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# Light-Trap Catch of Caddishflies (Trichoptera) in the Carpathian Basin and Anatolia in the Four Quarert of the Moon

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## ABSTRACT

The study deals with the effect of Moon on light trapping of caddisflies (Trichoptera) species. The light-traps have operated in the following years: 1980, 1981, 1982, 1984, 1988, 1992 and 2000 at seven Hungarian sampling sites. Diken and Boyaci (2008) operated light-traps in year 2004 at Eğirdir Lake (Turkey). We analysed of eleven species from four families in Hungary and eight species belonging to four families in Turkey. Relative catch values, calculated from daily catching data, were calculated by the four moon quarters: New Moon, First Quarter, Full Moon and Last Quarter.

The significant catch maxima of different species in different moon quarters can be found.

We could investigate only those species which were caught in great number by traps. Our results confirm that the Moon affects the lives of caddisflies (Trichoptera) and this fact is important in reproduction of caddisflies, taxonomy studies, protection of aquatic habitats and nature conservation research as well.

*Key words*: Caddisflies, light-trap, moon quarters, Carpathian-Basin, Anatolia.

## INTRODUCTION

The most important sampling tool for the entomological research of the night flying insects is the light-trap, which is used by researchers worldwide nearly a hundred years ago. The number of collected specimens is influenced by a number of environmental factors and the moonlight is one of the most important factors. The examined caddisflies species, studied in our work, live in the moderate zone in different climatic territories. The swarming distribution of caddisflies is influenced by more factors such as the favourable or unfavourable change of meteorological elements to the swarming. It was demonstrated that higher evening temperature can increase the intensity of swarming. According to previous several studies most of individuals fly at ascendant air temperature (Waringer, 1991; Hirabayashi *et al*., 2011). There are some factors, beyond the meteorological conditions, that make trapping more successful. These are: the numerous aquatic elements in the environment (fountains, runnels, rivers and lakes), the groups of vagrant imagos which can fly also large distances and they reach the light-trap at different periods. These insects can extend the efficiency of catch and also the number of species and individuals. Our study searched the influence of different moon quarters for light-trap catch of caddisflies (Trichoptera).

The caddisflies (Trichoptera) are one of the most important groups of aquatic insects, the seasonal activity is therefore essential to understanding the ecological investigations (Kiss, 2003).

The caddisflies (Trichoptera) imagos generally are active at night and they fly well to artificial light. Therefore the most suitable method is the light trapping to know their swarming period (its beginning and end and peaks), the swarming activity if investigated species and mass proportion according to Crichton and Fisher (1978), Crichton (1988), Malicky (1980), Urk *et al*. (1991), Waringer (1991), Szentkirályi (1997) and Kiss (2003). It is important in this research the characterization of caddisflies species and their function in nature conservation research.

Numerous studies are devoted to the role of the Moon in modifying light trapping catch. Most authors observed a decline in the catch under the influence of the Moon. Williams (1936) offers two possible explanations: Moonlight reduces insect's activity (particularly Lepidoptera: Noctuidae), or if there is moonlight at night, the traps ollect the insects from smaller area. Important experiments by Dacke *et al*. (2003) proved that the African scarabid beetle (*Scarabeus zambesianus* Péringuey) is able to navigate with the use of polarization sky pattern of moonlight.

Only a few authors mention that the moonlight decreases the light-trap catch of the caddisflies. Mackay (1972) found that the number of caddisflies caught by black light trap was low on nights of full moon, especially when the moon was above the horizon. Jackson and Resh (1991) used sex pheromones to catch for three caddisflies (Trichoptera) species, *Dicosmoecus gilvipes* (Hagen, 1875) (Limnephilidae), *Gumaga nigricula* (McLachlan, 1871) (Sericostomatidae) and *Gumaga griseola* (McLachlan, 1871). They found that the intensity of light affects the flight activity, but not the daily periodicity of flight. According to Janzen (1983) less caddisflies - like moths - are attracted by artificial light in the moonlit night. Corbet (1958, 1964) using Robinson-type light traps (125W mercury vapour bulbs) collected Trichoptera species over a hundred consecutive nights on the shore of Lake Victoria. The light-trap catch of the *Athripsodes ugandanus* Kimmins, 1953 (Leptoceridae) was found to have two peaks in the first and last quarter. We did not find in the literature other than our previous study (Nowinszky *et al*., 2010) dealing with the light-trap catch of the caddisflies (Trichoptera) in connection with the moon phases.

The swarming of caddisflies starts mainly after dusk and peaks before midnight at the early or late evening, but flying of many species continues till dawn (Tshernyshev 1961; Jackson and Resh, 1991). According to Ward (1992) the most of Trichoptera species are active at dusk and at night. The flight behaviour of each species is very important to know because it may explain the different behaviour in the lunar quarters.

## MATERIAL AND METHODS

The light-trap collection points in Hungary, their geographical coordinates, the species lists, their caught specimens and the number of nights on which trapping occurred are shown in the Table 1. The data come from our own collection, but the data of *Oecetis ochracea* Curtis are from Újhelyi (1971).

The light-trap used in Hungary consists of a 125 W mercury vapour lamp and 1 m in diameter of a protecting cover. Under the lamp there is a collecting funnel, its diameter is 40 cm, and leads into a glass bin. Pure chloroform was used as killing agent. Our light-traps operated every night of every year between 1st April and 31st October.

