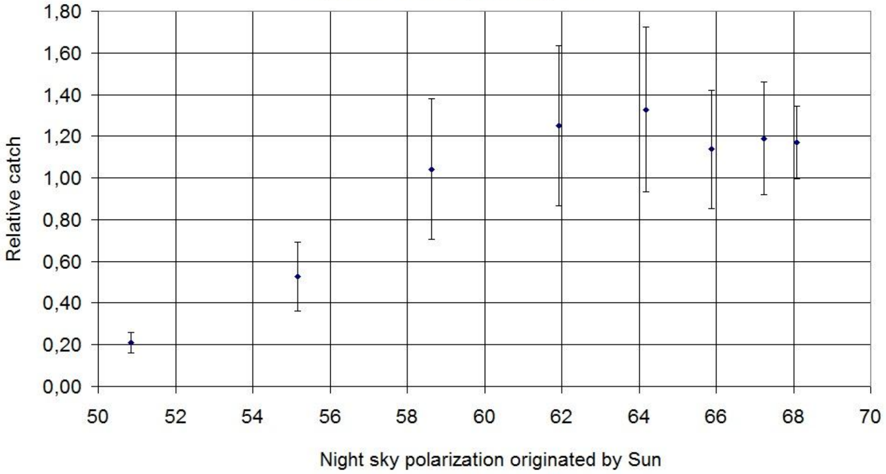


Figure 5 Light-trap catch of *Ecnomus tenellus* Rambur in connection with night sky polarization originated by Sun

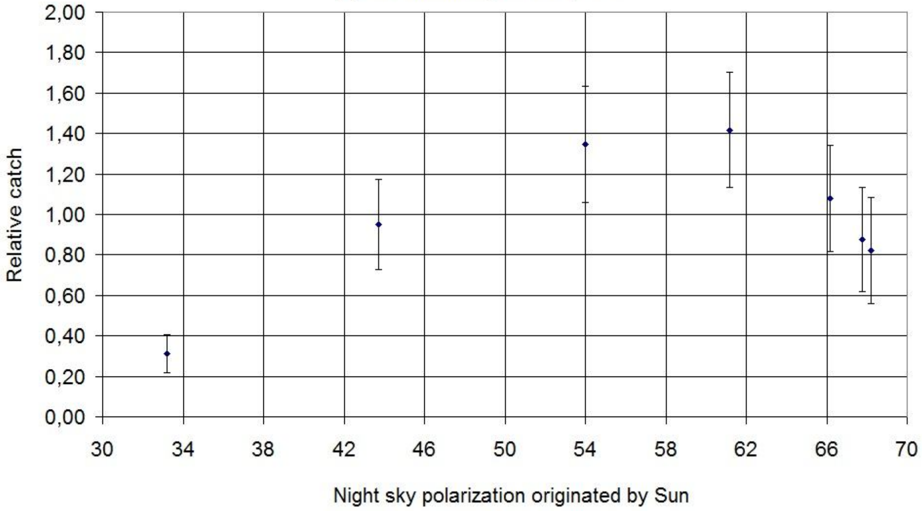


Figure 6 Light-trap catch of *Hydropsyche contubernalis* McLachlan in connection with night sky polarization originated by Sun

