

Further Studies on the Daily Activity Pattern of Neuroptera with some Remarks on the Diurnal Activities

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Using laboratory experiments, the daily activity patterns of 16 Neuroptera species (6 Chrysopidae, 2 Coniopterygidae, 3 Hemerobiidae, 3 Myrmeleontidae, 1 Mantispidae, 1 Ascalaphidae) were studied by the authors. The results of the experiments were described by activity diagrams and were categorized into Duelli-type flight activity pattern. During the study, 14 species showed *carnea* type of nocturnal activity. *Mantissa styriaca* proved to belong to *hypochrysoidea* type which is active at daytime. The daily activity pattern of *Libelloides macaronius* differs from the *hypochrysoidea* type due to its strong preference of UV radiation; therefore it is described as a separate *libelloides* type.

Keywords: Neuroptera, daily activity pattern.

The species and abundance composition of the lacewing samples collected at different parts of the day threw light on the difference in the daily activity patterns of the lacewings (Banks, 1952, New, 1967).

Ábrahám et al. (1998); Vas et al. (1996, 1997, 1999) analyzed the diurnal and nocturnal activity pattern of the species based on samples collected by widely used traps (light traps, Malaise traps, sucking trap or sticky plates). However, these results hardly reflected a true picture on the types of activity pattern among *Chrysopidae* species (Duelli, 1986), because sampling with different types of traps disturbs the normal behaviours of the species. Duelli (1986), during laboratory experiments electrically recorded and analyzed the acoustic noises of the chrysopid species, distinguished four basic types of diurnal and nocturnal flight activity pattern.

A series of experiments was carried out under similar conditions by visually observing the samples of *Chrysopidae*, *Hemerobiidae*, *Sisyridae*, *Coniopterygidae* and *Osmylidae* populations collected in Hungary. Based on the experiments, the daily activity patterns of 16 Neuroptera species were registered and all of them fell under one of the activity types described for the chrysopid species. The experiments started in the past (Ábrahám and Vas, 1999) were continued and completed with the examination of all the

families of lacewing occurring in Hungary in order to present the activity pattern of the common species.

The main aim of this paper is to give a presentation on the results of the research on the daily activity pattern of Neuroptera species.

Materials and Methods

A very simple method was applied to determine the diurnal and nocturnal activity of species. The individuals collected by netting mainly in Somogy County were brought into the laboratory and placed individually into 300 ml translucent glass vials, covered by wet filter paper. The filter paper was humidified every 3 hours during the observations, thus keeping 80 + 10% humidity in the vials. In the course of the experiment the individuals observed were kept at 25 + 1 °C in order that changes in temperature should not cause changes in activity. As shown with Neuroptera by Duelli (1986) the species were 100% active above 20 °C. The temperature range (25 + 1 °C) chosen by us was well above the known lower threshold (12 °C) and still well under the upper threshold value that influences the activity of insects in a negative way (Taylor, 1963). So some environmental conditions were kept more or less constant during the observations whereas others, like air pressure, front situation, internal factors and population relationships had to be disregarded to decrease the number of variation. The vials containing the observed animals were in natural light but without direct exposure to sunlight. The observations were carried out under long-day conditions. The actual observations were started after two hours (time of acclimatisation). At least 10–10 individuals belonging to the same species were observed daily.

The activity of animals was registered for 24 hours, every 15 minutes. For the night observation low-intensity red light was used, each vial for a period of 5 seconds. The movement of antennae, walking, flight, were all considered as activities. This was based on an earlier observation when an intensive antennal movement and walking were usually followed by flight.

Afterwards the animals were killed and in case of Coniopterygidae both the males and females were dissected and their genitals studied to determine the species (Meinander, 1972; Aspöck et al., 1980; Sziráki, 1992).

In order to find the activity pattern of *Libelloides macaronius* and to check the laboratory experiments, observations were also made during fieldwork.

At Orfalu (Vas County), where the species lived in high abundance, a transect measured 50 × 10 m was marked. Inactive individuals of *Libelloides macaronius* sitting in resting position on the blades of grass was registered in every 15 minutes because here and there flying individuals could not be counted. On 27 June, 2004 between 7.30 am 20 pm the fieldwork was carried out in ideal meteorological conditions, when there was bright sunshine all day. The temperature data was also recorded with digital thermometer during the experiment.