We processed the data of Anatolia (Turkey) from the study of Diken and Boyaci (2008). They collected the shore of Eğirdir Lake (37°50'N-38°15N' and 30°04'-30°51'E) in Turkey in Isparta province between April and October 2004. The light-traps of Diken and Boyaci (2008) were set up in different three stations in the lake shore. The light-trap type used in their research was operated with the fluorescent BL tube. Trichoptera sampled once a week, during two hours, after the sunset. Published data of Diken and Boyaci (2008) can be seen in Table 2.

It was necessary to our work to determine the four typical moon quarters - New Moon, First Quarter, Full Moon and Last Quarter - in the investigated periods. The phase angle is the value of φ angle at the Moon in plane triangle of Sun - Earth - Moon system (Nowinszky *et al*., 1979).

The lunar phase angle values were calculated with our own computer program, at 10 p. m. (UT) is Hungary and 8 p. m. (UT) in Turkey.

Based on the number of specimens caught in Hungary and Turkey, we calculated relative catch values for each species and swarming. Relative catch (RC) is the ratio of the number of specimen caught in a given sample unit of time and the average number of specimen caught in the same time unit calculated for the whole brood. If the number of the specimen trapped equals the average, the value of relative catch is: 1.

The relative catch (RC) values of each species is assigned to phase angle values of the catching nights. The lunar phase angle values and the corresponding relative catch values along the four lunar quarters (full moon = 0° or 360°, first quarter = 90°, new moon = 180° and the last quarter = 270°) have been categorized around and then hold a quarter each have been summarized and averaged them. The data of species that behave same way were plotted together.

We listed our collecting data - separately for males and females - as a four moon quarter surroundings. The four quarters of the Moon's moonlight were divided into by photometric characteristics of the moonlight in different phase angles. The total lunar month, angle of 360 months (approximately 30 days) included

7-7 days (72-72 phase angles) belong to the First Quarter and Last Quarter. This time the polarization of moonlight is positive, the plane of polarization is perpendicular to the plane of the horizon. The plane angle of polarization lies to the plane direction of slight. 5 days (phase angle 48) belong to the Full Moon. At the time of a Full Moon the moonlight is unpolarized. With the increase of the phase angle, negative polarization is observable that is the oscillation plane of the electrical vector lies in the plane of sight.

Table 1. The species caught, the trapping sites and years, number of individuals and nights own collection and *Oecetis ochracea* Curtis unpublished data from Újhelyi (1971).

| *Species and light-trap station* | *Geographic coordinates* | *Number of individuals* | *Number of nights* |
|---|---|---|---|
| **Rhyacophilidae** | | | |
| *Rhyacophila fasciata* Hagen 1859 | | | |
| Szilvásvárad Szalajka stream, 1980 | 48°64'N; 20°23'E | 103 | 141 |
| Nagyvisnyó Nagy brook, 1981 | 48°08'N, 20°25'E | 110 | 168 |
| *Hydropsyche contubernalis* Mc Lachlan 1865 | | | |
| **Ecnomidae** | | | |
| *Ecnomus tenellus* Rambur 1842 | | | |
| Nagy-Eged, Csomós farm-stead, Eger, 1981 | 47°54'N; 20°22'E | 239 | 81 |
| Uppony Mountains, Csernely brook, 1992 | 48°13'N, 20°25'E | 4047 | 101 |
| **Hydropsychidae** | | | |
| *Hydropsyche instabilis* Curtis 1834 | | | |
| Szilvásvárad, Szalajka stream, 1980 | 48°64'N; 20°23'E | 1761 | 89 |
| Nagy-Eged, Csomós farm-stread, Eger, 1980 | 47°54'N; 20°22'E | 76 | 146 |
| Bükk, Mountains, Vöröskő-Valley, 1981 | 48°34'N; 20°27'E | 2656 | 123 |
| Bükk, Mountains, Vöröskő-Valley, 1982 | 48°34'N; 20°27'E | 7169 | 99 |
| *Hydropsyche bulgaromanorum* Malicky 1977* | | | |
| Szolnok, Tisza River, 2000 | 47°10'N, 20°11'E | 22343 | 109 |
| **Limnephilidae** | | | |
| *Ecclisopteryx madida* Mc Lachlan 1867* | | | |
| Nagyvisnyó, Nagy brook, 1981 | 48°08'N, 20°25'E | 54 | 78 |
| Nagyvisnyó, Nagy brook, 1984 | 48°08'N, 20°25'E | 502 | 102 |
| Uppony Mountains, Csernely brook, 1992 | 48°13'N, 20°25'E | 431 | 98 |
| *Limnephilus lunatus* Curtis 1834 | | | |
| Szilvásvárad Szalajka stream, 1980 | 48°64'N; 20°23'E | 341 | 98 |
| *Limnephilus flavicornis* Fabricius 1787 | | | |
| Szilvásvárad, Szalajka stream, 1980 | 48°64'N; 20°23'E | 99 | 125 |
| *Limnephilus rhombicus* Linaeus 1758* | | | |
| Szilvásvárad, Szalajka stream, 1980 | 48°64'N; 20°23'E | 249 | 126 |