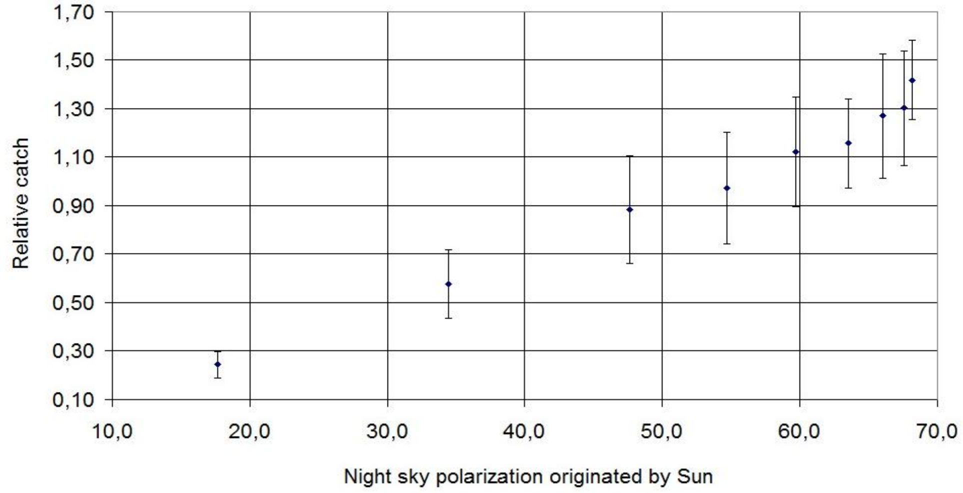


Figure 7 Light-trap catch of *Hydropsyche bulgaromanorum* Malicky in connection with night sky polarization originated by Sun

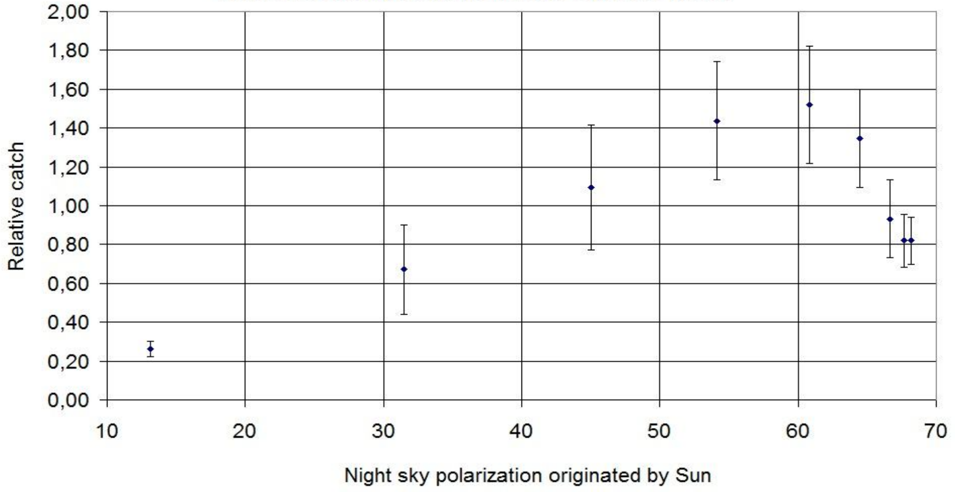


Figure 8 Light-trap catch of *Brachycentrus subnubilus* Curtis in connection with night sky polarization originated by Sun

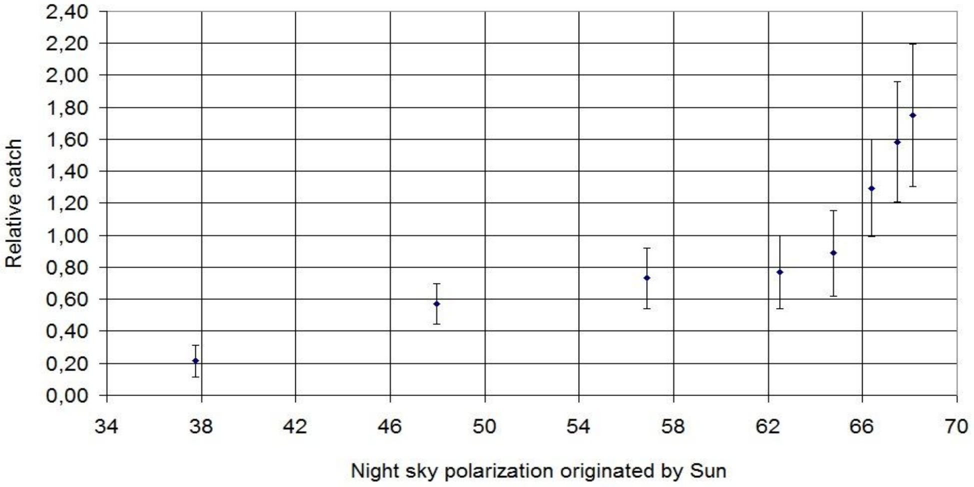


Figure 9 Light-trap catch of *Lepidostoma hirtum* Fabricius in connection with night sky polarization originated by Sun

