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Nocturnal activity of *Culicoides imicola* Kieffer (Diptera: Ceratopogonidae) in Israel

Ночная активность *Culicoides imicola* Kieffer (Diptera: Ceratopogonidae) в Израиле

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КЛЮЧЕВЫЕ СЛОВА: мокрецы, *Culicoides imicola*, почасовая ночная активность, светоловушка, сезонность, Израиль.

ABSTRACT. Forty-three nocturnal suction light trap collections were made in a horse stable at Bet Dagan, Israel, in order to determine the hourly flight activity of *Culicoides imicola*. Although *C. imicola* is active during the entire night, peak numbers of midges were found 1–3 hours after sunset, which were significantly higher than the numbers caught at 4–6 hours after sunset. The latter were significantly higher than those caught at 7–9 hours, and these were significantly higher than at 10–12 hours. No significant differences were found in the number of *C. imicola* at the various hour groups between summer (July 1 – September 15) and autumn (September 16 – November 30), as well as between 1996 and 2000–2001.

РЕЗЮМЕ. Почасовая динамика активности имаго *Culicoides imicola* в ночное время изучалась с помощью светоловушки, оснащённой всасывающим устройством. Сборы проводились в конюшне в пос. Бет-Даган (Израиль) в течение 43 суток. *C. imicola* были активны всю ночь. Максимальная численность мокреца отмечена в первые три часа после заката. После этого численность статистически достоверно уменьшалась каждые три часа по сравнению с предыдущими отрезками времени (в периоды: 4–6, 7–9 и 10–12 часов после заката). Не отмечено значимых различий между численностью *C. imicola* в различные периоды ночи летом (1 июля – 15 сентября) и осенью (16 сентября – 30 ноября), а также в 1996 г. и в 2000–2001 гг.

Introduction

Despite the great importance of *Culicoides imicola* Kieffer, 1913 as a vector of arboviruses causing diseases such as bluetongue, African horse sickness, epizootic hemorrhagic disease and Akabane [Mellor et al., 2000], little is known about its hourly activity during the evening. Nevill [1967] in South Africa found that the peak night flight activity of *C. imicola* sensu lato [Meiswinkel, 1989], based on five nights of two hourly trappings, was variable ranging between 9:00 p.m. to 5:00 a.m. In Israel where *C. imicola* sensu stricto is found, ten hourly light trap collections showed that the sharpest increase in flight activity in July–August occurred between the seventh and eighth hours of darkness, i.e. 3:00–5:00 a.m. [Braverman et al., 2003]. A significant difference was found in the activity of nulliparous, engorged nulliparous, parous and engorged parous females. Forty suction light trappings during daytime hours in 1978 and 1979 yielded small numbers of *Culicoides* spp., and among these only six specimens of *C. imicola* were collected [Braverman et al., 2003]. The accurate times of flight activity have significant importance when protecting susceptible animals from arboviral diseases such as bluetongue and epizootic hemorrhagic disease that are transmitted by *Culicoides* (e.g., in insemination centres). Once the hourly flight activity is known, it becomes possible to operate time-controlled automatic foggers that spray repellents at the optimal time [Braverman, 1989].

The aim of this study was to examine the hourly night flight activity of *C. imicola* during the summer and autumn of different years by conducting large enough numbers of suction light trappings, and thus to determine accurately the hours of peak flight activity and fluctuations throughout these seasons.

Materials and methods

The study was carried out in a horse stable holding seven horses at the Kimron Veterinary Institute at Bet Dagan (32°00'N 34°49'E). Suction light traps [Du Toit, 1944] equipped with a black light source (HPW 125 W-TS, Belgium) were operated for 12 hours from sunset to sunrise. The times for turning the light traps on and off varied with the seasons according to the actual time of sunset and sunrise. After every hour the collecting cage of the trap was replaced and the number of *C. imicola* inside the cage was counted. Thirty-two hourly nocturnal suction light trap collections were made from July to November 1996, ten from August to November 2000, and one in July, 2001. Coinciding with the official seasons in Israel, summer was from July 1 until September 15 and autumn from September 16 to November 30.

The Kolmogorov-Smirnov test was used to learn the peculiarity of variable distribution. Because all variables were distributed non-normally, the non-parametric tests of Wilcoxon and Friedman were used to analyze *C. imicola* flight activity at different time periods at night (Tables 1 and 2). The Mann-Whitney test was used for comparison of *C. imicola* activity during different seasons and years (Table 3). The data were analyzed using SPSS software (Version 14). P-values of ≤0.05 were considered significant.

Results

The numbers of *C. imicola* in suction light traps at night at different time periods are given in Tables 1–3. The tables indicate that *C. imicola* fly throughout the night hours. The peak numbers were found 1–3 hours after sunset, which were significantly higher than the numbers caught at 4–6 hours after sunset. The latter was significantly higher than those caught at 7–9 hours and these were significantly higher than 10–12 hours (Table 1). A similar trend for a decrease in numbers of midges from early to later nocturnal hours was traced for all months, seasons and years (Tables 2 and 3).

During the period July–October, significant differences were found between 1–3 hours and the other hour groups, whereas during August–November the 7–9 hours group was significantly different from the other hour groups (Table 2).

