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Research Article

Investigation of Environmental Factors Influencing the Light-Trap Catch of Caddisfly (Trichoptera) Species Using Multivariate Methods

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Abstract

Based on multi-variable calculations, it was established that the light-trap catch of the examined 7 caddisfly species is primarily influenced by the Sun, out of the 27 environmental factors taken into account. The Moon and the weather also have a smaller but significant influence. The influence of other factors is less important than these ones.

Keywords: Trichoptera; SPSS; weather

Introduction

The caddisflies (Trichoptera) are the largest order of aquatic insects, approx. with ten thousand species [1]. Therefore, they deserve special attention in limnological research (Kiss, 2003). Caddisflies spend their larval stage in springs, streams, rivers, lakes and swamps. They are found all over the world and are important parts of the food chain of freshwater ecosystems. Larvae are food for freshwater fish, and adults are food for birds and bats. The species of Trichoptera are one of the most important groups of aquatic insects therefore, knowledge of their seasonal activity is essential [2]. The majority of the caddisfly species are active at night and fly en masse to the artificial light. According to [3], caddisfly (Trichoptera) species are one of the most widespread groups of freshwater insects and most of them are attracted to artificial light.

From our own light-trap collections, which Ottó Kiss carried out between 1980 and 1989 next to mountain streams in Northern Hungary [4-8], and later, in 1999, on the banks of the Danube and in 2000, on the banks of the Tisza River [9,10], we also found that caddisflies react extremely sensitively to different environmental conditions under the influence of factors. Despite this, there are relatively few studies in literature dealing with the study of environmental effects that modify the light trapping of caddisfly species. We refer to some of these studies. [11-13] several investigations were carried out to measure the effects of various weather variables, like precipitation, wind speed, cloud cover, relative humidity, or night air temperature.

Smith et al. (2002) observed in New Zealand that flying caddisflies required an air temperature of at least 9 °C, but intensive flight was at a temperature higher than 14 °C. [14] did not observe flight to light in the caddisflies he studied below 13 °C at Lake Itasca, Minnesota. [15] analyzed the crepuscular and nocturnal flight of Trichoptera from results of light-trap catches. The catching sequence is initiated at a light intensity of four foot-candles. In previous years, we carried out research in order to learn about the influence of the Sun, the Moon, the height of the tropopause, and the Earth's magnetism on the results of the light trapping of caddisfly species. We also published the results in a book [16]. In the following years, we will continue our research and have obtained new results regarding the influence of the Sun [17], the night sky polarization originated by the Sun and Moon [18] and the geomagnetism [19].

The results of our own previous research proved that, in addition to the weather, the light-trap catch of caddisfly species is greatly influenced by the processes taking place on the Sun, the terrestrial effects of solar activity, and the Moon. Knowing all this, in the present work we will try to determine the most important modifying environmental variables using multivariate methods.

Material

The caddisfly species were collected by Ottó Kiss in 2000 on the banks of the Tisza River near the town of Szolnok, using a Jermy-type light-trap. He identified and registered the captured individuals. All specimens of all captured species were processed. We chose these collection data for these calculations because there is only a meteorological station in the city of Szolnok. The catching data of the collected species is included in Table 1. The environmental variables taken into account and their abbreviations are listed in Table 2.

Table1: Catching data of examined caddisfly (Trichoptera) species.

Examined species	Catching period	Numbers of	
		Individuals	Data
Hydroptilidae			
Agraylea sexmaculata Curtis, 1834	17th April –30th August	1,228	104
Ecnomidae			
Ecnomus tenellus Rambur, 1842	2nd June – 30th September	24,603	1,087
Polycentropodidae			
Neureclipsis bimaculata Linnaeus, 1758	2nd June – 29th September	26,605	229
Hydropsychidae			
Hydropsyche contubernalis McLachlan, 1865	16th April – 30th October	33,524	497
Hydropsyche bulgaromanorum Malicky, 1977	1st June –12th September	50,732	760
Leptoceridae			
Athripsodes albifrons Linnaeus, 1758	1st June – 30th September	672	91
Trichoptera spec. complex	16th April – 30th October	137,304	2,768

Table 2: The name and abbreviation of the environmental factors taken into account.

Abbreviation	The name of the environmental factors
1 RC	Relative catch
2 Sun-Az	The azimuth angle of the Sun (°)
3 Sun-Alt	The height of the Sun above the horizon (°)
4 Sun-Grav	Gravitational potential of the Sun (μJ/kg)
5 Sun-Moon-Grav	The gravitational potential of the Sun and the Moon (μJ/kg)
6 Sun-Pol	Night sky polarization from the Sun (%)
7 Sun-Ar-Az	The azimuth angle of the Sun's Arago point (°)

8 Sun-Ar-Alt	The height of the Sun's Arago point above the horizon (°)
9 Sun-FAN	Flare Activity Numbers of the Sun
10 Sunspot	The numbers of Sunspots
11 10.7cm	Solar flux numbers measured at 10.7 cm
12 H-index	The numbers of the geomagnetic H-index (nanoTesla)
13 Q-index	Q-index characterizing solar activity
14 D_{st}	D_{st} index characterizing the geomagnetism (nanoTesla)
15 Ozone	The value of atmospheric ozone
16 Phase	Phase angle of the Moon (°)
17 Moon-Az	The azimuth angle of the Moon (°)
18 Moon-Ba-Az	The azimuth angle of the Moon's Babinet point (°)
19 Catch-Dist	Catching distance (meters)
20 Moon-Grav	The gravitational potential of the Moon (μJ/kg)
21 Air-Temp-Max	The maximum value of the air temperature (°C)
22 Air-Temp-Min	The minimum value of the air temperature (°C)
23 Air-Temp-Aver	The average value of the air temperature (°C)
24 Water-Temp	The water temperature of the River Tisza (°C)
25 Moon-Pol	Night sky polarization from the Moon (%)
26 Temp-Fluct	Air temperature fluctuations (°C)
27 Wind	Wind speed (km/hour)

Table 3: Results of the Multivariable Calculations.