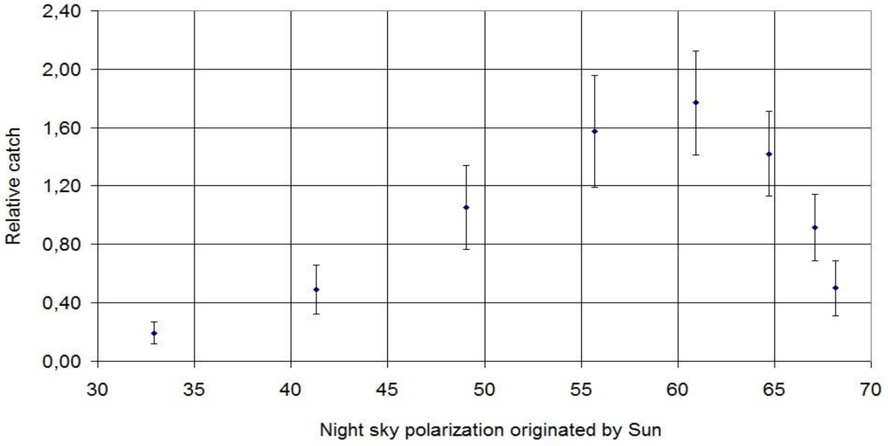


Figure 10 Light-trap catch of *Neureclipsis bimaculata* Linnaeus in connection with night sky polarization originated by Sun

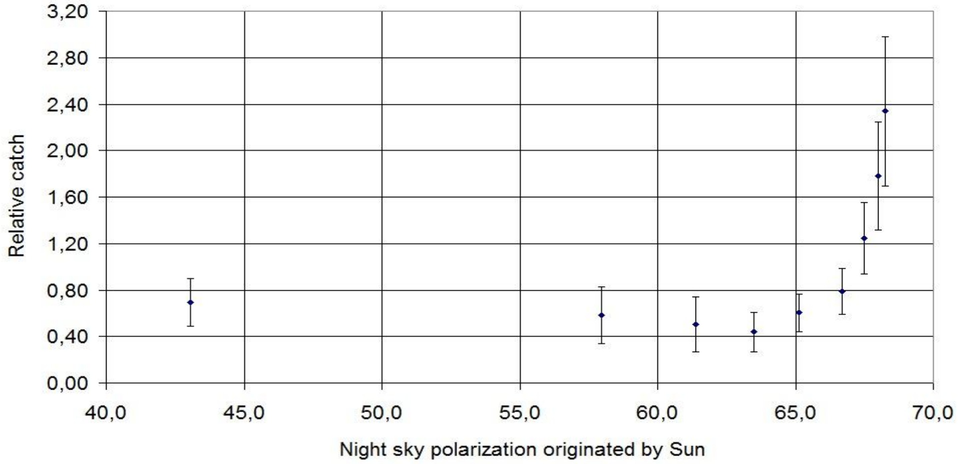


Figure 11 Light-trap catch of *Ecclipsoteryx madida* Mc Lachlan in connection with night sky polarization originated by Sun

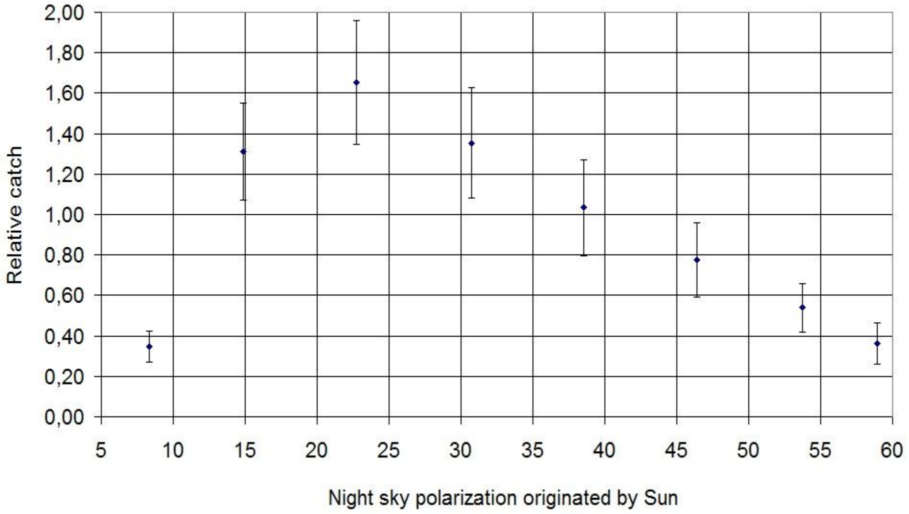


Figure 12 Light-trap catch of *Potamophylax nigricornis* Pictet in connection with night sky polarization originated by Sun