The observations percentage diagrams were constructed to be able to evaluate the results graphically. The time trend of the data was plotted by a moving average where

each point on this moving average line represents the average of the respective sample and the N-1 number of preceding samples. Thus, this line will smooth the pattern of means across samples.

$$F_{(j+1)} = \frac{1}{N} \sum_{j=1}^N A_{t j+1}$$

where, N is the period number of the moving average, A_j the actual value of j juncture, F_j the estimated value of juncture.

Results

The present study introduces the results of the research on the diurnal and nocturnal activity of 16 Neuroptera species (6 *Chrysopidae*, 2 *Coniopterygidae*, 3 *Hemerobiidae*, 3 *Myrmeleontidae*, 1 *Mantispidae*, 1 *Ascalaphidae*). The data presented here give new information on the daily activity pattern of *Coniopterygidae*, *Chrysopidae*, *Mantispidae* and *Hemerobiidae*.

We examined the species individually while trying to keep all the factors at a standard value which influence the daily activity pattern except the daily changes of natural light. Therefore, during the experiment, the two most important factors of the movement activity, the temperature (25 ± 1 °C) and the relative humidity ($80\% \pm 10\%$), were kept within a standard optimal range.

During the 24-hour experiment, we visually observed the individuals' activity (movement of antennae, walking and flight) and for each species this data was described in a diagram plotted against time. The differences (noise elements) in the daily activity patterns of each specimens belonging to the same species were straightened out by the moving average method used in statistic to even out the peaks of the diagram.

Finally, according to the data of the diagram, the lacewing species were grouped into activity types given by Duelli (1986)

The species whose daily activity patterns known as *carnea* type are active in the first half of the night. According to the present research the following species belong to this type: *Nineta guadarramensis* (Fig. 1), *Chrysopa phyllochroma* (Fig. 2), *Chrysopa pallens* (Fig. 3), *Chrysopa formosa* (Fig. 4), *Dichochrysa ventralis* (Fig. 5), *Dichochrysa flavifrons* (Fig. 6), *Coniopteryx aspoECKi* (Fig. 7), *Coniopteryx tjederi* (Fig. 8), *Hemerobius nitidulus* (Fig. 9), *Hemerobius marginatus* (Fig. 10), *Symphorobius pygmaeus* (Fig. 11), *Myrmeleon bore* (Fig. 12), *Euroleon nostras* (Fig. 13) and *Megistopus flavicornis* (Fig. 14).

The *hypochrysoDES* type daily activity pattern was only observed in the case of *Mantispa styriaca* (Fig. 15).

Observing the *perla* activity type, the afternoon and the early night activity maximum was typical. The *basalis* type species are usually active at dawn and at dusk. During the experiment none of the examined species proved to be these two activity types mentioned above.

The diurnal activity pattern of *Libelloides macaronius* (Fig. 16) in laboratory is different from the *hypochrysoDES* type daily activity pattern. The daily activity of this species