Table 1. The species caught, the trapping sites and years, number of individuals and nights own collection and Oecetis ochracea Curtis unpublished data from Újhelyi (1971).

| *Species and light-trap station* | *Geographic coordinates* | *Number of individuals* | *Number of nights* |
|---|---|---|---|
| **Limnephilidae** | | | |
| Potamophylax | | | |
| *Potamophylax nigricornis* Pictet 1834 | | | |
| Bükk, Mountains, Vöröskő-Valley, 1982 | 48°34'N; 20°27'E | 3666 | 89 |
| *Halesus digitatus* Schrank 1781 | | | |
| Szilvásvárad, Szaljka stream 1980 | 48°64'N; 20°23'E | 839 | 90 |
| Bükk Vöröskő-Valley, 1981 | 48°34'N; 20°27'E | 104 | 70 |
| Bükk Vöröskő-Valley, 1982 | 48°34'N; 20°27'E | 1287 | 104 |
| Uppony Mountains, Csernely brook, 1992 | 48°13'N, 20°25'E | 1037 | 129 |
| **Goeridae** | | | |
| *Goera pilosa* Fabricius 1775* | 48°13'N, 20°25'E | 1037 | 129 |
| *Silo pallipes* Fabricius 1781* | | | |
| Szilvásvárad, Szalajka stream, 1980 | 48°64'N; 20°23'E | 199 | 110 |
| Szilvásvárad, Szalajka stream, 1981 | 48°64'N; 20°23'E | 641 | 110 |
| Nagyvisnyó, Nagy brook, 1984 | 48°08'N, 20°25'E | 86 | 106 |
| **Odontoceridae** | | | |
| *Odontocerum albicorne* Scopoli 1763 | | | |
| Szilvásvárad, 1980 | 48°64'N; 20°23'E | 316 | 120 |
| Szilvásvárad, 1981 | 48°64'N; 20°23'E | 451 | 114 |
| Bükk Vöröskő-Valley, 1982 | 48°34'N; 20°27'E | 618 | 112 |
| Bükk Vöröskő-Valley, 1983 | 48°34'N; 20°27'E | 845 | 131 |
| Nagyvisnyó, 1984 | 48°08'N, 20°25'E | 65 | 59 |
| **Leptoceridae** | | | |
| *Oecetis ochracea* Curtis 1825 | | | |
| Hódmezővásárhely | 46°25'N, 20°19'E | 1175 | 59 |
| Kenderes | 47°13'N, 20°25'E | 1187 | 59 |
| Kompolt | 47°44'N, 20°14'E | 1351 | 59 |
| Kisvárda | 48°13'N, 22°04'E | 678 | 59 |

Table 1. The species caught, the trapping sites and years, number of individuals and nights own collection and Oecetis ochracea Curtis unpublished data from Újhelyi (1971) Continue.

| *Species and light-trap station* | *Geographic coordinates* | *Number of individuals* | *Number of nights* |
|---|---|---|---|
| **Leptoceridae** | | | |
| Mikepércs | 47°26'N, 21°38'E | 1448 | 59 |
| Tarhos | 46°48'N, 21°12'E | 1486 | 59 |
| Velence | 47°14'N, 18°39'E | 256 | 59 |

Table 2. The species caught, the trapping sites and years, number of individuals and nights from published data of Diken and Boyacı (2008).

| *Light-trap station and species and geographic coordinates* | *Number of individuals* | *Number of nights* |
|---|---|---|
| Eğirdir Lake between 37°50'N, 30°04'and 38°16'N, 30°57'E | | |
| **Ecnomidae** | | |
| *Ecnomus tenellus* Rambur 1842 | 4028 | 7 |
| Hydropsyche | | |
| *Hydropsyche bulbifera* McLachlan,1878 | 383 | 20 |
| **Hydroptilidae** | | |
| *Hydroptila angustata* Mosely,1939 | 543 | 20 |
| *Hydroptila aegyptia* Ulmer,1963 | 7068 | 21 |
| *Agraylea sexmaculata* Curtis, 1834 | 848 | 17 |
| *Orthoctrichia costalis* Curtis, 1834 | 40 | 9 |
| **Leptoceridae** | | |
| *Mystacides nigra* Linnaeus, 1825 | 756 | 20 |
| *Oecetis ochracea* Curtis,1825 | 29340 | 20 |
| *Athripsodes longispinosus* Martynov,1909 | 25517 | 21 |
| *Ceraclea senilis* Burmeister,1839 | 251 | 18 |
| *Oecetis furva* Rambur,1825 | 94 | 15 |
| **Phryganeidae** | | |
| *Phryganea grandis serti* Sipahiler, 2000 | 968 | 7 |

Finally 11 days (168 phase angles) belong to the New Moon; there is no measurable polarization of moonlight of course (Nowinszky *et al*., 1994).

We determined in which moon quarter flew higher number the different species to light-trap.

Relatively little data were available for each species, so the species where the swarming peak can be found in the same Moon Quarter, were included. This ensured that significant results are obtained.

## RESULTS AND DISCUSSION

With the help of t-tests we have found that some species flew in a significantly higher number to traps during a particular moon quarter.