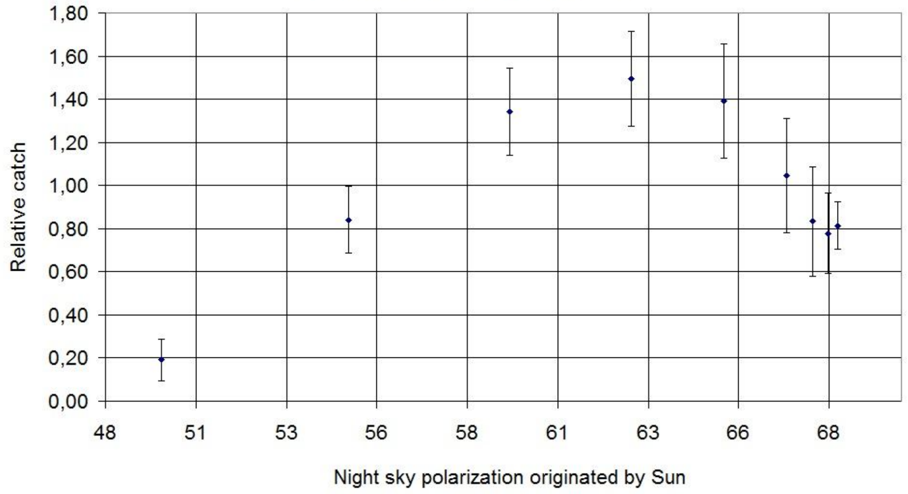


Figure 13 Light-trap catch of *Halesus digitatus* Schrank in connection with night sky polarization originated by Sun

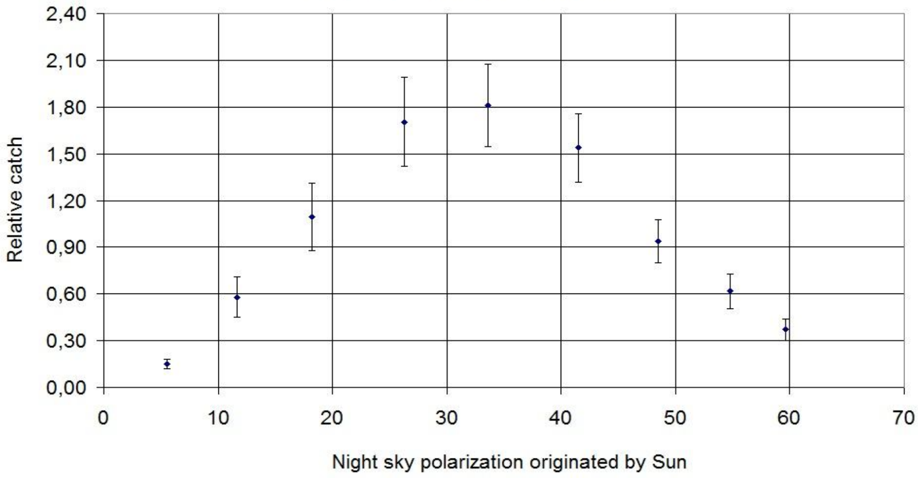


Figure 14 Light-trap catch of *Limnephilus rhomboicus* Linnaeus in connection with the night sky polarization originated by Sun