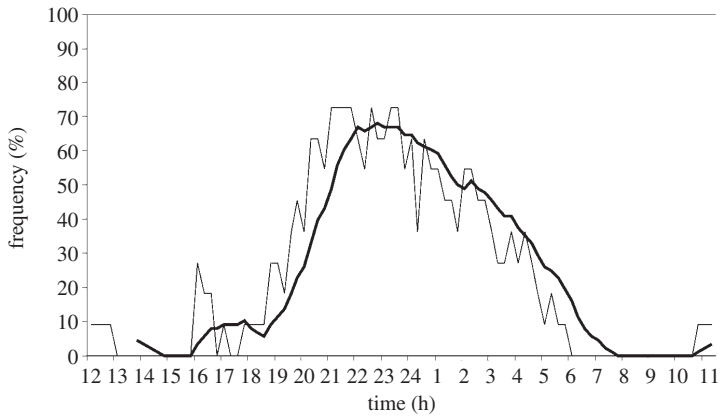


Fig. 1. Activity graph of *Nineta quadarramensis* in laboratory experiment

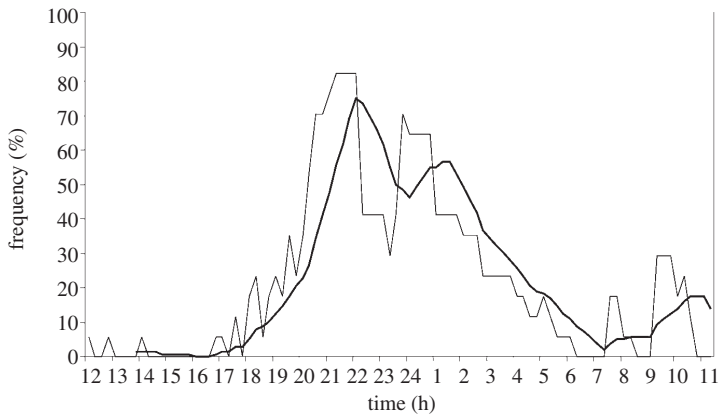


Fig. 2. Activity graph of *Chrysopa phyllochroma* in laboratory experiment

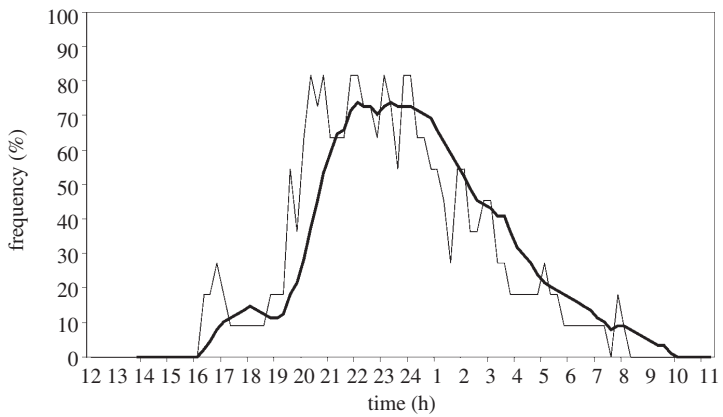


Fig. 3. Activity graph of *Chrysopa pallens* in laboratory experiment

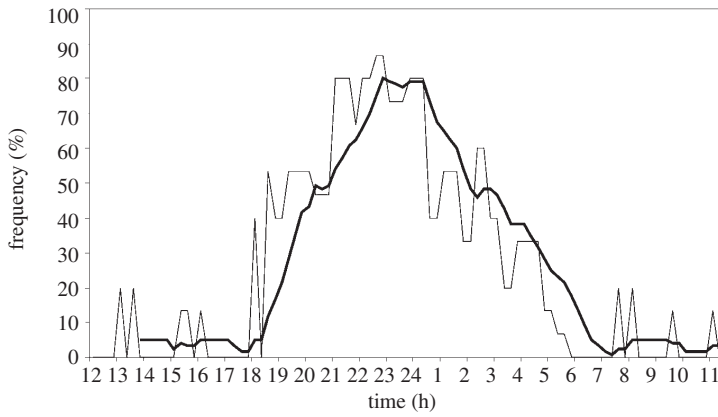


Fig. 4. Activity graph of *Chrysopa formosa* in laboratory experiment

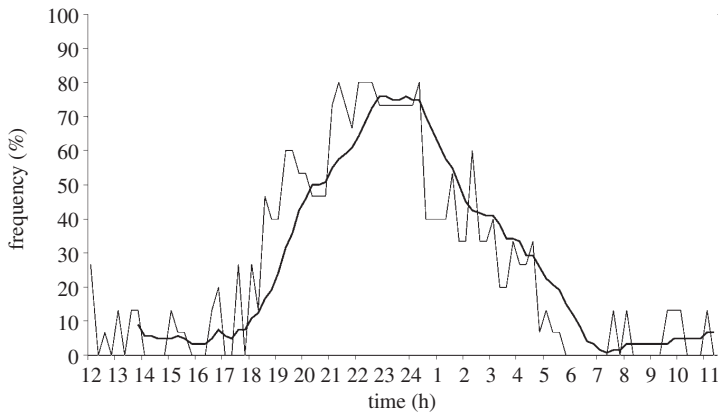