Light-trap catch of five caddisflies species living in the Carpathian Basin (Hungary) (*Goera pilosa* Fabricius, 1775, *Hydropsyche instabilis* Curtis, 1834, *Hydropsyche contubernalis* McLachlan, 1865, *Limnephilus auricula* Curtis, 1834 and *Limnephilus flavicornis* Fabricius, 1787) were significantly higher in the Last Quarter of the Moon compared to the other three ones (Fig. 1).

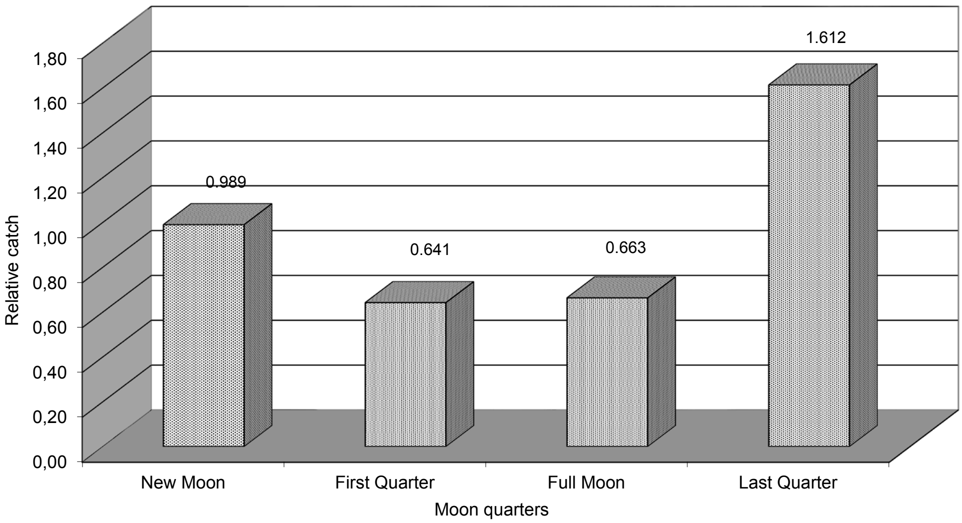


Fig. 1. Light-trap catch of *Goera pilosa* Fabr., *Hydropsyche instabilis* Curtis, *Hydropsyche contubernalis* McLachlan and *Limnephilus flavicornis* Fabr. in connection with the Moon Quarters (Hungary). Significant catching peak (P < 0.01) is at the Last Quarter.

The Moon can be seen in Last Quarter in the early morning sky and during this time is found the highest percentage of the ratio of polarized moonlight. The insects are able to use the polarized moonlight for their spatial orientation (Nowinszky *et al*., 1979, Danthanarayana and Dashper, 1986, Dacke *et al*., 2003). These species are also likely to fly at dawn. Tshernyshev (1961) and Jackson and Resh (1991) also stated that many caddisflies species fly until dawn.

We have found that the catch of *Ecclysopteryx madida* McLachlan, 1867 and the *Limnephilus rhombicus* Linnaeus, 1758 in the Carpathian Basin and *Ceraclea senilis* Baurmeister, 1839 and the *Phrygane grandis serti* Sipahiler, 2000 at Lake Eğirdir was high in the Last Quarter and also at New Moon (Fig. 2 and 3). Probably these species can fly to long distance during one night, therefore the high percent of polarized moonlight and also the biggest collecting distance at New Moon (Nowinszky, 2008) extends the success of light-trap catch.

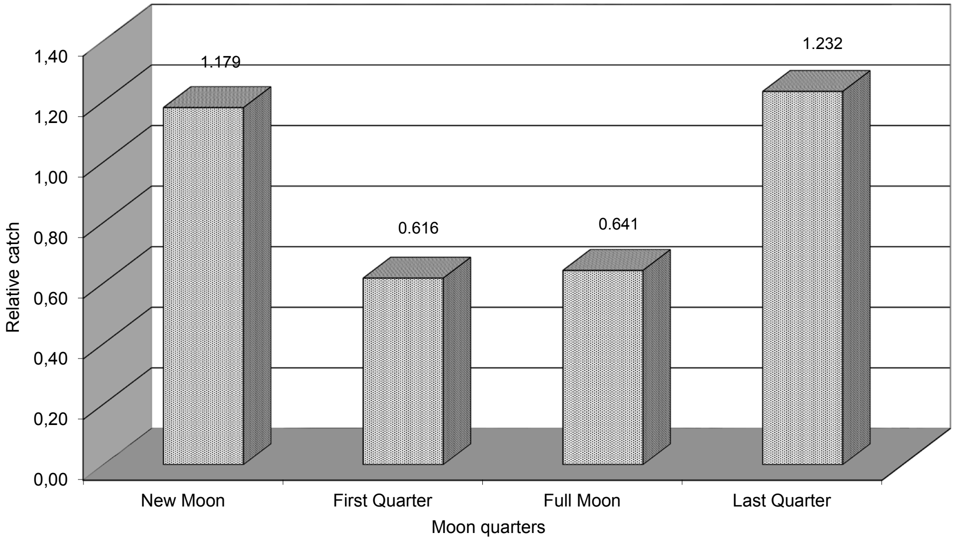


Fig. 2. Light-trap catch of the *Ecclysopteryx madida* McLachlan and *Limnephilus rhombicus* L. in connection with the Moon Quarters. Significant catching peaks ($P < 0.05$) are at the New Moon and Last Quarter (Hungary).

