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Swarming patterns of light trapped individuals of caddisfly species (Trichoptera) in Central Europe

Research Article

László Nowinszky[1,*], Ottó Kiss[2], János Puskás[1]

[1]University of West Hungary, Savaria University Centre,
H-9700 Szombathely, Hungary

[2]Department of Zoology, Eszterházy Károly College,
H-3300 Eger, Hungary

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Abstract: This study is on the light trapping of caddisfly species (Insecta: Trichoptera) related to the proportion of males and females and the moon phases. The data collected includes 24 species in 9 light-trap stations, for 49 swarming events between the years 1980 and 2000. We found the massive emergence of adults happens fractionally in swarming intervals. This is connected with the phenology and life cycle of each species. The percentage of males and females of the same species during different swarming events cannot be considered equal. The proportion of males and females are different in the swarming of different species. We found that the number of male and female individuals is substantially synchronized with each other within the swarming, but it can be different in the case of each species. The duration of the swarming, even in the same species, are not always uniform. The effect of the Moon cannot be clearly identified in any species, even if data from several swarmings are available. The swarming peaks appear near different Moon quarters.

Keywords: *Sex ratio • Light-trap • Moon Quarters*

1. Introduction

The caddisflies (Trichoptera) are one of the most important groups of aquatic insects, which include 13,574 species [1]. Their seasonal activity is therefore essential to understanding the ecological impacts [2].

The caddisflies imagos generally are active at night and they are attracted to artificial light. Therefore according to prior investigations [2-8], light trapping is one of the most suitable methods of identifying their swarming patterns and abundance. This includes the beginning and end of swarming, and the length and peaks of activities. This research is important for the characterization of caddisflies species and their function in nature conservation research.

Thousands of adults were collected in the study [9,10]. This trapping method has been extensively used by trichopterologists from temperate areas [9,11-16] through Mediterranean aquatic habitats [17,18] to subtropical/tropical regions [10,19,20].

By 'swarming' we mean the length of the flight-period of the imagos. The caught caddisflies are short-lived, thus observed flight by light-trap can be considered as a time series of the different emerging and dying specimens. Accordingly, the swarming reflects the hatching of imagos from the pupae, with some probably negligible delay [21].

The daily distribution of flight activity is an important aspect in the study of potential moonlight effects on caddisflies, because the nightly duration of the moon staying above the horizon is changing during the moon phases [21,22].

The caddisflies may have very different types of daily activity patterns. Many trichopteran species fly exclusively in daylight [23,24]. Most of the caddisflies are active during evening or night, but some species have a daily bimodal activity pattern [25]. Other studies reported that the swarming of caddisfly adults starts mainly after dusk and peaks before midnight at early or late evening, but the flying of many species continues until dawn [26].

* E-mail: lnowinszky@gmail.com

According to Harris [27], Trichoptera species were not caught by light trap when solar light level was greater than sixteen cd. The swarming of caddisflies started when the light intensity decreased below four cd.

Jackson and Resh [28] monitored the daily flight pattern of three caddisfly species using female sex pheromones to attract males: *Dicosmoecus gilvipes* (Hagen) (Limnephilidae), *Gumaga nigricula* (McL.) (Sericostomatidae) and *Gumaga griseola* (McL.). They established that the light intensity strongly influenced the flight activity of these species but not their flight periodicity. Although many studies have communicated the proportion of males and females of the light trapped caddisfly species: [18,29-38], only a few authors examined the drawing synchrony of them during swarming.

Adult Trichoptera were caught by Waringer [15] in May 1986 to June 1987 on the banks of the Danube at Altenwörth, Lower Austria, using a set of 3 Jermy-type light traps. Waringer found that in 17 species the sex ratio was significantly different from 1:1 and it changed during the night but did not disclose any of later study. Waringer [39] wrote that in nine out of the eleven most abundant species the sex ratios significantly differed from 1:1, with an excess of females.

Schmera [41] found that at the beginning of the flight period (May and June) the ratio of males was significantly higher compared to the expected 50% and towards the end of the flight period there was no significant difference.

Urbanovič [42] found the males of the most abundant species *Potamophylax cingulatus* (Steph.) which belonged to two subspecies, showed different distributional pattern in Slovenia.

Monson [43] carried out detailed studies of Lake Itasca (Minnesota, USA) and he published results for 126 caddisflies species. Unfortunately, his results cannot be compared to our results, because they are not of the same species collected.

Only few observations have been published on reactions of caddisflies to moonlight. Mackay [44] reported that the number of caddisflies (*Pycnopsyche* spp, Limnephilidae) caught by BL trap was low on nights of Full Moon, especially, when the moon disc was above the horizon. The daily distribution of flight activity is an important aspect in the study of potential moonlight effects on caddisflies, because the nightly duration of the moon disc staying above the horizon is changing during the various quarters [21].