Fig. 5. Activity graph of *Dichochrysa ventralis* in laboratory experiment

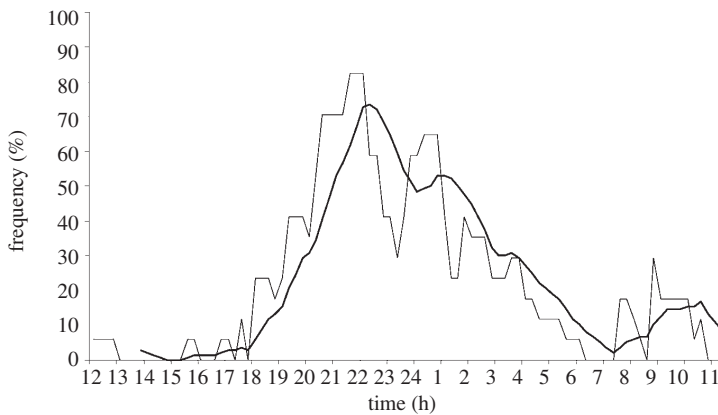
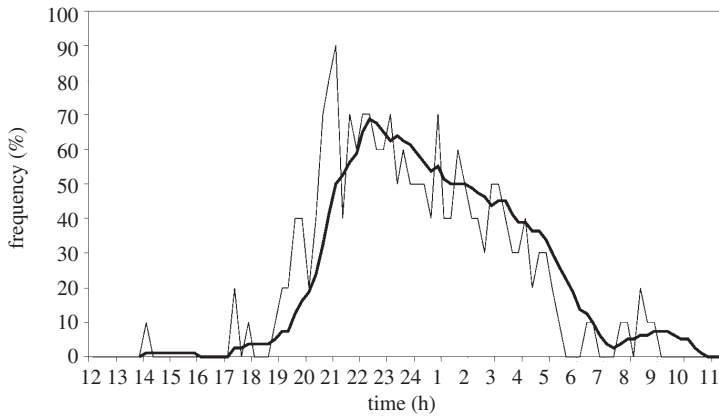
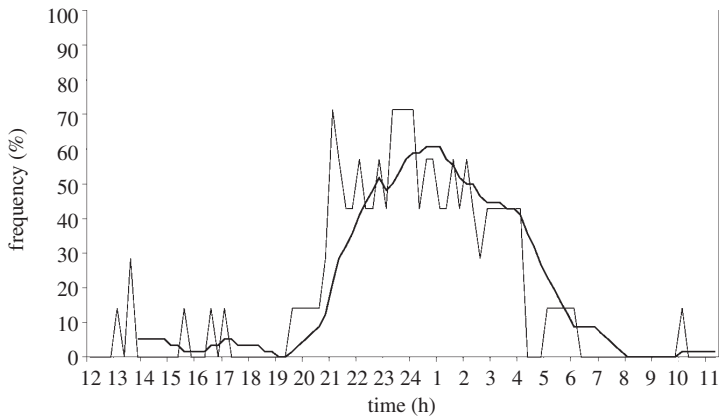
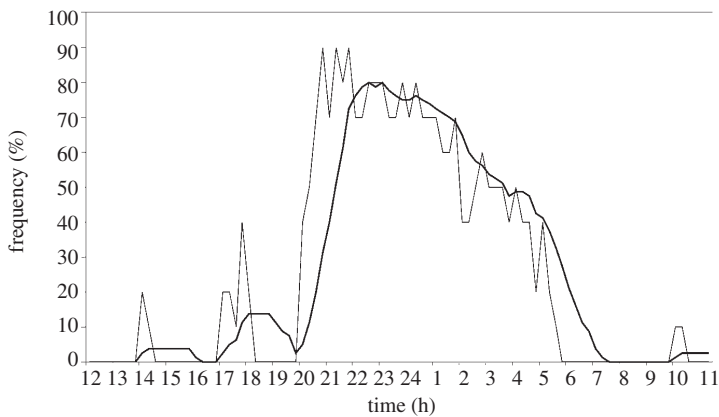


Fig. 6. Activity graph of *Dichochrysa flavifrons* in laboratory experiment

Fig. 7. Activity graph of *Coniopteryx aspoeki* in laboratory experimentFig. 8. Activity graph of *Coniopteryx tjederi* in laboratory experimentFig. 9. Activity graph of *Hemerobius nitidulus* in laboratory experiment

