Aquilo Ser. Zool. 14: 80—83. 1973

Diel rhythmic pattern of Leptophlebia marginata L. and L. vespertina L. (Ephemeroptera)

JOHN O. SOLEM

The Museum, Royal Norwegian Society of Sciences and Letters, University of Trondheim, Trondheim, Norway

Received 3. VII. 1973

Solem, J. O. 1973: Diel rhythmic pattern of *Leptophlebia marginata* L. and *L. vespertina* L. (Ephemeroptera). — Aquilo, Ser. Zool. 14: 80—83.

Preliminary results on the diel rhythm of the species *Leptophlebia marginata* L. and. *L. vespertina* L. are presented. The nymphs were trapped in lake Målsjöen, Trondheim, Norway (63°14'N, 10°26'E), and the number trapped during time-intervals of 2 hours are regarded to reflect the diel activity of the nymphs. In March and April the nocturnal rhythm is predominating, while in May and June a diurnal activity also is pronounced. The day activity is related to emergence activity and the night activity to searching for food. The day activity may also be looked upon as preliminary to the circadian rhythm of the imaginal stage. At the time of emergence, the predominating of the diurnal or the nocturnal activity is dependent on the weather conditions.

I. Introduction

In aquatic ecology, investigations on the diel rhythm of invertebrates have been focused on those inhabiting running water, but references to circadian rhythmic pattern of invertebrates of the littoral zone of lakes may be given to Pieczynski (1961, 1964).

Concerning the Ephemeroptera in running water, the locomotoric activity of all species in high northern latitudes is synchronized to the 24-hr cycle, and has a clear nocturnal pattern during the whole year, except at midsummer when the activity is arhythmic. Similar features also occur in other insect groups, e.g. Plecoptera and Simuliidae (Müller 1970, 1972, Müller & Thomas 1972). The investigations cited are mostly carried out on larvae and nymphs and their locomotoric activity may be expected to be mainly related to the searching of food.

The different phases of the diel rhythm at summer- and wintertime of the nymphs/larvae of Ephemeroptera, Plecoptera and Simuliidae may give reliable reasons to the following question: May the circadian rhythm at spring/summertime be correlated to other kinds of activities than those predominating at wintertime? This is a subject that so far has been paid little attention as to the insect-groups in question. More knowledge about this problem may lead to a better understanding of the activity curves.

In the following, preliminary results on

the circadian rhythm of *Leptophlebia marginata* L. and *L. vespertina* L. will be presented.

II. Investigated area and methods

The present investigation has been carried out in the lake Målsjöen (63°14'N, 10°26'E), situated 25 km south of Trondheim. The altitude above sea level of the lake is 164 m, and the area belongs to the coniferous region.

Except for some modifications, the traps found appropriate to the study, are described by Ricker (1968). To prevent water stagnation in the traps, which may act as an attractant or repellant, several holes were made on the piece opposite to the opening. The holes were covered with a brass net with an actual mesh width of 0.5 mm.

At the depths of 0.2—0.5 m and 1 m, four traps at each depth were operated, and they were emptied manually every second hour through the 24-hr periods shown in Fig. 1. The traps were filled with water through the holes covered with the brass net, and they were carefully placed on an even bottom substratum. When emptied, the water in the traps was filtered through a plankton net. In the wintertime, the traps were operated through holes in the ice, while in the summertime a boat was used. The ice-break of the lake occurs in late April— early May. More or less each trap covered a particular direction when they were working.

As the traps were placed on the bottom in a lake, only active animals, e.g. animals that crawl or swim etc., could be captured.

III. Results

The diel rhythm of the species *Leptophlebia marginata* and *L. vespertina* covering the months March to June 1972 is shown in Fig. 1. As both species were found to have a similar activity pattern, they are treated together. The period of activity is defined as the time