The catch of *Limnephilus ignavus* McLachlan, 1865 and *Potamophylax rotundipennis* Brauer, 1857 is really effective only at New Moon. These species are able to take advantage of the large collection distance (Fig. 4).

The catch peak is at New Moon and Full Moon for *Ecnomus tenellus* Rambur, 1842 and *Silo pallipes* Fabricus, 1781 in the Carpathian Basin and *Orthoctrichia costalis* Curtis, 1834, *Mystacides nigra* Linnaeus, 1758 and *Oecetis ochracea* Curtis, 1825 at Lake Eğirdir (Fig. 5 and 6), but the catch peak of *Hydropsyche bulgaromanorum* Malicky, 1977 is at Full Moon (Fig. 7). This is surprising, because there were no catch maximum in relation with moths at Full Moon according to previous studies (Nowinszky, 2008). The moon is almost full moon all night, staying above the horizon. It is assumed that the presence of Moon can give the major orientation information for these insects.

According to Wehner (1984), insects active at night helped by the light of the Moon, are capable of finding orientation in space, despite the fact that being able to do so is much more difficult than getting orientation by the Sun at daytime. Orientation of some species may be more important by the vision of the Moon during whole night, as the polarized portion of the moonlight.

The success of catch is best in the First Quarter for *Halesus digitatus* Schrank, 1781, *Limnephilus lunatus* Curtis, 1834, *Odontocerum albicorne* Scopoli, 1763 and *Rhyacophila fasciata* Hagen, 1859 (Fig. 8).

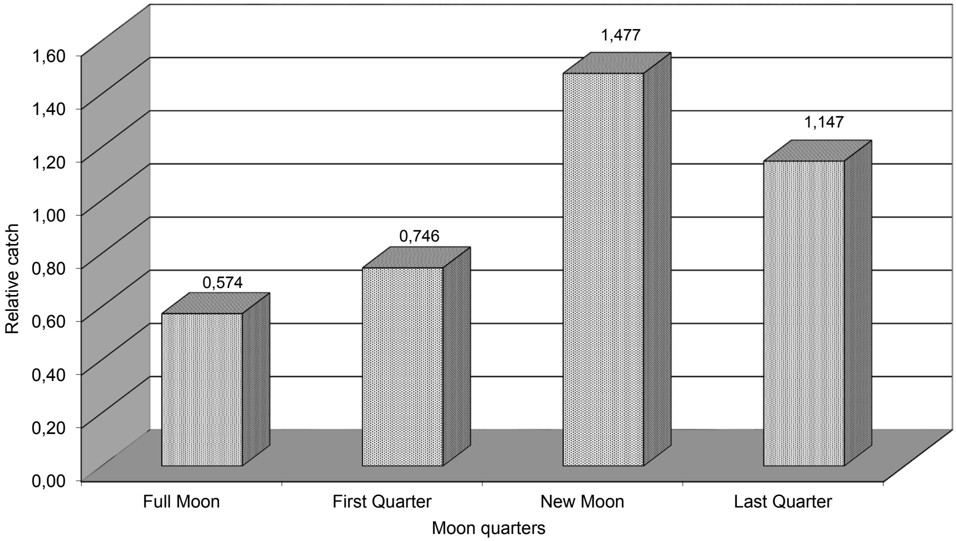


Fig. 3. Light-trap catch of the *Ceraclea senilis* Baurmeister and *Phrygane grandis serti* Sipehiler in connection with the Moon Quarters. Significant catching peaks ($P < 0.05$) are at the New Moon and Last Quarter (Turkey).

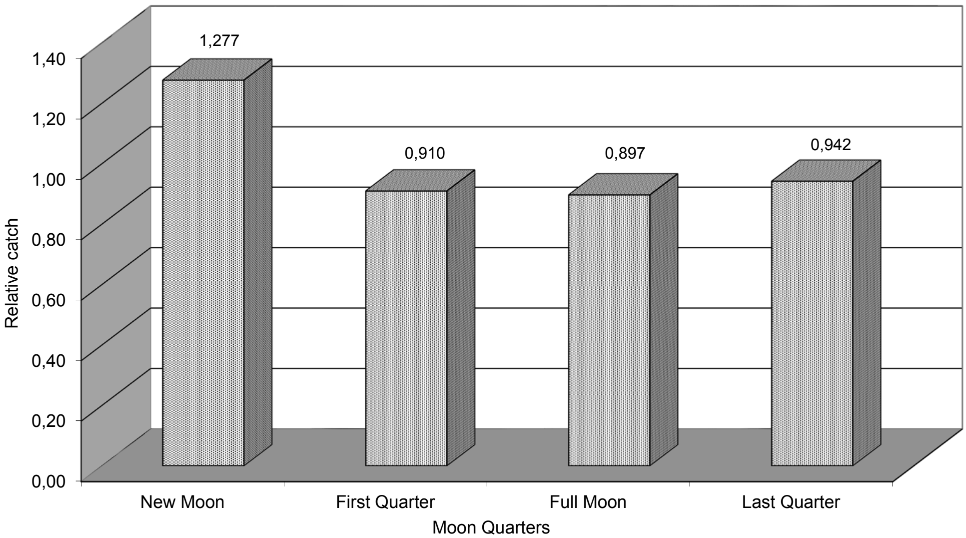


Fig. 4. Light-trap catch of *Potamopylax nigricornis* Pictet in connection with Moon Quarters Significant catching peak ( $P< 0.05$) is at the New Moon (Hungary).