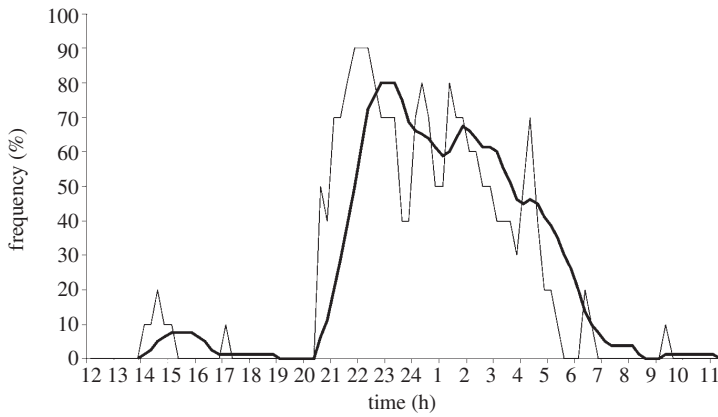


Fig. 10. Activity graph of *Hemerobius marginatus* in laboratory experiment

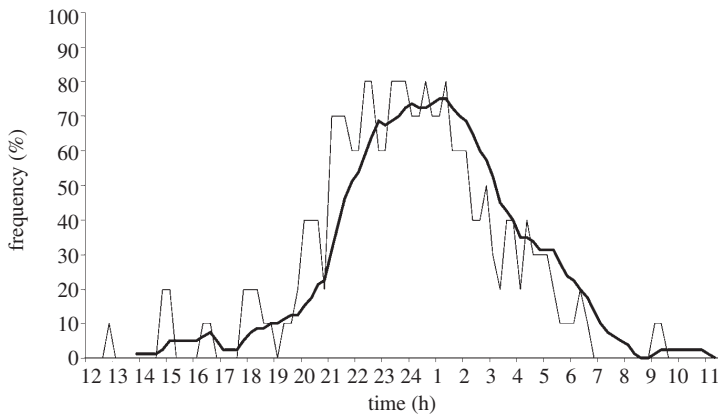


Fig. 11. Activity graph of *Sympherobius pygmaeus* in laboratory experiment

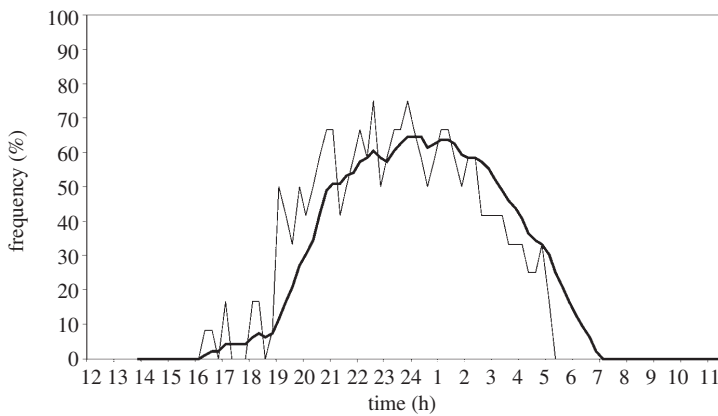
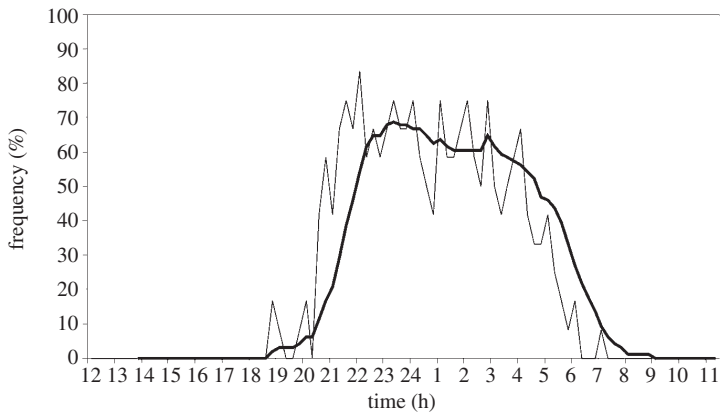
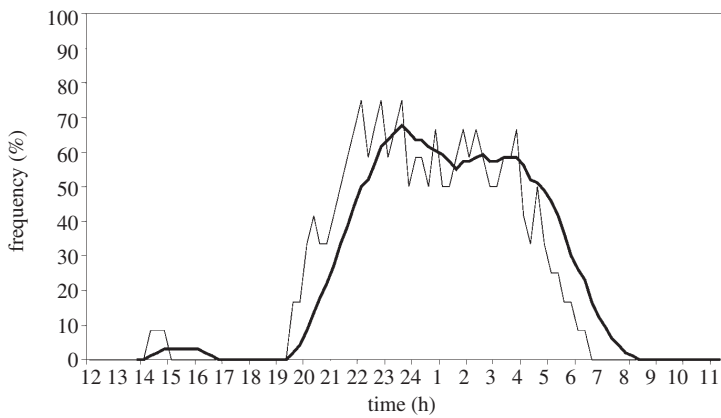
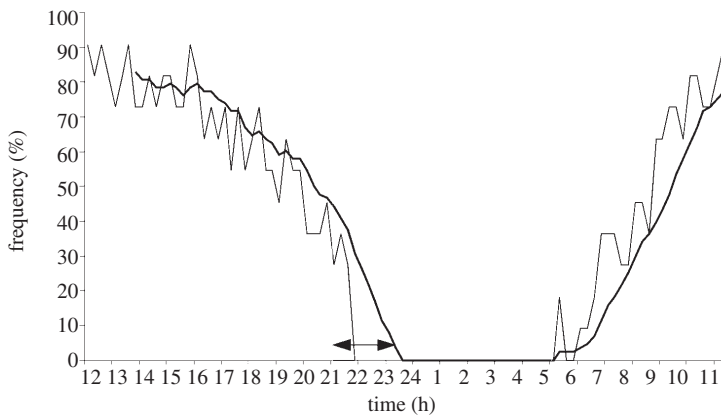