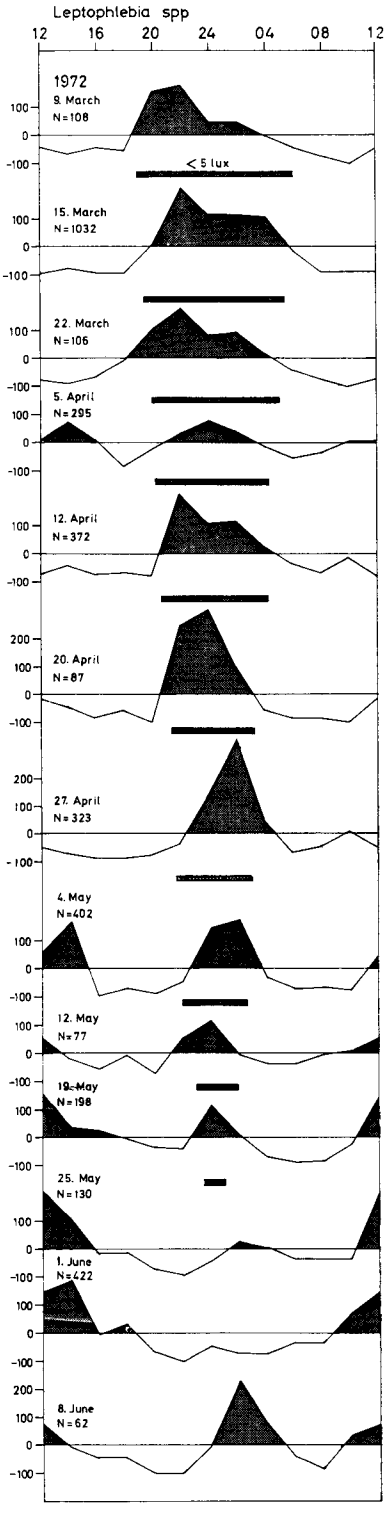

Fig. 1. The diel rhythm of the locomotoric activity of the nymphs of *Leptophlebia* spp.

when the curve, which is the percental deviation from the mean 2-hr sum of the catches, exceeds the mean 2-hr sum. This 2 hr sum is regarded as the zero level.

In March, data were obtained at three 24-hr periods, and the diel rhythm has a clear nocturnal pattern. The length of the activity period, per definition, corresponds well with the length of the night that have light intensities below the 5 lux level, and the greatest peak on the curves occurs early in the night. There is also indications for a very small peak at midday. On the date 5 April this daytime activity is greatly pronounced. The curve exceeds the zero level, and the daytime and nighttime peaks are about equal in size. During the rest of April, the nighttime activity greatly exceeds that of the daytime, at which only a small peak may be followed. On the 27 April the daytime peak very shortly exceeds the zero level. The nighttime period exceeding the zero line becomes shorter throughout April and follows the shortening of the night, which here is defined as the period at which light intensities fall below 5 lux.

A distinct change in the diel rhythm appear in May. The daytime activity increases, and the nighttime one decreases, and in the first part of the month the peaks of the day- and nighttime activity are of about equal high. Later in May, the daytime activity greatly exceeds that of the nighttime. On 1 June the activity is almost only confined to daytime. However, on 8 June the nocturnal activity peak again exceeds the diurnal.

Although the curves clearly provide peaks of activity during the 24-hr periods investigated, it must be noted that the curves seldomly reach the minus 100 % level, which corresponds to no specimens captured and consequently no or very little activity is maintained. In the total population there is some activity carried out throughout the whole 24-hr period.

The very top of the nocturnal activity is confined to the hours before midnight in March, while the very top is shifted to midnight or the hours just after in April, May, and June.

The flight period of *L. marginata* is in the second half of May, and that of *L. vespertina* in late May—June. In both of the years 1971 and 1972, the main emergence of *L. marginata* was about two weeks earlier than that of *L. vespertina.*

IV. Discussion

In March and April, the nocturnal rhythm is predominating in both *L. marginata* and *L. vespertina.* A night activity of the nymphs of. *L. vespertina* is earlier reported by Elliott (1965) and Kjellberg (1972). The light is assumed to be Zeitgeber as the water temperature at the depth in question is nearly constant, only varying with a few 1/10°C at the end of April. This nocturnal activity is related to the searching for food as is also reported by Kjellberg (1972).

The day activity in May and June is related to the emergence of the nymphs, which occurs at daytime. Thomas (1969) found *L. marginata* to have an emergence peak around midday (12 am.), and observations at Målsjöen showed the emergence peak of *L. vespertina* to appear at the same daytime. Any peak in the emergence of sub-imagines of *L. marginata* at Målsjöen could not be stated, because this species was not so abundant as *L. vespertina.* But *L. marginata* was emerging during daytime.