Corbet [19,45], by use of Robinson-type light traps equipped with 125 W mercury vapour bulbs, collected Plecoptera, Ephemeroptera, Chaoborus and Trichoptera species on one hundred consecutive nights on the shore of Lake Victoria. In four of the 37 species examined, the number of individuals showed a periodical change corresponding to the changes of the lunar phases. He proposed that these catching peaks reflect the emergence pattern of adults influenced by moonlight rather than changes in the catching ability of light-traps [19,44].

Detailed studies discussing the effects of various moon phases on the light-trapping effectiveness of caddisflies are rare in the literature. Therefore, it is important to extend the tests to potential moonlight effects on caddisflies.

2. Experimental Procedures

Our catching data were collected from registers (between 1980 and 2000) and studies of Kiss [2,30,32,33,45,48], Kiss *et al.* [49,50].

Jermy-type light traps were used to collect caddisflies. The light source of the applied Jermy-type light-traps was a 100 W normal white light electric bulb hung under a metal cover (Ø: 1m) 200 cm above the ground. The traps were operated every night throughout the season from April until October.

The name of the species caught, number of individuals, the trapping sites and years are shown in Table 1 and Table 2.

We determined the four typical phases of the moon (the first- and last quarter, full moon and new moon), and all the swarming periods of time (UT) by our own computer program. This program was created by astronomer György Tóth for our earlier studies [40].

We calculated catch value using number of males and females separately for each species and swarming for one trap over one night.

We examined the question: does the percentage of males and females differ from the expected ratio (50-50%) in each swarming? The χ^2 test was used to determine this. Schmera [41] used this test for this purpose. We also investigated the case of the same species; can the male and female ratio be considered to be constant or are they modified by environmental factors?

We established the duration of all swarming events and sorted them by month. We also determined the percentage of males for those swarming where the number of caught specimens was over a thousand.

The number of specimens were plotted and the swarming pattern was determined, so that the one- (unimodal), two- (bimodal), three or more (polymodal) distribution was involved. With correlation analysis, we found that two or more species are not in synchronized

Species and light-trap station	*Geographic coordinates*	*Number of individuals*	*Number of nights*
Rhyacophilidae			
Rhyacophila tristis Pictet 1834			
Zemplén Mountains, Kemence brook, 1998	48°45'N, 21°48'E	566	100
Rhyacophila nubila Zetterstedt 1840			
Uppony Mountains, Csernely brook, 1992	48°13'N, 20°25'E	461	123
Rhyacophila fasciata Hagen			
Szilvásvárad, Szalajka stream 1980	48°64'N; 20°23'E	110	158
Szilvásvárad, Szalajka stream 1981	48°64'N; 20°23'E	103	143
Szarvaskő, Eger brook, 1989 Eger brook, 1989	47°59'N, 20°51'E	441	174
Ecnomidae			
Ecnomus tenellus Rambur			
Nagy-Eged, Csomós farm-stead, Eger, 1981	47°54'N; 20°22'E	239	81
Glossosomatidae			
Glossosoma conformis Neboiss 1963			
Zemplén Mountains, Kemence brook, 1998	48°45'N, 21°48'E	504	99
Hydropsychidae			
Hydropsyche instabilis Curtis 1834			
Nagy-Eged, Csomós farm-stread, Eger, 1980	47°54'N; 20°22'E	76	146
Dédestapolcsány, Bán stream, 1988	48°08'N, 20°25'E	837	68
Polycentropodidae			
Plectronemia conspersa Curtis 1934			
Szarvaskő, Eger brook, 1989	47°59'N, 20°51'E	137	91
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
Potamophylax rotundipennis Brauer 1857			
Dédestapolcsány Bán stream, 1988	48°08'N, 20°25'E	717	75
Halesus digitatus Schrank 1781			
Szilvásvárad, Szalajka stream, 1980	48°64'N; 20°23'E	839	90
Bükk Mountains, Vöröskő-Valley, 1981	48°34'N; 20°27'E	104	70
Dédestapolcsány Bán stream, 1988	48°08'N, 20°25'E	837	68
Szarvaskő, Eger brook, 1989	47°59'N, 20°51'E	714	108
Goeridae			

Table 1. The name of the species caught, the trapping sites and years, and the number of individuals and nights. The number of individuals is fewer than 1,000.

Species and light-trap station	*Geographic coordinates*	*Number of individuals*	*Number of nights*
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
Dédestapolcsány, Bán stream, 1988	48°10'N, 20°29'E	442	109
Silo pallipes Fabricius			
Szarvaskő, Eger brook, 1989	47°59'N, 20°51'E	296	118
Sericostomatidae			
Sericostoma personatum Kirby & Spence 1862			
Bükk Mountains Vöröskő-Valley, 1982	48°34'N; 20°27'E	983	143
Odontoceridae			
Odontocerum albicorne Scopoli 1763			
Szilvásvárad, Szalajka stream, 1980	48°64'N; 20°23'E	316	120
Szilvásvárad, Szalajka stream, 1981	48°64'N; 20°23'E	451	114
Bükk Mountains, Vöröskő-Valley, 1982	48°34'N; 20°27'E	618	112
Bükk Mountains , Vöröskő-Valley, 1983	48°34'N; 20°27'E	845	131
Nagyvisnyó, Nagy brook, 1984	48°08'N, 20°25'E	65	59

continued **Table 1.** The name of the species caught, the trapping sites and years, and the number of individuals and nights. The number of individuals is fewer than 1,000.

with each other's swarmings. Level of significance of the correlation quotient was also calculated.