No significant differences were found in the number of *C. imicola* at the various hour groups between summer and autumn months. No significant differences were found in the numbers of *C. imicola* at the various hour groups in 1996 and 2000/2001 (Table 3).

Discussion

The study shows that during the first three hours of trapping, peak numbers of *C. imicola* were recorded,

Table 1. Numbers of *C. imicola* (ind./trap) at nocturnal hours, from 43 light trap collections during July–November 1996, August–November 2000 and July 2001 (median values; ranges in parentheses).
Таблица 1. Численность *C. imicola* (экз. на ловушку) в ночные часы, по данным сборов светоловушкой за 43 ночи, с июля по ноябрь 1996 г., с августа по ноябрь 2000 г. и в июле 2001 г. (медианные значения; в скобках – крайние значения).

Hours after sunset	1–3	4–6	7–9	10–12
Numbers	73.0 (21–391)*	40.0 (4–237)*	11.0 (0–181)*	2.0 (0–129)*

* P≤0.05

Table 2. Numbers of *C. imicola* (ind./trap) at nocturnal hours during different months in 1996, 2000 and 2001 (median values; ranges in parentheses).
Таблица 2. Численность *C. imicola* (экз. на ловушку) в ночные часы в различные месяцы в 1996, 2000 и 2001 гг. (медианные значения; в скобках – крайние значения).

Months	Hours after sunset			
	1–3	4–6	7–9	10–12
July	40.0 (33–59)[1]	15.0 (10–73)	6.0 (3–40)	2.0 (0–3)
August	73.0 (41–109)[2]	40.0 (5–237)	15.0 (5–77)[5]	2.0 (1–17)
September	85.5 (23–122)[3]	51.5 (7–203)	25.0 (6–46)[6]	4.0 (0–53)
October	78.5 (26–278)[4]	51.0 (9–201)	24.5 (6–122)[7]	3.0 (0–96)
November	71.0 (21–391)	19.0 (4–90)	5.0 (0–181)[8]	2.0 (0–129)

[1] P=0.019; [2] P=0.019; [3] P=0.028; [4] P=0.048; [5] P=0.07; [6] P=0.025; [7] P=0.017; [8] P=0.025.

Table 3. Numbers of *C. imicola* (ind./trap) during nocturnal hours in summer (July 1 – September 15) versus autumn (September 16 – November 30), and in 1996 compared to 2000–2001 (median values; ranges in parentheses).
Таблица 3. Численность *C. imicola* (экз. на ловушку) в ночные часы летом (1 июля – 15 сентября) по сравнению с осенью (16 сентября – 30 ноября), и в 1996 г. по сравнению с 2000–2001 гг. (медианные значения; в скобках – крайние значения).

Seasons or years	Hours after sunset			
	1–3	4–6	7–9	10–12
Summer	58.5 (37–107)	26.5 (5–73)	9.5 (3–40)	2.0 (0–7)
Autumn	75.0 (21–391)	47.0 (4–237)	24.0 (0–181)	2.0 (0–129)
1996	58.0 (21–114)	30.0 (4–101)	10.0 (0–40)	2.0 (0–11)
2000–2001	112.0 (33–391)	80.0 (10–237)	32.0 (1–181)	10.0 (0–129)

after which the numbers declined continually till sunrise. This pattern differs from that described by Braverman et al. [2003], who collected *C. imicola* landing on/biting a calf and showed that the peak observed at sunset was significantly lower than a second peak at sunrise. The difference in peaks from suction light trap collections and the direct collection from a calf indicates that the two methods collect different segments of the populations of *C. imicola*. It is possible that the individuals of *C. imicola* in the suction light trap have a different flight peak than the biting ones collected from a calf.

The numbers of *C. imicola* caught during the first three hours of the night rose from July to September and then decreased. From July to November, the numbers of *C. imicola* caught in the first three hours were significantly higher than in the other hour groups. Nevill [1967] stated that *Culicoides* (mostly *C. imicola*) had no single peak of hourly activity but that this varied nightly between 9:00 p.m. and 5:00 a.m. According to Braverman et al. [2003], the peak flight activity in July–August was between the seventh and eighth hours of darkness (2:00–3:00 a.m.), and the peaks changed between the various months as a result of changes in temperature, humidity and length of the day at the different months. The finding that the flight activity of *C. imicola* peaks during the first three hours after sunset when the hot air layer near the ground moves upwards by convection may support the assumption that individuals of this species are carried upwards and then are carried by air currents for long distances. The tendency of *C. imicola* to fly upward has been noted by Braverman & Linley [1993].

The fact that the numbers of *C. imicola* increase from summer to autumn is in accordance with previous reports from Israel [Braverman & Galun, 1973]. The numbers of *C. imicola* caught during the various hour groups in 2000/2001 was much higher than the numbers caught in 1996, probably due to the use of repellents in the stable in 1996.

The current study shows that *C. imicola* biting midges are active throughout the night and that, in order to protect animals from transmission of *Culicoides*-borne pathogens, repellents should be employed. To our knowledge, the only repellent that is active for *C. imicola* throughout the night is pyrethroid-T [Braverman et al., 1997].

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