During the months for which data are presented, there is a shift from a nocturnal to a diurnal rhythm. The diurnal activity, which for the first time is clearly seen in early April, develops throughout April and is fully established in May. The diurnal activity was found to be very pronounced at days when the weather conditions were favourable for emergence. This is exemplified by the trapping on the dates 25 May, 1 June, and 8 June, at which dates only *L. vespertina* was left as nymphs. On the first dates, the weather conditions were excellent, and mass emergence of sub-imagines occurred. During daytime, the number trapped was high, while it was fairly low during the night. However, at 8 June, the weather was unfavourable, and no mass emergence was observed, and the

peak of the night activity again exceeded that of the daytime.

The results show the inner rhythm and the activity phase not to be fixed to either night or day at the emergence period. Depending on the exogenous factors, the nocturnal or the diurnal phase is predominating. The nocturnal activity is correlated with the searching for food, while the diurnal activity is correlated with the emergence of the nymphs. The diurnal activity seems to develop during the growing of the nymphs, and this guides to that two inner rhythmic systems operate at the time of emergence. The diurnal one may also be looked upon as preliminary to the circadian rhythm of the imaginal stage, e.g. flight, swarming etc., which occur at daytime.

In the present investigation, *L. vespertina* was found to emerge around 12 am., but Kjellberg (1972), who was working in Hälsingland, Sweden, found the emergence to occur in the morning, and the very peak was confined to between 06 and 08 am. In spite of the delayed emergence at Målsjöen when compared with the results of Kjellberg (1972), we shall note that both emergence peaks are restricted to the daytime.

However, in the same way as there is a flexibility in the diurnal and nocturnal activity, it seems to be a flexibility also in the time of emergence. The emergence is confined to daytime, but depending on climatic conditions, the emergence peak may occur at various times of the day (cfr. also Nuorteva 1965 a, b; Nielsen & Nielsen 1963). A flexibility in the circadian rhythm like the present described, is of great importance as the animals, independent of the area and within certain time limits, may carry out a particular activity at times that are most suitable.

References

Elliott, J. M. 1965: Daily fluctuations of drift invertebrates in a Dartmoor stream. — Nature 205: 1127—1129.

Kjellberg, G. 1972: Autekologiska studier över Leptophlebia vespertina (Ephemeroptera) i en mindre skogstjärn 1966—1968. — Entomol. Tidsskr. 93: 1—29.

Müller, K. 1970: Tages- und Jahresperiodik der Drift in Fliessgewässern in verschiedenen geographischen Breiten. — Oikos Suppl. 13: 21—44.

Müller, K. 1972: Rytmiskt beteende hos djur i den subarktiska sommaren. (Summary: Rhythmic behaviour in animals). — Fauna och flora 67: 23—29.

Müller, K. & Thomas, E. 1972: Bäcksländornas rytmik i Messaureområdet. — Fauna och flora 67: 191—195.

Nielsen, E. T. & Nielsen, H. T. 1963: The swarming habits of some Danish Mosquitoes. — Entomol. Meddel. 32: 99—170.

Nuorteva, P. 1965 a: The flying activity of Helina binotata Zett. (Dipt. Muscidae) in subarctic conditions. — Ann. Entomol. Fennici 31: 117—131.

Nuorteva, P. 1965 b: The flying activity of blowflies (Dipt. Calliphoridae) in subarctic conditions. — Ann. Entomol Fennici 31: 242—245.

Pieczynski, E. 1961: The trap method of capturing water mites (Hydracarina). — Ekol. Polonica B 7: 111—115.

Pieczynski, E. 1964: Analysis of numbers, activity, and distribution of water mites (Hydracarina), and of some other aquatic invertebrates in the lake littoral and sublittoral. — Ekol. Polonica A. 25: 691—735.

Ricker, W. E. 1968: Methods for Assessment of Fish Production in Fresh Water. — IBP Handbook No. 3: 1—313. Oxford.

Thomas, E. 1969: Zur Tagesperiodik des Schlüpfens von Ephemeropteren und Plecopteren. — Oecologia 3: 230—239.