Then, we adopted the model of two sexes swarming synchronized if the correlation quotient was less than the level of significance $P < 0.05$.

They also demonstrated the existence of a relationship. Therefore, if there was more swarming of the same species available, we investigated whether the same swarming peaks can be found in the same months or not; are the numbers of swarming peaks the same?

We calculated catch value using number of males and females separately for each species and swarming for one trap over one night.

Since most of the caddisfly species swarm more or less permanently in the summer season, the total number of individuals was used in the relative catch (RC) calculations. The application of relative catch allows us to work with catching data from different swarming periods.

The number of basic data exceeded the number of sampling nights because in most collecting years more light-traps operated synchronously. In order to compare the differing sampling data of a species, relative catching values were calculated from the number of individuals. We calculated for investigated species the relative catch (RC) value for each day per light-trap station per year. The RC was defined as the quotient of the number of individuals caught during a sampling period (1 night) per the average catch (number of individuals) within the same generation relating to the same time unit. For example when the actual catch was equal to the average individual number captured in the same generation/swarming, the RC value was 1. Because most of caddisflies species are more or less permanently swarming in the summer season, the total number of individuals was used in the calculations.

We listed our collecting data - separately for males and females - as four moon quarter surroundings. Moonlight during the four quarters of the moon was divided into by photometric characteristics of the moonlight thus gathering a number of different phase angles. The total lunar month, angle of 360 months (approximately 30 days) included. To First- and Last Quarter – when seen positively polarized moonlight - 72–72 phase angles (7–7 days) are listed below. To Full Moon – this time in the negative and low-polarized moonlight - 48 phase angle (5 days) belongs. New Moon period – when there is no measurable moonlight – 168 phase angle (11 days) belongs.

Our relative catch data is averaged and divided into four moon quarters. In those moon quarters where an apparently higher number of catches was observed, the difference of average value between the level

Species, trap sites and years	*Specimens*	*May* ♂%	*June* ♂%	*July* ♂%	*Au-gust* ♂%	*Septem-ber* ♂%
				Percentages		
Glossosomatidae						
Agapetus orchipes Curtis 1834						
Zemplén Mountains, 1998	2 485	24.3**	11.9**	15.6**	33.3	
Hydropsychidae						
Hydropsyche contubernalis Mc Lachlan						
Uppony Mountains, 1992	4 047		40.0**	47.8	38.6**	76.5**
Hydropsyche instabilis Curtis						
Szilvásvárad, 1980	1 761		33.3**	12.1**	30.5**	45.2
Bükk Mountains, 1981	2 656	17.1**	9.1**	9.1**	7.2**	
Bükk Mountains, 1982	7 169	10.0**	42.7**	24.3**	21.5**	
Bükk Mountains, 1983	11 483	32.8**	35.3**	43.6**	33.4**	14.3**
Szarvaskő, Eger stream, 1989	2 273	65.8**	58.3**	62.7**	66.7**	
Hydropsyche bulgaromanorum Malicky, 1977						
Szolnok, Tisza River, 2000	22 343		42.3**	43.7**	44.2**	35.9**
Polycentropodidae						
Neureclipsis bimaculata Linnaeus						
Bükk Mountains, 1983	15 636	51.4	54.1**	54.3**	50.0	
Limnephilidae	1 049	47.0	53.1**	49.8	43.3	
Limnephilus rhombicus Linaeus						
Zemplén Mountains, 1982						
Potamophylax nigricornis Pictet	3 708		54.3	66.4**	57.3**	58.2**
Bükk Mountains, 1982						
Bükk Mountains, 1983	3 666		43.3**	56.8**	60.0**	
Halesus digitatus Schrank	5 866		48.9	55.7**	62.0**	
Bükk Mountains, 1982						
Bükk Mountains, 1983	1 287				63.5**	75.6**
Goeridae	1 049				73.0**	76.0**
Goera pilosa Fabricius						
Uppony Mountains, 1992						
Silo pallipes Fabricius	1 037	1.9	36.9**	31.0**	0.6	0.1
Zemplén Mountains, 1998						
Sericostoma personatum Kirby & Spence	1 204		55.4	64.0**	56.9*	78.8**
Bükk Mountains, 1983	1 272		73.8**	69.1**	63.3**	72.1**

Table 2. The name of the species, trapping sites and years and percentages of males per month. Number of individuals is more than 1,000. Notes = Significance levels are * = P <0.01, ** = P < 0.001. Geographical coordinates: Szolnok 47°10'N, 20°11'E

of significance was tested by t-test. We arranged the days of each swarming of each species by the days of swarming and those points are plotted. By the figures we calculated in which ten days are the peaks of swarming. We arranged all swarming of all species in four lunar quarters (First Quarter, Full Moon, Last Quarter and New Moon) and depicted them as well. According to the figures, it was determined that the peak of the swarming happens during quarter moon.