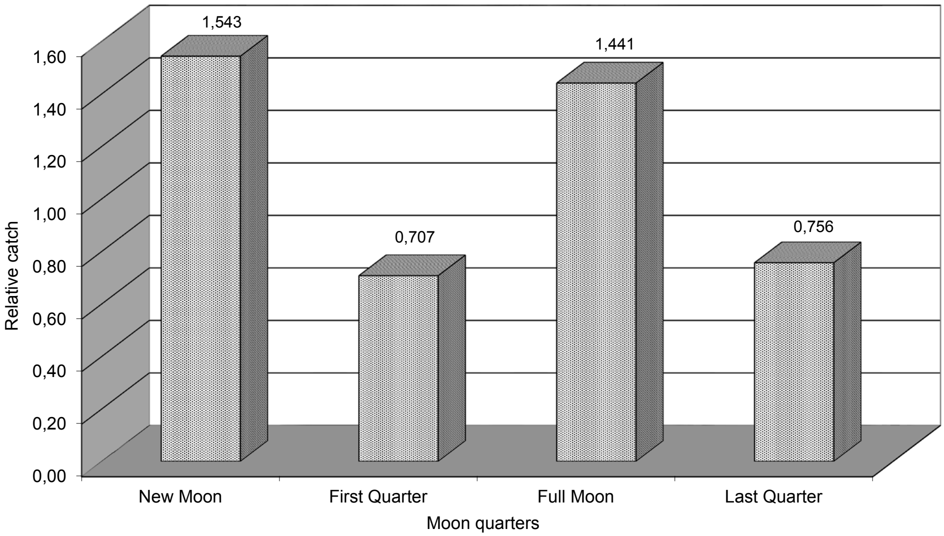


Fig. 5. Light-trap catch of the *Ecnomus tenellus* Rambur and *Silo pallipes* Fabr. in collection with the Moon Quarters. Significant catching peaks (P < 0.01) are at the New Moon and Full Moon (Hungary).

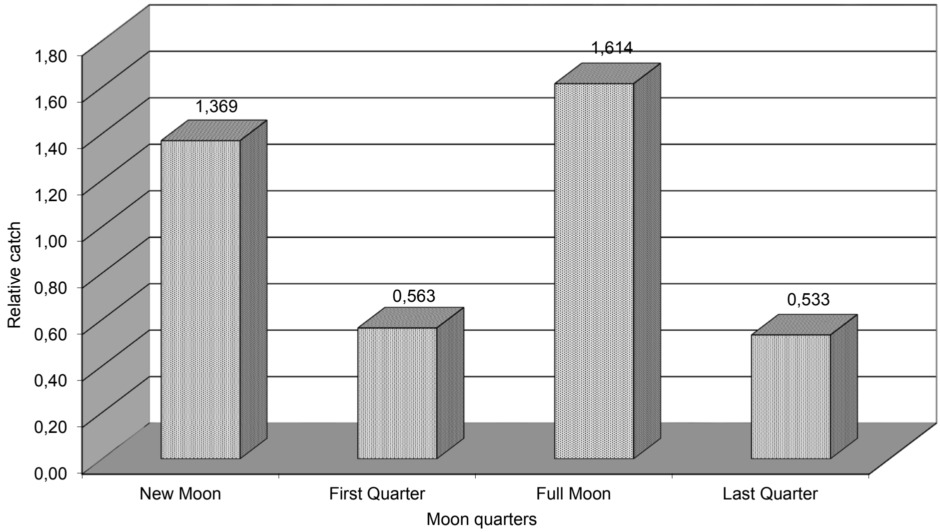


Fig. 6. Light-trap catch of the *Orthoctrichia costalis* Curtis, *Mystacides nigra* Linnaeus and *Oecetis ochracea* Curtis in connection with the Moon Quarters. Significant catching peaks (P < 0.05) are at the Full Moon and New Moon (Turkey).

