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Flight Activity Patterns in Lacewings (Planipennia: Chrysopidae)

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ABSTRACT

Flight activity patterns of various chrysopid species were investigated in laboratory experiments. Wing beat activities of lacewings kept in plastic containers were monitored by extremely sensitive microphones connected to an event recorder. Four distinct types of diel flight activity patterns were observed: (1) The CARNEA-type, in which flight starts after sunset and ends before sunrise. Most chrysopid species show this type of flight activity. (2) The BASALIS-type, in which flight has two twilight peaks, one at dusk and one at dawn (**Mallada basalis**). (3) The PERLA-type, in which flight starts in the afternoon and ends after the onset of total darkness (**Chrysopa perla, C. dorsalis**). (4) The HYPOCHRYSODES-type, which is basically a diurnal flier (**Hypochrysodes elegans**).
Thresholds for ambient illumination and temperature were determined. Most CARNEA-type lacewings fly below ca. 10 lux. Between 11 and 23°C, flight activity is an almost linear function of temperature. Day-length has no influence on the flight pattern.

INTRODUCTION

There were few published records of flight activity diagrams in lacewings; this is probably because lacewings have long been known to be nocturnal fliers, and surprises were not expected. Of the several methods used, light traps are the most unreliable to establish a diagram, because they select for nocturnal flight. Suction traps and sticky traps, on the other hand, have the disadvantage of trapping only small numbers of each species per light cycle. Still, from suction trap data (NEW, 1967; HONEK and KRAUS, 1981) and sticky trap data (DUELLI, 1980) it became evident that at least the most common species of the **Chrysoperla carnea** complex are clearly nocturnal fliers, with peak flight activity after sunset and a more or less continuous decrease towards sunrise. To my knowledge, no diagrams of other chrysopid species have been published so far.

METHODS

Laboratory experiments under controllable climatic conditions were used to establish flight activity diagrams of various species. The lacewings were placed singly or in couples in 500 ml plastic containers, provided with an artificial food mix (HAGEN and TASSAN, 1966) and a moist piece of foam rubber. The **finely perforated lids** of the containers were in contact with extremely sensitive microphones. When flying inside the container, the lacewings touched the lid with their wings. The sound of this contact can be heard even by the human ear. Crawling on the lid alone does not elicit a signal. The output signal of each microphone was fed into a 20 channel event recorder (Esterline Angus). Each container was surrounded by 4 cm of isolating material; 5 containers formed one unit, covered with a glass plate. One of the containers in each unit was used as a control without lacewings, in order to record the effects of outside noise or foreign switching artefacts. Moreover, inside these control containers light intensity was measured with an unfiltered selenium element which was calibrated with a luxmeter. As the sensitivity of all channels, even after careful adjustment, was not always the same, activity as seen on the charts of the event recorder was expressed in percent of the maximum activity of each container or specimen. Measuring the influence of temperature, activity at 20°C was used as 100 % level for calibration of the data of other temperatures.

The experiments took place in a greenhouse, where fluorescent light (40 lux, as measured inside the containers) was used in addition to natural daylight. This produced "long days" during the period of ca. 9 months of the year, when natural light conditions induce diapause in **C. carnea.**

RESULTS

1. Types of flight activity patterns

The flight activity diagram of **Chrysoperla carnea** shows the expected nocturnal pattern with a marked peak after sunset. This peak is not the effect of twilight conditions, it also occurs in laboratory experiments with sharp light-on/off transients. At constant temperature conditions above the temperature threshold, flight activity did not decrease during the night, as opposed to observations from field records with suction and sticky traps (DUELLI, 1980; HONEK and KRAUS, 1981). Flight stops rather abruptly in the morning without any dawn peak.

Most lacewing species tested so far show the above CARNEA-type of flight activity pattern (Tab. I), but there are exceptions. Four distinct types of diagrams are discernible at present (Fig. 1). The CARNEA-type starts flying after sunset, before it is completely dark, has a short but consistent activity peak after the onset of flight, then, under constant environmental conditions, a rather stable flight activity up to dawn, when flight activity decreases sharply.