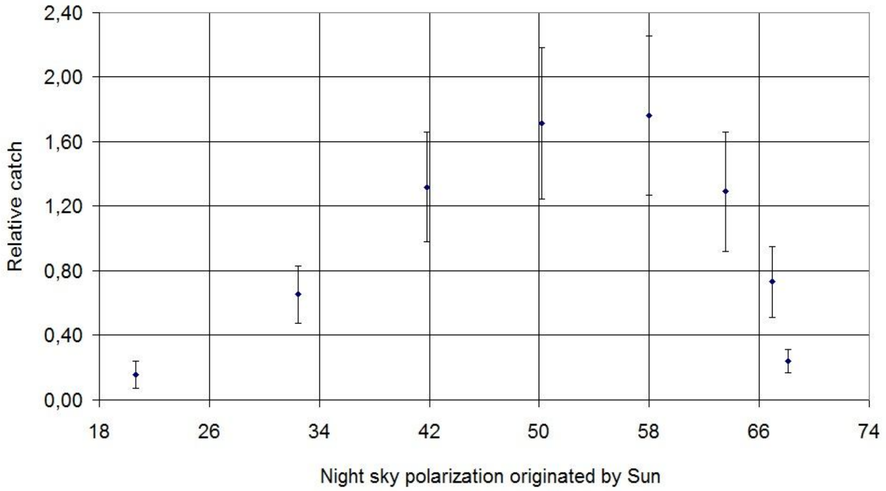


Figure 15 Light-trap catch of *Silo pallipes* Fabricius in connection with night sky polarization originated by Sun

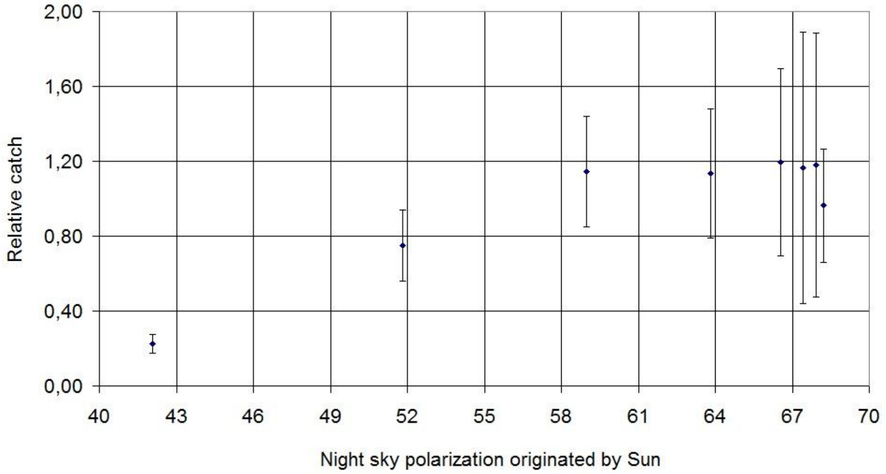


Figure 16 Light-trap catch of *Sericostoma personatum* Kirby & Spence in connection with night sky polarization originated by Sun

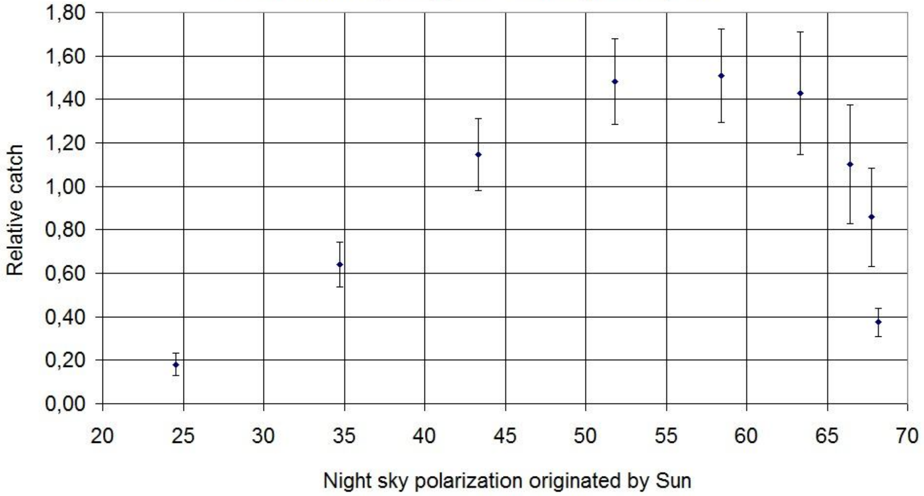


Figure 17 Light-trap catch of *Odontocerum albicorne* Scopoli in connection with the night sky polarization originated by Sun