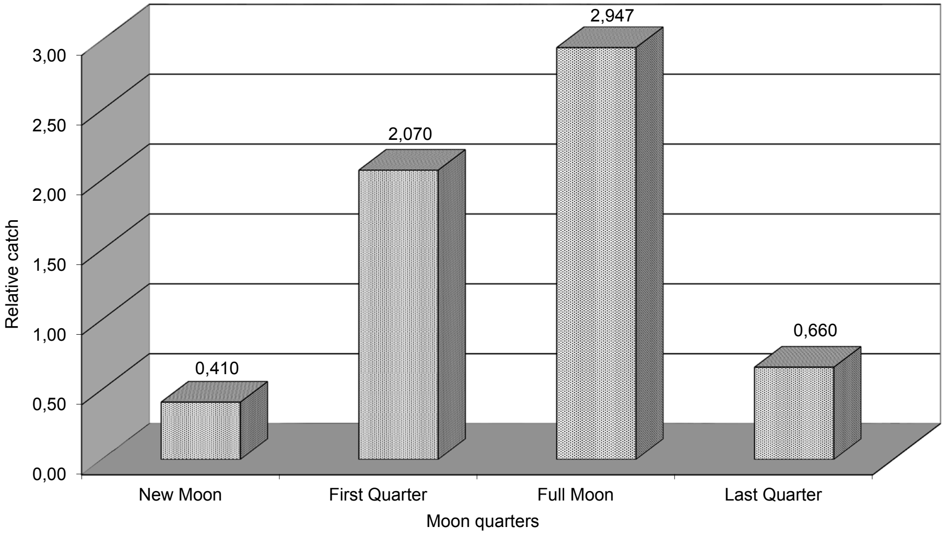


Fig. 7. Light-trap catch of the *Hydropsyche bulgaromanorum* Malicky in connection with the Moon Quarters. Significant catching peaks (P < 0.05) are at the First Quarter and Full Moon (Hungary).

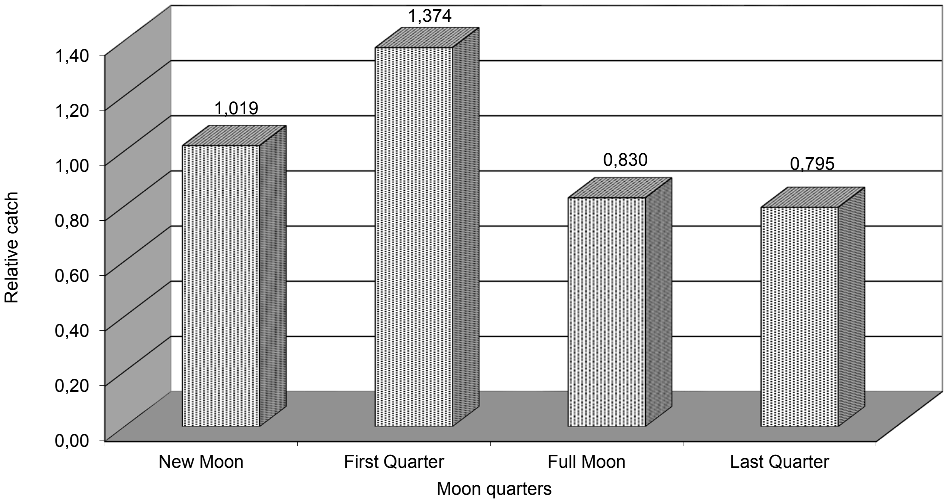


Fig. 8. Light-trap catch of the *Halesus digitatus* Schrank, *Limnephilus lunatus* Curtis, *Odontocerum albicorne* Scop. and *Rhyacophila fasciata* Hagen in connection with the Moon Quarters. Significant catching peak (P < 0.01) is at the First Quarter (Hungary).

Perhaps the reason is, the Moon can be seen at gloaming and evening sky this time. These species probably fly in large mass in this period. This result enhances the same observations of Tshernyshev (1961) and Jackson and Resh (1991). Diken and Boyaci (2008) also caught the specimen of *Ecnomus tenellus* Rambur, 1842 and *Hydroptila angustata* Mosely, 1939 at Lake Eğirdir in the First Quarter (Fig. 9).

It is striking, however, that *Ecnomus tenellus* Rambur was collected successful both in the Carpathian Basin and in Asia Minor, but period of successfull catch is completely different. The explanation may be that the Turkish researchers' light-trap operated only at dusk.

The Turkish researchers experienced the catching maximum of *Hydroptila aegyptia* Ulmer, 1963 (Fig. 10) at the New Moon and First Quarter. In Hungary Újhelyi (1971) collected the specimen of *Oecetis ochracea* Curtis specimens at the New Moon and First Quarter (Fig.11).

Expect of the *Ecnomus tenellus* Rambur and *Oecetis ochracea* Curtis) the caught species in Hungariy and Turkey were not the same.

Therefore, unfortunately, we were not able to compare of catching results of all species.

Our results proved that a little difficult to draw reliable conclusions swamping the lunar impact. All four moon quarter can be seen swarming peaks.

The light-trap catch of *Ecnomus tenellus* Rambur is equally the highest at New Moon and Full Moon in Hungary and Turkey. We therefore conclude that the flight activity of this species is more dependent on the phase angles of the moon as from local environmental impacts. In contrast, the catch of *Oecetis ochracea* Curtis is high in both countries at the Full Moon, however, another peak is at New Moon in Turkey, but the second peak can be experienced at First Quarter in Hungary. The local environmental effects may play a big role according to our assumption on this species. Our results contribute to better understanding of lifestyle of the investigated species.