Examined Species
Agraylea sexmaculata Curtis, 1834
Sun: 1 RC, 3 Sun-Alt* 4 Sun-Grav*, 6 Sun-Pol*, 8 Sun-Ar-Alt*
Moon: 1 RC, 19 Catch-Dist*
Weather:
Ecnomus tenellus Rambur, 1842
Sun: 1 RC, 2 Sun-Az* 3 Sun-Alt* 3 Sun-Alt* 5 Sun-Moon-Grav* 6 Sun-Pol*, 8 Sun-Ar-Alt*
Moon:
Weather: 1 RC, 22 Air-Temp-Min* 23 Air-Temp-Aver
Neureclipsis bimaculata Linnaeus, 1758
Sun: 1 RC, 2 Sun-Az*, 3 Sun-Alt*, 4 Sun-Grav*, 7 Sun-Ar-Az*,
Moon: 1 RC, 16 Phase*, 17 Moon-Az*, 18 Moon-Ba-Az*. 19 Catch-Dist, 20 Moon-Grav
Weather: 1 RC, 22 Air-Temp-Min, 23 Air-Temp-Aver, 26 Temp-Fluct, 27 Wind
Hydropsyche contubernalis McLachlan, 1865
Sun: 1 RC, 2 Sun-Az*, 3 Sun-Alt*, 5 Sun-Moon-Grav*, 6 Sun-Pol*, 7 Sun-Ar-Az*, 8 Sun-Ar-Alt*
Moon: 1 RC, 20 Moon-Grav*
Weather: 1 RC*, 21-Air-Temp-Max*, 22 Air-Temp-Min*, 23 Air-Temp-Aver*, 24 Water-Temp
Hydropsyche bulgaromanorum Malicky, 1977
Sun: 1 RC*, 2 Sun-Az, 9 Sun-Ar-Az
Moon:

Weather: 1 RC, 21 Air-Temp-Max*, 22 Air-Temp-Min* 23 Air-Temp-Aver/
Athripsodes albifrons Linnaeus, 1758
Sun: 1 RC*, 10 Sunspot*, 13 Q-index, 14 D_{st}
Moon: 1 RC, 16 Phase*, 17 Moon-Az*, 18 Moon-Ba-Az*
Weather:
Trichoptera spec. complex
Sun: 1 RC*, 4 Sun-Grav*, 6 Sun-Pol*
Moon: 1 RC, 20 Moon-Grav, 25 Moon-Pol
Weather:

Note: * =Higher significance than the others, calculated based on the work of Sváb (1979).

Methods

We cannot directly work with the exact number of insects caught with the light-trap in the research, even if the light-trap operates in the same place in consecutive years. Environmental conditions are different every night. Therefore, the number of caught individuals always represents a different ratio among the catchable individuals of the given species. We developed a very simple method to solve the problem. The relative catch (RF) is the quotient of the number of individuals caught in the given sampling time unit (this can be 1 hour or even 1 night) and the average number of individuals of the generation in the sampling time unit. The average value of the relative catch is therefore 1. This can be considered the expected catch. Numbers less than one mean a smaller catch, while numbers greater than one mean a larger catch [20]. We performed the calculations with the relative catch values.

The observation data of 7 species were analyzed using the SPSS program package. We took into account significant factor weights based on the rotated component matrix, the background variables were named in the order of their effect on the relative catch: they can be linked to the effects of the Sun, Moon and Weather. The critical significant values of the factor weights were determined based on the correlations suggested on page 63 of J. Sváb's book (Sváb, 1979) based on low L= 1/(p)½ and high $H=a^2>=r5\%$, where p=a number of variables, a=factor weight, r5%= the value of the correlation coefficient FG=p-1 degree of freedom, n=the number of observations.

Results and Discussion

Our results are given in Table 3. From the results presented in Table 3 it is clear that the light-trap catch of all caddisfly species is influenced to the greatest extent by the Sun. In addition to the Sun, we also obtained significant results in conjunction with the Moon and the weather. With the exception of *Athripsodes albifrons* L., the collection of the other species is mostly influenced by the Azimuth angle of the Sun and/or the associated gravity and polarization. However, the catch of *A. albifrons* is also influenced by sunspot numbers and the Q-index. The gravitational potential of the Sun has a strong effect on the catch. The catch is highest when the suction effect of gravity is strongest.

According to the calculations of M. Kiss when the insects flies up to height of 1 millimeter, the maximum negative or positive value of the gravitational potential reduces or raises to 5% the energy required to fly up [21]. The effect of the Sun and Moon on gravity helps or inhibits the ascent of insects. This effect is especially great at the beginning of the ascension. If the suction effect prevails, i.e. the gravitational potential is negative, it helps, in a positive case it inhibits the ascent. For example, at maximum negative gravity, an ascent of 1 mm reduces the energy required to ascend by 5%.

The night sky polarization caused by celestial bodies is closely related to gravity. Insects can use the polarization pattern of the night sky for spatial orientation [22-26]. In the night sky in some places are areas of a few arc-square grades these are the Sun's Arago and Moon's Babinet points. In these are polarization practically zero. They can also help the orientation of insects that are active at night. Perhaps it seems surprising that the influence of the Moon is less than that of the Sun. It is understandable, however, since the Moon is constantly changing during a lunation, even within a night. The Sun, on the other hand, does not change so drastically, so it provides more "reliable" information for insects than the Moon. In addition, the life of caddisflies is short, it is not even likely that they will live a full lunar month. The role of the weather is clear.

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