May it be hypothesized whether the male and female ratio is approximately constant, or whether environmental factors modify it?

Is the number of male and female individuals caught synchronized during each swarming days of the

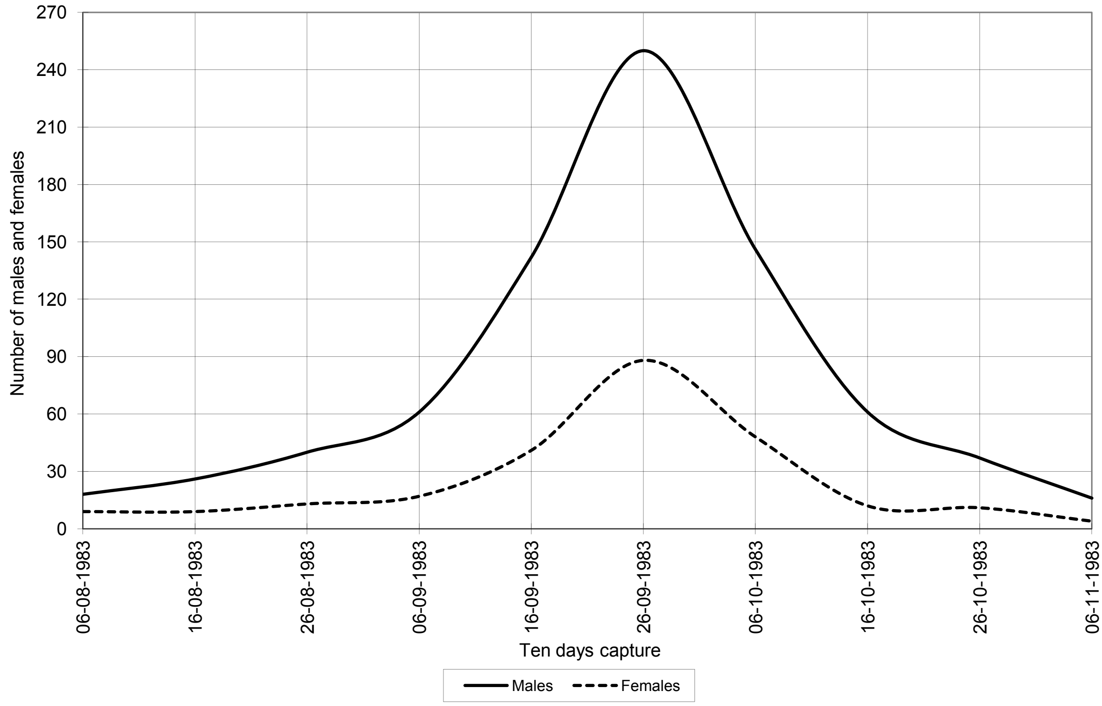

Figure 1. Swarming pattern of light trapped males and females of *Halesus digitatus* Schrank over ten days in1983 (Bükk Vöröskő-Valley).