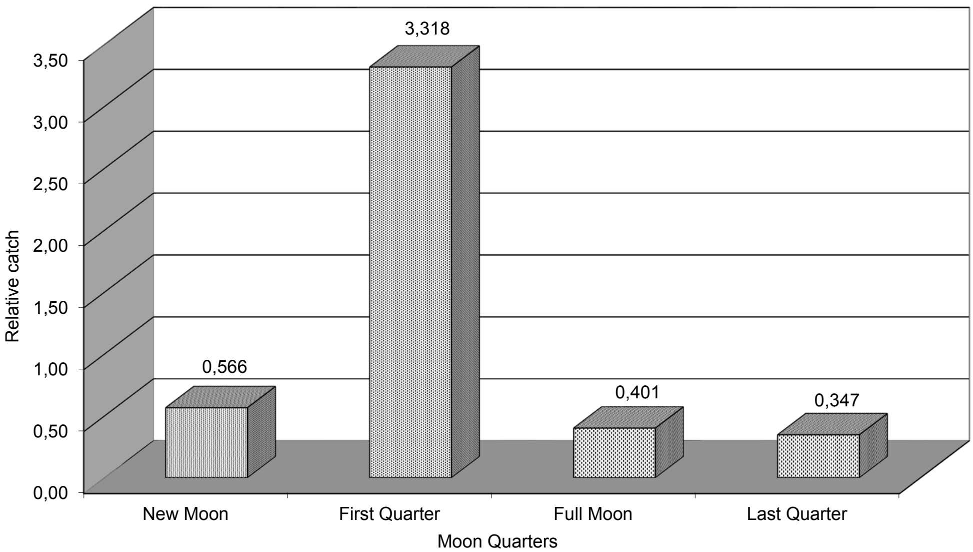


Fig. 9. Light-trap catch of the *Ecnomus tenellus* Rambur and *Hydroptila angustata* Mosely in connection of the Moon Quarters. Significant catching peak ($P < 0.01$) at the First Qarter (Turkey).

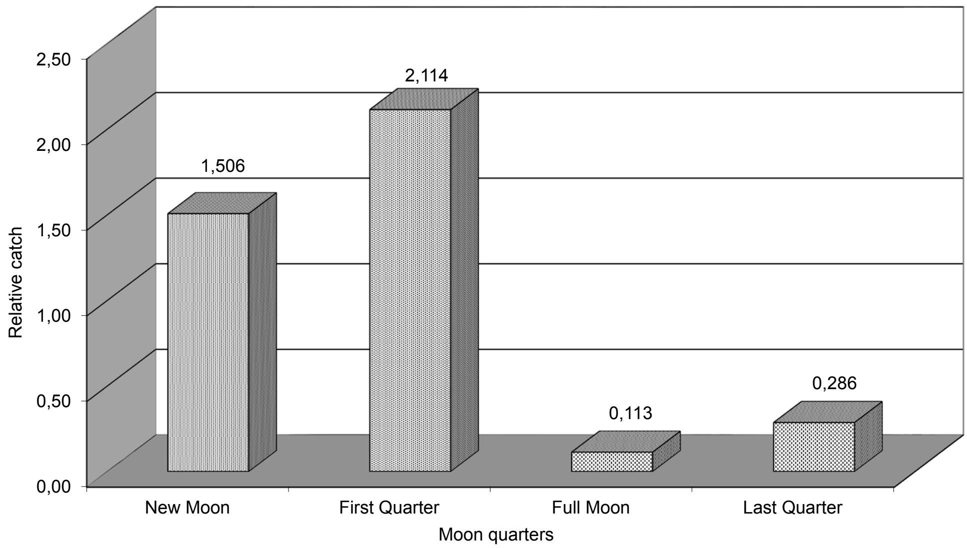


Fig. 10. Light-trap catch of *Hydroptila aegyptia* Ulmer in connection with the Moon Quaters. Significant catching peaks ($P < 0.05$) are at the First Quarter and New Moon (Turkey).

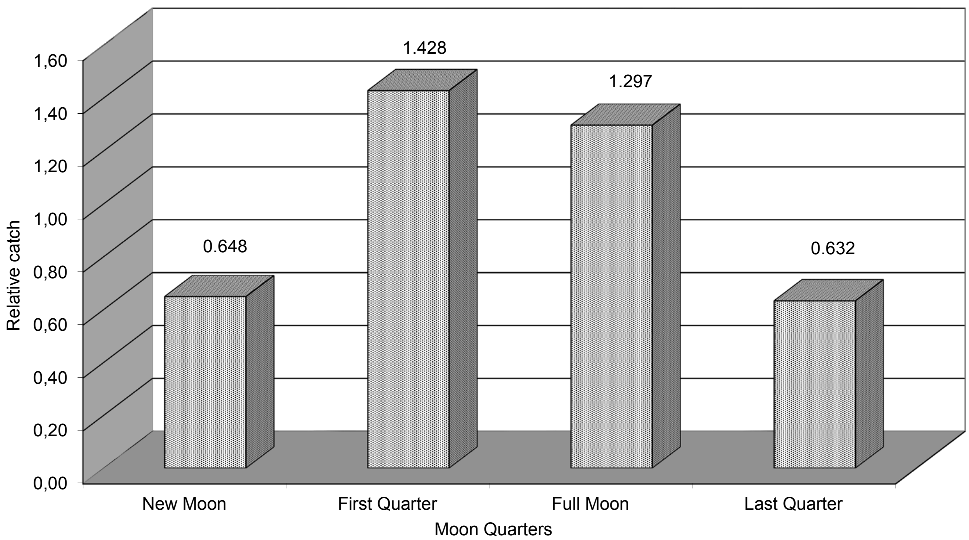


Fig. 11. Light-trap catch of *Oecetis ochracea* Curtis in connection with Moon Quarters (Data from 6 traps of the Hungarian National Light-trap Network, 1960 (Újhelyi, 1971). Significant catching peaks ($P < 0.05$) are at the New Moon and First Quarter.

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