An interesting twilight type was found in **Mallada (Anisochrysa) basalis** from the Pacific **islands.** This BASALIS-type is characterized by two flight activity peaks at dusk and dawn.

The PERLA-type, so far recorded only from **Chrysopa perla** and **C. dorsalis,** starts flying in the early afternoon and some even in the morning. Peak flight activity is before total darkness.

The most extreme diurnal flier is **Hypochrysodes elegans.** In the laboratory experiments they usually started flying before noon and mostly ceased before sunset.

In all the species the sexes were tested singly and in combination. No differences in the basic pattern of flight activity were observed.

2. Light

Light, or the absence of light, is a key factor for lacewing flight behavior. The exact threshold of illumination was measured in several species of the CARNEA-type. Flight activity begins at about 10 lux. To give a comparison: Full moon measured with the same photometer is ca. 3 lux. In the morning, flight stops at about 10 lux. Numerous experiments with **Chrysoperla carnea** have shown that flight can be induced at any time of the day by

HYPOCHRYSODES-type:	
Hypochrysodes elegans (BURMEISTER)	Sundgau, France
BASALIS-type:	
Mallada basalis (Walker)	American Samoa
PERLA-type:	
Chrysopa perla (L.)	Leventina, TI
Chrysopa dorsalis BURMEISTER	Pfynwald, VS
CARNEA-type:	
Chrysopa phyllochroma WESMAEL	Magadino, TI
C. septempunctata WESMAEL	Bözberg, AG
C. walkeri McLACHLAN	Montpellier, France
C. formosa BRAUER	Pfynwald, VS
C. viridana SCHNEIDER	Ganges, France
Anisochrysa flavifrons (BRAUER)	Bözberg, AG
A. ventralis (CURTIS)	Bözberg, AG
A. prasina (BURMEISTER)	Bözberg, AG
A. picteti (McLACHLAN)	Ganges, France
A. zelleri (SCHNEIDER)	Esterel, France
Cunctochrysa albolineata (KILLINGTON)	Bözberg, AG
C. baetica (HÖLZEL)	Esterel, France
Chrysoperla carnea (Stephens)	Sisseln, AG
C. mediterranea (HÖLZEL)	Pfynwald, VS
C. externa (HAGEN)	Paraguay
Nineta flava (SCOPOLI)	Bözberg, AG
N. pallida (SCHNEIDER)	Pfynwald, VS
Ceraeochrysa cubana (HAGEN)	Paraguay

Tab. I. Diel flight activity patterns.
Pattern identification of each species in this list is based on a total of at least 10 runs over 24 hours, contributed by various numbers of individuals of both sexes. Collection site, unless otherwise stated, is in Switzerland.

darkening below 10 lux. Using sharp light-on/off transients, flight starts with a delay of 13 ± 2 minutes.
Illuminating at night with more than 10 lux stops flight activity within 2-3 minutes. This reaction causes the lacewings to settle at night by the lights of a lantern or the blacklight of an entomologist.

3. Day length

Chrysoperla carnea adults from Basel were tested in long-day (16h light) and short-day (8h light) conditions at 20°C. Whether reared in a long-day or a diapause inducing short-day regime, the lacewings always showed the normal CARNEA-type flight activity pattern. Even after 2 weeks of flight experiments, when all animals were in diapause, flight continued unchanged.

4. Temperature

Several species have been tested at various temperatures (Fig. 2). They exhibit a sigmoid function of temperature, with an almost linear relationship between 11 and 23°C, which covers the temperature range of most nights in temperate regions from spring to fall. It was a surprise to see that the subtropical **Ceraeochrysa cubana** from Paraguay also had its zero level at about 10°C. **Chrysopa formosa** was the only species with a different threshold.