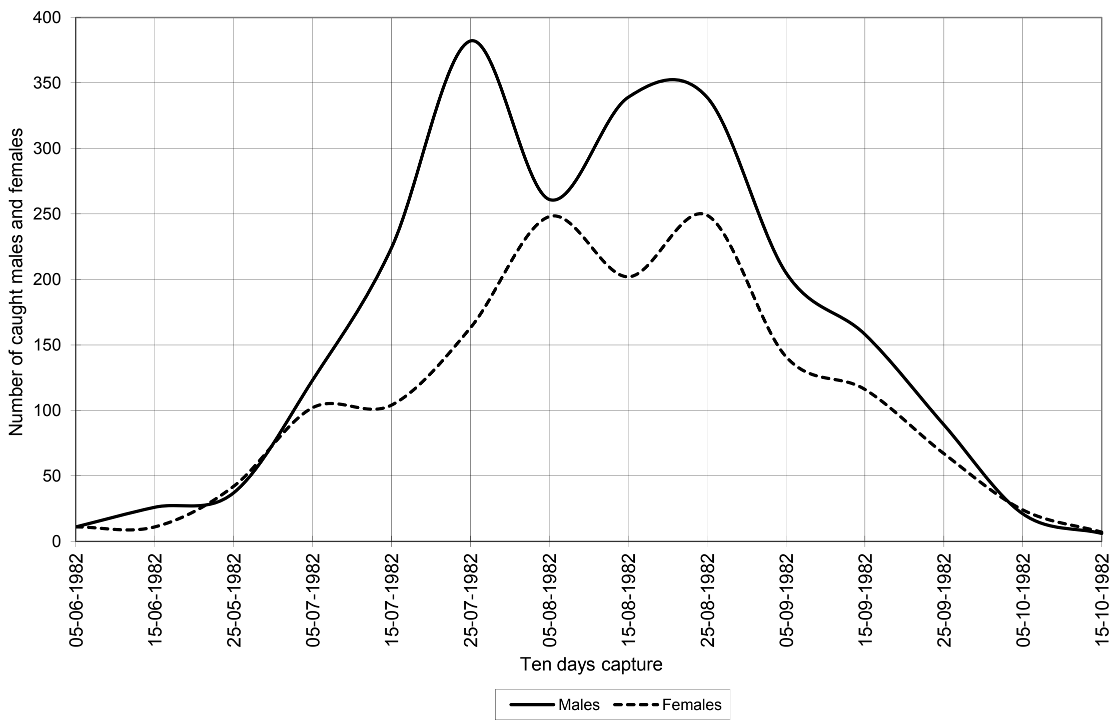

Figure 2. Swarming pattern of light trapped males and females of *Limnephilus rhombicus* Linnaeus over the ten days of 1982 (Zemplén Mountains Kemence brook)

lunar month? Correlation analysis was carried out to determine this and determine its level of significance. We adopted the model of two sexes swarming synchronized if the correlation quotient was less than the level of significance P <0.05.

If there was more swarming of the same species available, we investigated if the swarming peaks can be found in the same months or not.

We arranged and plotted the days of each swarming of each species by the days of swarming. By the figures, we calculated which ten days are the peaks of swarming.

We hypothesized that the swarming of the species is modified by environmental effects. Therefore, if there was more swarming of same species available, we investigated whether the same swarming peaks can be found in the same months or not; are the numbers of swarming peaks the same?

3. Results

The percentage of males and females of different swarming events, even in the same species, cannot be considered equal (Tables 2 and 3). The swarming pattern observed are as follows: unimodal 20, bimodal 12, polymodal 9 and atypical 8.

Our results regarding some species were compared with the results of other researchers (Table 4). We found

Species and light-trap stations and years	♂%	♀%	*Pattern*	*r*
Rhyacophilidae				
Rhyacophila fasciata Hagen 1859				
Szilvásvárad Szalajka stream, 1980	77.5 **	22.5	Polymodal	0.433
Nagyvisnyó Nagy brook, 1981	77.3 **	22.7	Polymodal	0.647 **
Szarvaskő Eger brook, 1989	66.4 **	33.6	Polymodal	0.604 **
Rhyacophila tristis Pictet 1834				
Zemplén Mountains, Kemence brook, 1998	53.5	47.6	Polymodal	0.527 *
Rhyacophila obliterata McLachlan 1863				
Szilvásvárad Szalajka stream, 1980	95.0 **	0.5	Bimodal	0.508
Rhyacophila nubila Zetterstedt 1840				
Uppony Mountains Csermely stream 1992	60.0 **	40.0	Polymodal	0.795 **
Ecnomidae				
Ecnomus tenellus Rambur 1842				
Nagy-Eged Csomós farm-stead Eger, 1981	24.3	75.7 **	Bimodal	0.369
Glossosomatidae				
Agapetus orchipes Curtis 1834				
Zemplén Mountains, Kemence brook, 1998	19.9	80.1 **	Atypical	0.843 **
Glossosoma conformis Neboiss 1963				
Zemplén Mountains, Kemence brook, 1998	49.2	50.8	Atypical	0.504 *
Hydropsychidae				
Hydropsyche contubernalis Mc Lachlan 1865				
Uppony Mountains Csermely stream 1992	45.0	55.0**	Bimodal	0.846**
Hydropsyche instabilis Curtis 1834				
Szilvásvárad Szalajka stream, 1980	29.7	70.3 **	Unimodal	0.875**
Nagy-Eged Csomós farm-stead Eger, 1980	26.3	73.7 **	Polymodal	0.482 *
Bükk Vöröskő-Valley, 1981	8.3	91.7 **	Unimodal	0.609 **
Bükk Vöröskő-Valley, 1982	28.2	71.8 **	Unimodal	0.032
Bükk Vöröskő-Valley, 1983	37.7	62.3 **	Unimodal	0.869 **

Table 3. The name of the species caught, the trapping sites, years, percentage of males and females and the swarming pattern (continuity) Notes: * = P < 0.01;** = P < 0.001 Significance level between actual percentages of males and females and their prospective values (50%) and correlation quotients of synchronization the patterns of individuals captured of males and females.