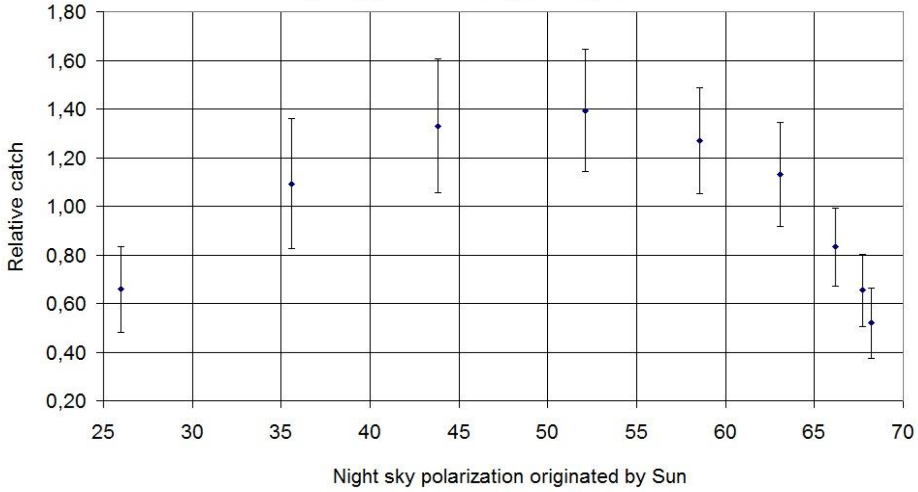


Figure 18 Light-trap catch of *Oecetis ochracea* Curtis in connection with night sky polarization originated by Sun

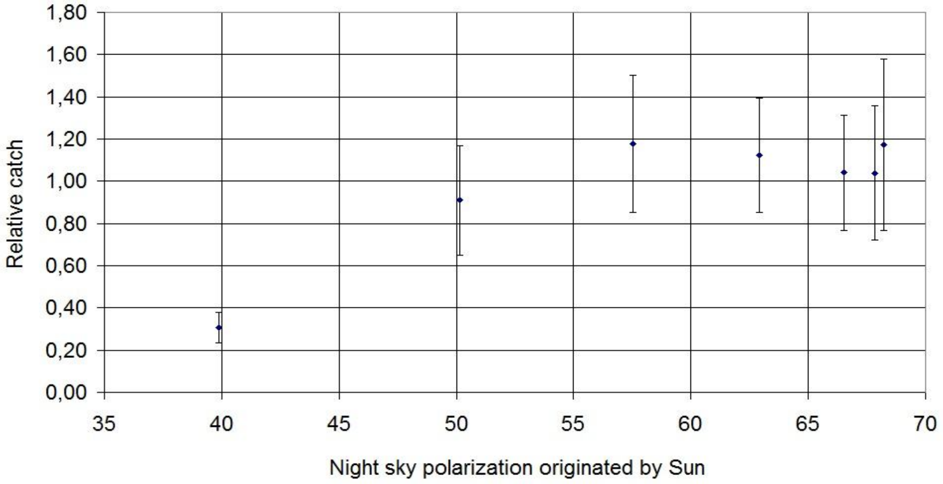


Figure 19 Light-trap catch of *Athripsodes albifrons* Linnaeus in connection with night sky polarization originated by Sun

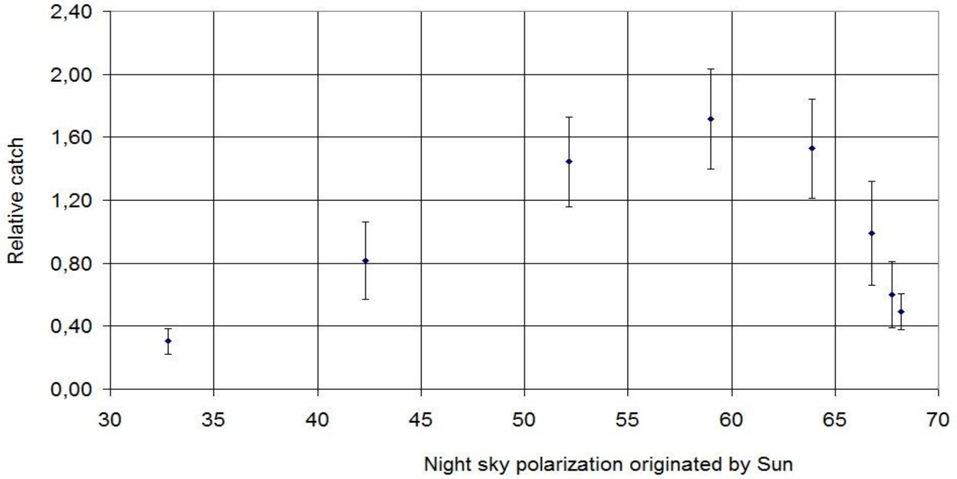


Figure 20 Light-trap catch of *Setodes punctatus* Fabricius in connection with night sky polarization originated by Sun