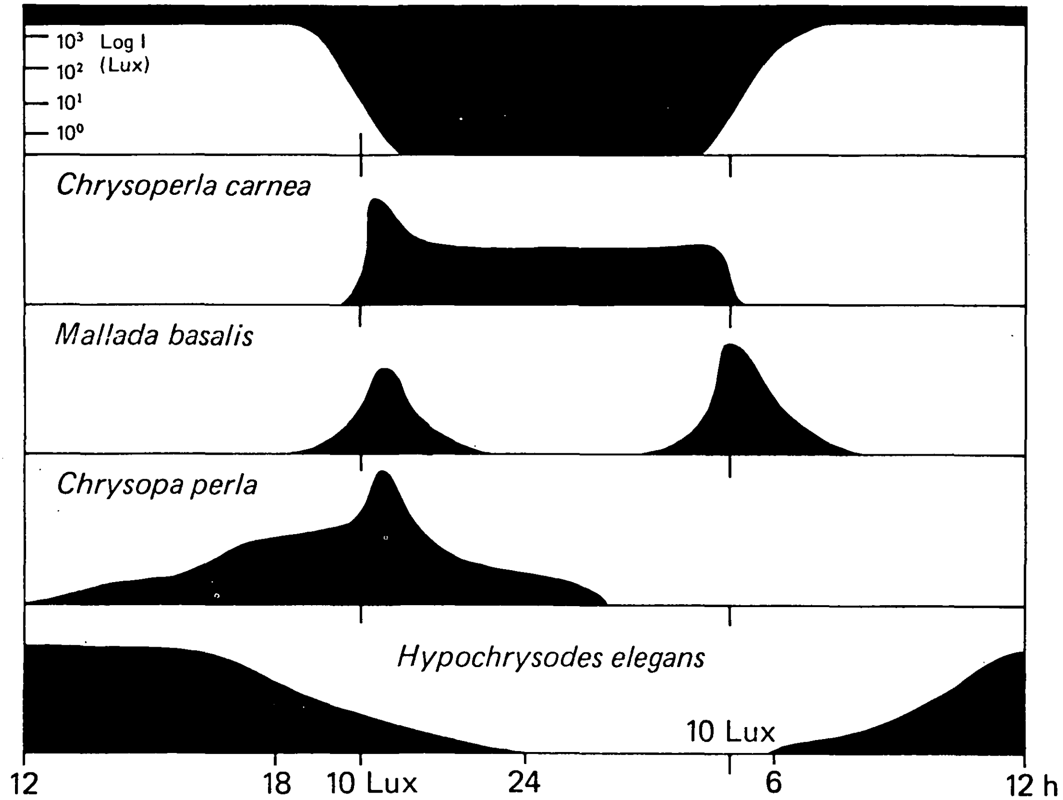

Fig. 1: Four distinct types of flight activity patterns in the family Chrysopidae. The top graph shows the intensity curve of natural day light in the containers.

DISCUSSION

The Neuroptera are generally considered to be mainly nocturnal fliers, but in most families there are more or less obvious exceptions. While the spectacular coloration of many Ascalaphidae and Nemopteridae indicate diurnal flight habits, the rather cryptic coloration of the Chrysopidae can be seen as a hint to a prevalence of nocturnal activity. The advantages of nocturnal flight are obvious: many visually oriented potential predators such as birds, dragonflies, damselflies and robber flies are diurnal hunters. They cease flight just before the main peak of lacewing flight. Judging from the large number of species with a CARNEA-type flight activity pattern, a strictly nocturnal flight habit seems to be the best solution for these slow and mostly defenseless fliers.

Both of the two species with PERLA-type flight habits have strongly developed stink glands. Maybe this is how they can afford to become active during daytime. On the other hand, the most extreme diurnal flier, **Hypochrysodes elegans**, to my knowledge, is defenseless. It is interesting to note here that **Chrysopa walkeri**, though very close to **C. perla**, belongs to the CARNEA-type.

Species of the HYPOCHRYSODES-type and PERLA-type are obviously underrepresented in light trap catches, since their main flight activity does not coincide with the trapping period.

A possible explanation for the evolution of the BASALIS-type, with two peaks at dusk and dawn, is the hypothesis that on very small islands in the middle of the Pacific Ocean a flight period of several hours in total darkness would inevitably lead to a loss in the sea. It might be the safest way to restrict flight to the short time when the diurnal predators are gone, while the silhouettes of the landscape are still visible.