Species and light-trap stations and years	♂%	♀%	*Pattern*	*r*
Dédestapolcsány Bán stream, 1988	14.1	85.9 **	Unimodal	0.655 **
Szarvaskő Eger brook, 1989	63.8 **	36.2	Unimodal	0.903 **
Hydropsyche bulgaromanorum Maliczky, 1977				
Szolnok Tisza River, 2000	43.8	56.2 **	Unimodal	0.985 **
Polycentropodidae				
Neureclipsis bimaculata Linnaeus 1758				
Bükk Vöröskő-Valley, 1982	53.7**	46.3	Unimodal	0.981 **
Bükk Vöröskő-Valley, 1983	76.0 **	24.0	Unimodal	0.976 **
Plectronemia conspersa Curtis 1934				
Szarvaskő Eger brook, 1989	70.1 **	29.9	Polymodal	0.829 **
Limnephilidae				
Ecclisopteryx madida Mc Lachlan 1867				
Nagyvisnyó Nagy brook, 1981	69.2 **	30.8	Unimodal	0.987 **
Ecclisopteryx madida Mc Lachlan 1867				
Nagyvisnyó Nagy brook, 1984	63.5 **	36.5	Unimodal	0.801 **
Uppony Mountains Csermely stream 1992	65.3 **	34.7	Bimodal	0.517 *
Limnephilus lunatus Curtis 1834				
Szilvásvárad Szalajka stream, 1980	73.5 **	36.5	Unimodal	0.799 **
Limnephilus flavicornis Fabricius 1787				
Szilvásvárad Szalajka stream, 1980	52.5	47.5	Polymodal	0.843 **
Limnephilus rhombicus Linaeus 1758				
Szilvásvárad Szalajka stream, 1980	31.3	68.7 **	Bimodal	0.718 **
Zemplén Mountains, Kemence brook, 1998	59.9 **	40.1	Bimodal	0.910 **
Potamophylax rotundipennis Brauer 1857				
Dédestapolcsány Bán stream, 1988	74.2**	24.8	Atypical	0.258
Potamophylax nigricornis Pictet 1834				
Bükk Vöröskő-Valley 1982	55.6 **	44.4	Bimodal	0.874 **
Bükk Vöröskő-Valley 1983	55.9 **	44.1	Unimodal	0.927 **
Halesus digitatus Schrank 1781				
Szilvásvárad Szalajka stream, 1980	63.8 **	36.2	Unimodal	0.962 **
Bükk Vöröskő-Valley, 1981	58.6	41.4	Atypical	0.418
Bükk Vöröskő-Valley, 1982	68.8 **	31.2	Bimodal	0.852 **
Bükk Vöröskő-Valley, 1983	76.0 **	24.0	Unimodal	0.989 **
Szarvaskő Eger brook, 1989	69.2 **	30.8	Atypical	0.587 **
Goeridae				
Goera pilosa Fabricius 1775				
Uppony Mountains Csermely stream 1992	60.5 **	39.5	Bimodal	0.625 **
Silo pallipes Fabricius 1781				
Szilvásvárad Szalajka stream, 1980	79.9 **	20.1	Unimodal	0.519 *
Szilvásvárad Szalajka stream, 1981	77.7 **	22.3	Bimodal	0.481 *

continued **Table 3.** The name of the species caught, the trapping sites, years, percentage of males and females and the swarming pattern (continuity) Notes: * = P < 0.01;** = P < 0.001 Significance level between actual percentages of males and females and their prospective values (50%) and correlation quotients of synchronization the patterns of individuals captured of males and females.

Species and light-trap stations and years	♂%	♀%	Pattern	r
Nagyvisnyó Nagy brook, 1984	45.3	54.7	Polymoda	0.639 **
Dédestapolcsány Bán stream, 1988	50.0	50.0	Unimodal	0.945 **
Szarvaskő Eger brook, 1989	69.6 **	30.4	Atypical	0.733 **
Sericostomatidae				
Sericostoma personatum Kirby & Spence 1862				
Bükk Vöröskő-Valley, 1982	75.4 **	24.6	Unimodal	0.797 **
Bükk Vöröskő-Valley, 1983	69.5 **	30.5	Unimodal	0.965 **
Odontoceridae				
Odontocerum albicorne Scopoli 1763				
Szilvásvárad Szalajka stream, 1980	89.2 **	10.8	Bimodal	0.527 *
Szilvásvárad Szalajka stream, 1981	77.2 **	22.8	Bimodal	0.934 **
Bükk Vöröskő-Valley, 1982	77.2 **	22.8	Atypical	0.832 **
Bükk Vöröskő-Valley, 1983	21.8	78.2 **	Atypical	0.777 **
Nagyvisnyó Nagy brook, 1984	63.1 **	36.9	Unimodal	0.880 **

continued **Table 3.** The name of the species caught, the trapping sites, years, percentage of males and females and the swarming pattern (continuity) Notes: * = P < 0.01;** = P < 0.001 Significance level between actual percentages of males and females and their prospective values (50%) and correlation quotients of synchronization the patterns of individuals captured of males and females.