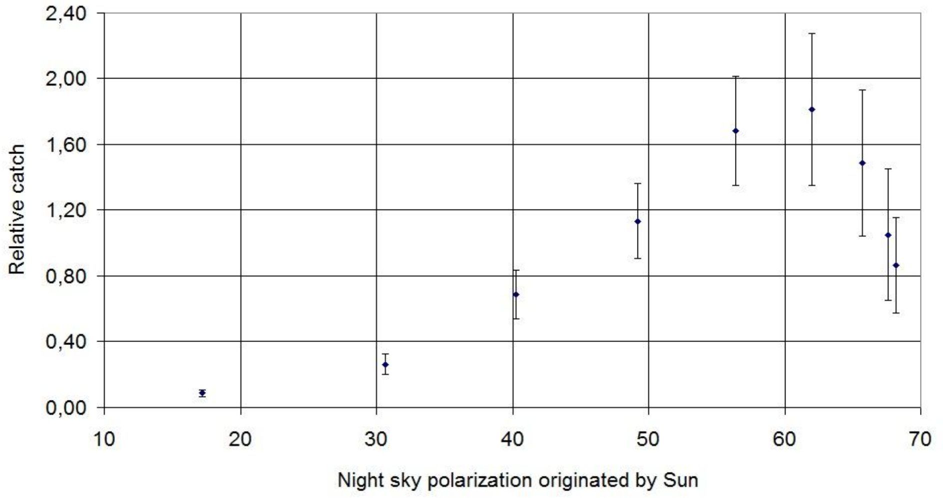
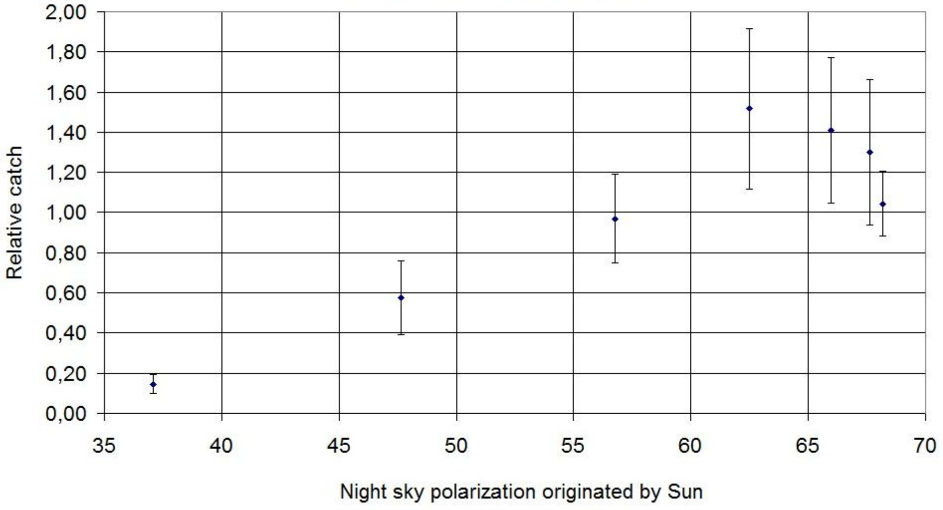


Figure 21 Light-trap catch of *Ceraclea dissimilis* Stephens in connection with night sky polarization originated by Sun



The illustrated Figures show that the catching results of the different species are significantly in connection with the night sky polarization originated by Sun.

The Sun is over the horizon only in the first and last catching hours, so it is there at dusk and dawn. Nevertheless, its effects of the sky polarization on the caddisflies individuals are larger than the Moon's influence.

In our earlier book (Nowinszky, *et al*. 2016) we have already reported that some environmental factors influence the light-trap catching results of Trichoptera species.

Our study proved that the night sky polarization of the Sun has an influence on the light-trap catch of Trichoptera species. This is a new result and we did not find any precedent in the literature out of our earlier studies. Therefore, these should be taken into account when assessing the light trap catch results.