Fig. 12. Activity graph of *Myrmeleon bore* in laboratory experiment

Fig. 13. Activity graph of *Euroleon nostras* in laboratory experimentFig. 14. Activity graph of *Megistopus flavicornis* in laboratory experimentFig. 15. Activity graph of *Mantispa styriaca* in laboratory experiment, the double arrows show only the short interval of the daily activity of collected specimens by light

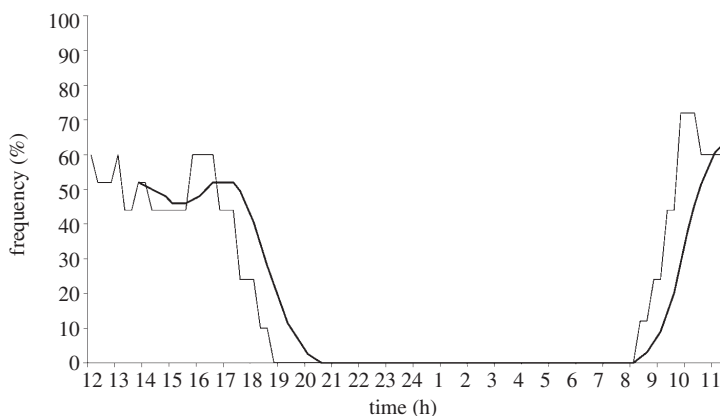


Fig. 16. Activity graph of *Libelloides macaronius* in laboratory experiment

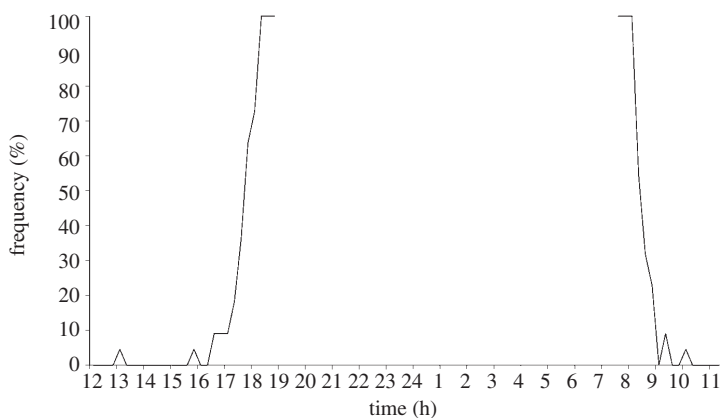


Fig. 17. Inactivity graph of *Libelloides macaronius* during the fieldwork experiment

can be observed during a shorter part of the day than in the case of *Hypochrysa elegans* therefore it is classified as a separate type of daily activity pattern.

In the case of *Libelloides macaronius* the experiment of the daily activity pattern were completed with observation during the fieldwork.

The observation of the flying specimens of *Libelloides macaronius* during fieldwork could not be carried out due to technical reasons. Therefore, data on not flying but only resting individuals could be recorded for the activity pattern in the morning and late afternoon. In contrast with the other *figs (1–16)*, *Fig. 17* does not show an activity graph but an inactivity graph of the species which means the distribution of resting state in time on a bright sunny day. Further personal fieldwork observations also confirmed that the direct sunlight was the key factor in flying activity.