Species and researchers	Waringer, 1989	Waringer, 2003	Waringer & Graf, 2008	Schmera, 2005	Our own present study
Agapetus orchipes Curtis		30.8			19.9
Ecnomus tenellus Rambur			13.9		75.7
Hydropsyche bulgaromanorum Malicky			58.6		53.7 and 76.0
Hydropsyche contubernalis Mc Lachlan			43.1		45.0
Neureclipsis bimaculata Linnaeus			52.8		43.8
Goera pilosa Fabricius	82.0			70.0	60.4
Silo pallipes Fabricius				71.0	59.9

Table 4. Comparison of the percentages of males (%) by different researchers.

that rates proportion of males and females are different and cannot be species specific.

The influence of the Moon on swarming peaks of caddisflies is not identified clearly with the little number of swarming (Table 5). Probably the appearance of the swarming peaks is primarily timed by meteorological factors such as rain, wind, temperature, humidity, and *etc*.

We made a comparative investigation about some researcher's former results with ours (Table 6).

4. Discussion

The massive emergence of adults swarming happens fractionally in swarming intervals. The percentage of males and females of the same species during different swarming events cannot be considered equal. Certain species the male predominate, but the ratio varies (51.7 to 76.0%). This may be due in part to morphological differences, and part to differences of characteristics of life. In other species, however,

Species, trap sites and years	*FQ*	*FQ*	*FM*	*FM*	*LQ*	*LQ*	*NM*	*NM*
Males and females	♂	♀	♂	♀	♂	♀	♂	♀
Hydropsyche contubernalis Mc Lachlan								
Uppony Mountains, 1992	0.967	0.975	0.913	1.084	1.156	1.102	0.995	0.932
Hydropsyche instabilis Curtis								
Szilvásvárad, 1980	0.676	0.260	0.063	0.842	1.181	2.188*	0.169	1.059
Bükk Mountains, 1981	0.845	0.335	0.358	0.456	1.486	1.702	1.123	1.268
Bükk Mountains, 1982	0.845	0.917	1.233	1.605	0.837	0.549	1.165	1.153
Bükk Mountains, 1983	1.053	0.958	0.628	1.061	1.186	0.937	1.044	1.033
Szarvaskő, Eger stream, 1989	0.723	0.687	0.637	0.688	0.590	0.661	1.554*	1.513*
Neureclipsis bimaculata Linnaeus								
Bükk Mountains, 1982	1.170	0.902	0.581	0.619	0.777	0.898	1.245	1.365
Bükk Mountains, 1983	1.588*	1.778*	1.066	0.872	0.753	0.775	0.844	0.835
Hydropsyche bulgaromanorum Malicky, 1977								
Szolnok, Tisza River, 2000	1.009	1.072	0.960	1.004	1.181	1.119	0.921	0.885
Limnephilus rhombicus Linaeus								
Zemplén Mountains, 1982	1.131	1.232	0.745	1.149	0.965	0.716	1.068	0.940
Potamophylax nigricornis Pictet								
Bükk Mountains, 1982	0.910	0.980	0.826	0.967	0.978	0.976	1.154	1.044
Bükk Mountains, 1983	0.989	1.162	1.183	0.894	1.031	0.908	0.918	1.016
Halesus digitatus Schrank								
Bükk Mountains, 1982	1.019	0.899	1.169	1.449	0.867	0.846	0.975	0.896
Bükk Mountains, 1983	0.985	0.719	1.146	1.161	1.400*	1.655*	0.766	0.820
Silo pallipes Fabricius								
Zemplén Mountains, 1998	0.989	1.054	0.880	1.009	0.933	0.775	1.139	1.100
Sericostoma personatum Kirby & Spence								
Bükk Mountains, 1983	0.858	0.965	1.004	1.053	1.000	0.855	1.076	1.081
Agapetus orchipes Curtis								
Zemplén Mountains, 1992	1.689*	1.506*	1.553	1.087	0.670	0.877	0.424	0.721
Goera pilosa Fabricius								
Uppony Mountains, 1992	0.933	1.100	0.634	0.696	1.196	1.367	1.065	0.766

Table 5. The name of the species, trapping sites and years and relative catch in Moon Quarters.

the females are significant majority (55.0 to 99.9%).

It is known the Hydropsyche species have a generally high proportion of females (proterogyny). This phenomenon may be due to an uneven sex ratio because of the higher mortality rate for males in the larval or pupal stages according to Waringer [39].

Müller-Peddinghaus [52] and Müller-Peddinghaus and Hering [53] found strong linear relationships between forewing length and body length (r^2=0.88), wing width (r^2=0.96), and wing area (r^2=0.88). Sexual dimorphism was species-specific. The wing of imagos was bigger in males than in females at important species. However, the results only partially confirm this conclusion.

The flight of females developing eggs is more difficult because of their increased weight, thus flight is slower. Males in flight may be more active, because they are looking for females to mate. The differences of sex ratios could be caused by location differences or due to (1) higher female mortality in instars, (2) the male potential for greater dispersion, (3) or greater affinity for the males to a light source [39]. Waringer [39] also found that the proportion of males of 9 species increased from sunset to sunrise.