It is striking, however, that the individuals of Trichoptera species fly in bulk to the light at different values of the night sky polarization originated by Sun. This phenomenon may be related to different night-time activities of different species. It is known that various species fly en masse at other hours of the night.

Unfortunately, there are no data on the species, which have been investigated, but foreign studies prove this fact.

Tchernyshev (1961) holds that the flight activity of each insect species has its specific daily rhythm. The caddisfly species start flying later of sunset and reach their peak early in the evening. Some East-African species fly throughout the night.

Jackson & Resh (1991) collected with live females and males of tree caddisfly species *Dicosmoecus gilvipes* Hagen, 1875 (Limnephilidae), *Gumaga nigricula* McLachlan, 1871 and *Gumaga griseola* McLachlan, 1871 (Sericostomatidae). They established the individuals of *Dicosmoecus gilvipes* are caught in the first hour after sunset, the *Gumaga nigricula* during the hour before sunrise and the *Gumaga griseola* 2-4 hours after sunrise.

Wright, *et al*. (2013) found that caddisfly specimens representing 44 species were collected from sunset until sunrise from a large river in northern Lower Michigan. Mean specimen abundance peaked at 22:30, approximately 1 hour after sunset.

Peak specimen abundance occurred at 22:30 in the meadow habitat and at 22:30 and 23:00 in the forest habitat (Brakel *et al*. 2015).

The peak of the swarming of *Athripsodes bergensis* Scott 1958 occurs within one hour after sunset, but changes every month: October and early November 25-33 minutes, November and mid-January 29-65 minutes, March 35-50 minutes (De Moor & McIlleron 2016).

In our previous work (Nowinszky, *et al*. 2017) we have already shown the night sky polarization originated by the Sun is visible to the insects throughout the night, but its percentage changes. It is highest at dusk and dawn, while the lowest in Hungary is between hours 22:30 and 23:30 (UT).

The results presented in Figures 1-21 demonstrate that different Trichoptera species can be effectively caught at different sky polarization values. From this fact and from Figure 22, we can give a conservative valuation of the most active flight hours of the examined species during the night.

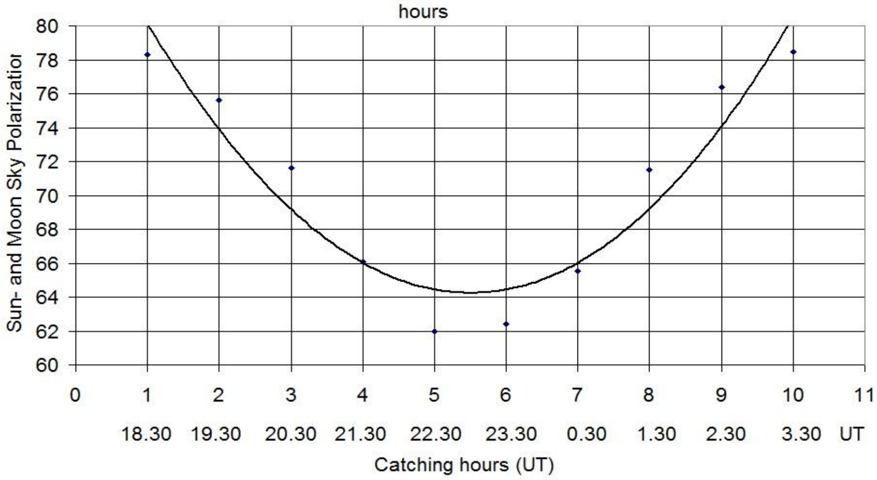


Figure 22 Night sky polarization originated by Sun in connection with the catching hours

Our recent work calls attention of researchers to new and perhaps even more influential environmental factor. It is the night sky polarization originated by the Sun and Moon.

It is striking that the light trapping of all twenty-one caddisfly species is more strongly modified by the Sun's gravitational potential and the night sky polarization than of the Moon. This fact can be experienced despite that the night sky polarization originated by Moon is much stronger than the Sun’s one except the twilight and early hours. However, the Moon's movement is one of the most complicated issues of celestial mechanics, its presence or absence varies according to complex periods (Nowinszk & Tóth, 1987). Therefore, the Sun represents more information than the Moon for the insects.

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