During this work we came to the conclusion that the species in ideal temperature conditions (20–35 °C) show maximum activity only in sunny weather. As the daily activ-

ity pattern is significantly influenced by direct sunshine, this activity type was named 'libelloides' basic type. In Hungary the diurnal activity of *Libelloides macaronius* is from 9 am till 18.30 pm in summer time as shown in Fig. 17.

Discussion

The lacewings are basically considered to be insects of nocturnal activity, according to the data of the sampling material (Honek and Kraus, 1981; New, 1967, 1989).

Considering the studies on the flight activity patterns, Duelli's (1986) publication was the first one which determined the activity pattern not from the amount of caught specimens but he used a well-planned laboratory series of experiments. He distinguished four basic types of activity pattern (*carnea*, *perla*, *basalis* and *hypochrysoides*) for chrysopid species coming mainly from Europe. The previous (Ábrahám and Vas, 1999) and the present investigation included not only Chrysopidae but all Neuroptera families occurring in Hungary and it confirmed the fact that daily activity pattern of most lacewings can be arranged into four basic types.

The *hypochrysoides* activity type of *Mantispa styriaca* is rather remarkable. Seemingly there is a contradiction in the fact that the present investigation classified it as a species of diurnal activity although it was collected several times at nights by light and different light traps (Ábrahám and Papp, 1994). This species lives in its typical habitat in high abundance; dozens of specimens were caught by netting and light traps (Ábrahám, 1998; 2000) in open dry scrubs and grasslands. During collecting by lamp at night, the activity peak was always observed in the first half of the night and the number of the collected individuals was gradually decreasing and practically disappeared between 11 and 12 pm (Fig. 15). Presumably the decrease in the intensity of the flight activity is mainly due to the drop of the temperature. In the tropical area similar phenomenon was described by Tjønnealand (1962) and New and Haddow (1973) considering *Mantispidae* species collected by light traps, although in this case the fall of the temperature influenced the activity pattern to less extent.

Based on the present investigation which proved the daily activity of *Mantispa styriaca*, this species is not expected to occur in the material collected by light traps. Indeed, this phenomenon can be explained with the fact, that sampling with light has a super normal stimulus on the insects and this species also shows a positive phototaxis as an abnormal behaviour pattern. Therefore during the collecting by light, only a steeply descending graph line can be constructed in the diagram of the daily activity of *Mantispa styriaca* and the number of specimens observed is strongly reduced even in ideal weather conditions (Fig. 15).

In the case of *Hypochrysa elegans*, which the type of activity was named after, similar phenomenon occurs when we underestimate the size of the relative population caught by light traps compared to those collected by netting in the same habitat. The individuals of this species are collected by light traps in small numbers because of its unique daily activity type although it occurs regularly in the traps used at daytime such as Malaise traps (Vas et al., 2001). Research made by Kral et al. (2000) confirms that *Mantispa styriaca* can be

classified as a type of diurnal activity. Under laboratory condition similar to present investigation, they examined the predatory behaviour and the daily activity patterns of the species recorded it with video camera. Séméria (1992) pointed out the camouflage of the predator (*Mantispa styriaca*) which is active at daytime and use the oak flowers as plant substrate. On the other hand, the mantis-type predator activity is typical at daytime. For the daily activity of *Mantispa styriaca* further evidence is provided by the examination of the morphological structure of its eyes (Eggenreich and Kral, 1990; Kral et al., 1990).

The daily activity of *Libelloides macaronius* has been well known (Aspöck et al., 1980). However, during the series of experiments, this kind of diurnal activity pattern was shown to small extent considering this species (Fig. 16). Based on both laboratory and fieldwork observations, it can be established that *Libelloides macaronius*, similarly to the other *Libelloides* species, prefers sunshine therefore it flies only in sunny weather. Gogala (1967) pointed out that the upper part of the divided eye of *Libelloides macaronius* is rather sensitive to UV radiation which promotes the effective predator activity of the diurnal insects. Observation during fieldwork supported this theory since on an overcast day the flying activity of *Libelloides macaronius* drastically reduced, and in their habitat the specimens settled on tall blade of grass or on braches of bushes. Due to the UV radiation which is the key factor in the diurnal activity pattern of the *Libelloides macaronius*, its activity pattern is different from the one of *hypochrysoidea*, and the difference mainly shows in the length of the flight period. Both *Ascalaphidae* (Kral, 2002) and the European *Nemoptera* species (Popov, 2002) whose flight activity is at daytime are classified as 'libelloides' type owing to the effect of the UV radiation on the activity.

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