According to Crichton and Fisher [54] the preponderance of males probably results from their greater activity at night and their wider dispersal.

Species and light-trap station	Season	Length	Other research	Season-Length
Rhyacophilidae				
Rhyacophila tristis Pictet 1834	Summer	Long		
Rhyacophila nubila Zetterstedt 1840	Summer	Long		
Rhyacophila fasciata Hagen	Summer-Autumn	Long		
Ecnomidae				
Ecnomus tenellus Rambur	Summer	Medium	Waringer & Graf [58]	Long
Glossosomatidae				
Glossosoma conformis Neboiss 1963	Summer	Medium		
Agapetus orchipes Curtis 1834	Summer	Long		
Hydropsychidae				
Hydropsyche instabilis Curtis 1834	Summer-Autumn	Long	Schmera [57]	Summer-Long
Hydropsyche contubernalis Mc Lachlan	Spring	Long	Waringer & Graf [58]	Long
Hydropsyche bulgaromanorum Malicky, 1977	Summer	Long	Waringer & Graf [58]	Long
Polycentropodidae				
Plectronemia conspersa Curtis 1934	Summer	Medium		
Neureclipsis bimaculata Linnaeus 1758	Summer	Long	Waringer & Graf [58]	Short
Limnephilidae				
Ecclisopteryx madida Mc Lachlan 1867	Autumn	Medium		
Limnephilus lunatus Curtis 1834	Autumn	Medium		
Limnephilus flavicornis Fabricius 1787	Autumn	Long		
Limnephilus rhombicus Linaeus 1758	Summer	Long		
Potamophylax rotundipennis Brauer 1857	Summer-Autumn	Long		
Potamophylax nigricornis Pictet 1834	Summer	Medium		
Halesus digitatus Schrank 1781	Summer	Long	Schmera [57]	Authum - Short
Goeridae				
Goera pilosa Fabricius 1775	Summer	Long	Schmera [57]	Summer-Medium
Silo pallipes Fabricius 1781	Spring-Summer	Long	Schmera [57]	Summer-Medium
Sericostomatidae				
Sericostoma personatum Kirby & Spence 1862	Summer	Long		
Odontoceridae				
Odontocerum albicorne Scopoli 1763	Summer-Autumn	Long		

Table 6. The name of the caught species, the swarming season and swarming length.

According to Pianka [55], cited by Monson [43], a higher number of females can be a strategy allowing males to mate with more females. Corbet [56] also reported parthenogenesis in some caddisflies species.

A single swarms swarming pattern or that of a single species cannot be determined unequivocally. The swarming peaks even in the same species in different months can appear in either the same number of peaks and swarming events.

We observed differences in swarming, where the number of males and females are not synchronized with each other, swarms where the number of specimens taken were less than 150, and in the swarming where swarming pattern were atypical. Therefore for our conclusions we used data only from the swarming in which the number of individuals captured were at least 150.

According to Schmera [57] the length of the flight of studied caddisfly species is determined as follows: The lengths of the flight activities were listed into 3 artificial groups: long if the length of the flight activity is longer than 14 weeks. Medium long is the activity if the length of the flight activity is between 8 and 14 weeks, and short if the interval is smaller than 8 weeks. The spring, summer or autumn species are defined on the occurrence of the highest percentage of the individuals collected in those periods.

There are some differences between our present results and other researcher's former ones. It may be because of different environmental circumstances.

The imagos as the appearance of a mass of swarming during different moon phases occurred. This is confirmed by *e.g.* the five swarming events of *Hydropsyche instabilis* Curtis. Furthermore, there is no significant difference in swarming to catch all the males and the females, but there is a difference in one of the Moon phases. Current results seem to contradict our previous ones [59], when we found that there was a significantly higher catch of *Ecnomus tenellus* Rambur in the first and last moon quarters than in any other moon phases. In the previous study, the results of 4 light trap stations were obtained from sampling data over 3 years and 16,206 observational dates was available for 834 individuals. In the present study, however, we only have data on about 239 individuals of 81 species. Current results do not confirm the results of previous studies' [60]. In a former study we used data of 9 years (although not all years for all species), nine species were unique and used 1798 of a total of 39695 observation data points. Our results showed that of the five studied species' (*Ecnomus tenellus* Rambur, *Hydropsyche instablis* Curtis, *Odontocerum albicorne* Scopoli, *Limnephilus lunatus* Curtis and *Halesus digitatus* Schrank) light-trap catch was high in the First- and the Last moon quarter, and two species' (*Rhyacophila fasciata* Hagen and *Psychomya pusilla* Fabricius) light-trap catch was the same during a Full Moon. The only species is *Agraylea sexmaculata* Curtis, when the peak was at New Moon.

Both the previous and the present results showed that the light trapping of caddisflies (Trichoptera) does not yet have a clear relationship with different moon phases. We therefore conclude that further investigation is necessary in order clarify the question.

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