Light, or the absence of light, is the overruling factor for flight activity. While flight intensity seems to be rather independent of light intensity, temperature can shape a diel flight activity pattern. Thus, in moderate climates with rather cold nights, the induction of flight after sunset is elicited by a decrease of ambient illumination below 10 lux. However, the gradual decrease of flight activity after midnight is mainly due to the decrease in temperature.

Cessation of flight activity in fall has been attributed to an all-or-none response to day length, similarly to the induction of diapause in late summer (BOWDEN, 1979). The laboratory experiments with natural short days in December, but at temperatures of 20°C, did not indicate any such effect in **C. carnea.**

Lacewings (mainly **C. carnea**) can sometimes be seen flying during the day or in cold nights. Most likely such individuals had been disturbed in their resting places. An important factor for flight induction is the microclimate of the resting site. In a dark crevice lacewings will become active much earlier in the evening than in a fully exposed site. Light measurements in corn fields (CORDILLOT unpubl.) after sunset indicate that the illumination threshold of 10 lux is reached more than 30 min. later on the top of corn plants than beneath a corn leaf, measured within the crop level at a height of 50 cm above ground. Similarly, a lacewing may become active on a cool evening in fall, because the resting site is still warm from the afternoon sun.

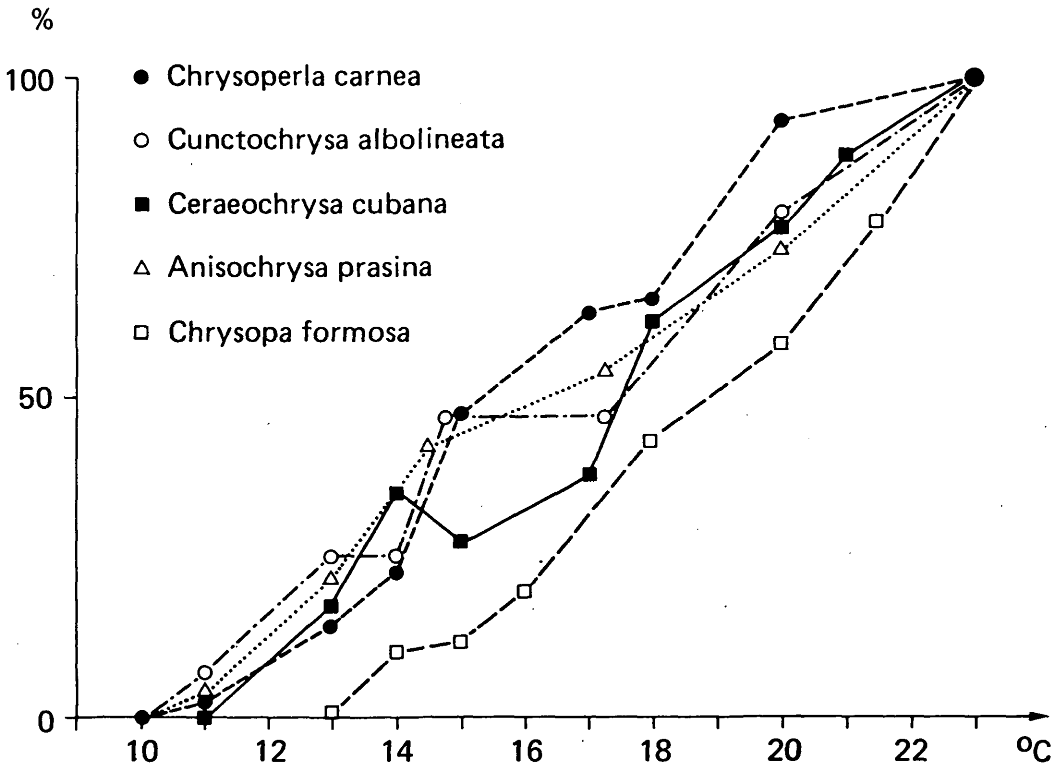

Fig. 2: Flight activity as a function of temperature, expressed for 5 species in percentages of flight activity at 23°C.

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