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NOTES ON THE EFFECT OF METEOROLOGICAL PARAMETERS ON FLIGHT ACTIVITY AND REPRODUCTIVE BEHAVIOUR OF *COENAGRION PUELLA* (L.) (ZYGOPTERA: COENAGRIONIDAE)

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The influence of temperature, light intensity, cloudiness and wind intensity on daily activity of *C. puella* at a pond in Lower Austria is discussed. For initiating flight activity, a minimum light intensity of 60×10^3 lux is needed. No flight activity was observed on cloudy days with light intensity values lying below the threshold of 60×10^3 lux or wind intensity $\geqslant 8$ m s^{-1}.

INTRODUCTION

It is known that flight intensity and reproduction in Odonata are influenced largely by climatological factors, such as temperature, light- and wind intensity. CORBET (1962) has shown that unfavourable temperatures can be avoided by migration, by flight to habitats with an equable microclimate or by a resting condition. Temperature changes on a daily basis can be regulated physiologically, e.g. by wing vibrations for raising the body temperature or behaviourally by choice of an appropriate resting site (MAY, 1977; CORBET, 1962). Another possibility is taken by crepuscular species, especially tropical Anisoptera.

The flight activity of *Coenagrion puella* is fully restricted to daytime. Although temperature plays a major role in egg development and larval growth of this species (Waringer, unpublished) and therefore in timing of the seasonal flight period, it has been found that daily flight activity is also affected by wind- and light intensity in a considerable way.

The aim of the present study was to obtain some quantitative information on the influence of meteorological parameters on daily flight activity of *Coenagrion puella.*

STUDY AREA AND METHODS

During the summer of 1980 observations on weather conditions and flight activity were made from the beginning of June to the end of September. The study area was a small pond (ca. 350 m², max. depth 50 cm), two kilometres south of Herzogenburg in Lower Austria (longitude: 15°42'E, latitude: 48° 16'N, altitude: 236 m).

Macrophytic vegetation in the pond consisted of *Phragmites communis* Trin., *Typha latifolia* L., *Myriophyllum verticillatum* L. and *Ranunculus trichophyllus* Caix., the latter being the favourite oviposition substrate.

As the surrounding wood has been cleared two years previously, the pool was unprotected against winds, which could be a limiting factor for oviposition and flight activity.

The main vegetation at the banks consisted of *Lysimachia vulgaris* L., *Filipendula ulmaria* (L.) Maxim., *Lythrum salicaria* L. and *Eupatorium cannabinum* L. Sixteen odonate species were observed at the pool, of which *Coenagrion puella* was the most abundant.

With the exception of June, nearly daily observations were made. Air temperatures were registered continuously with a recorder, light intensity values were obtained with a luxmeter. Cloudiness was recorded as n/8th of total cloud cover and also the cloud type. Wind intensity was estimated in degrees Beaufort and measured with an anemometer.

OBSERVATIONS

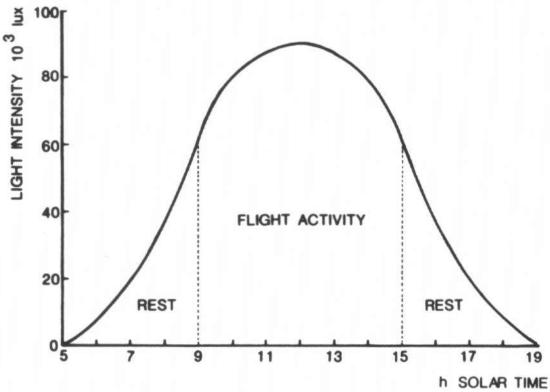

Fig. 1. The influence of light intensity (Y lux) on the flight activity of *Coenagrion puella* on August 7th, 1980.

August 7th was a clear, calm day. At 09.00 h solar time air temperature and light intensity recorded were 23°C and 61 x 10³ lux, respectively. At this time some of the males left their resting sites of the previous night on the banks and perched on macrophytes in the open water. No sexual activity was observed till 10.00 h. By then the females returned to the water. The maximum temperature and light values were recorded at 12.00 h (30°C and 88 x 10³ lux, respectively). Intensive mating behaviour and oviposition activity could be observed until it decreased at 15.00 h (temperature 30°C, light intensity 62 x 10³ lux). At 16.00 h flight activity had ceased. *Coenagrion puella* showed the same activity pattern (Fig. 1) on all bright days with clouds $< 2/8$ and wind intensity < 8 m s⁻¹. (20% of the time of the observation period).

Light intensity and temperature values were similar on August 6th; 2/8 of the sky were covered by Cumuli. A fairly strong westerly wind (8 m s⁻¹) made copulation and oviposition difficult. The wind did not allow accurate landings, thus limiting the damselflies' selection of suitable substrata for oviposition. I observed one tandem which succeeded in landing on a old leaf of *Typha latifolia* floating on the water surface. As the female started oviposition, the male tried to stand upright on the prothorax of the female as in many species of coenagrionids ("Coenagrion type" of oviposition by JURZITZA 1978, described also by ROBERT 1958 and SCHIEMENZ 1953). The wind made it impossible for the male to achieve its vertical position and the movements of the leaf in the water forced the couple to fly away. Other attempts occurred without success and the couple parted. No other tandem was observed on this day. Wind intensities ≥ 8 m s^{-1} were recorded in 14% of the observation period.

July 9th was a calm day (wind intensity < 1.5 m s^{-1}), the temperature at 12.00 h was 22°C, at 17.00 h it had dropped to 15°C. The entire sky was overcast with 8/8 Nimbostratus. Light intensity at 07.30 h was 5500 lux and increased to the maximum value of 45 x 10^3 lux at 12.00 h. Males and females were resting in the vegetation on the banks, and only physical disturbances made them fly up for a short distance; soon they perched again, preferably on protected sites underneath leaves. No reproductive behaviour was seen the whole day although both sexes were resting close together. Similar weather conditions (clouds ≥ 6/8, wind intensities < 8 m s^{-1}, light intensity < 60 x 10^3 lux the whole day) without flight activity were recorded in 45% of the time of the observation period.

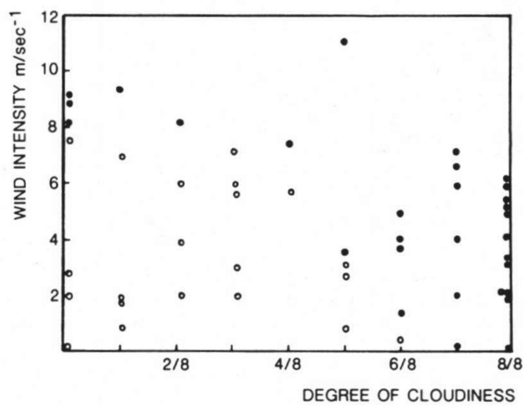

Fig. 2. The combined influence of cloudiness and wind intensity on the flight activity of *Coenagrion puella* on different days in July and August, 1980. o = flight activity and oviposition, • = no flight activity.

On the remaining days (21%), cloudiness between 2/8 and 6/8 was observed. Wind intensity varied from calm to 8 m s^{-1}. The influence of these parameters in combination on flight activity is shown on Figure 2.

DISCUSSION

Little information is available on the influence of meteorological parameters on the daily actvities of adult Odonata. CORBET (1957) has shown the effect of temperature and light intensity on the emergence and the maiden flight of *Anax imperator* in southern England by using the findings of NIELSEN (1961); he provided data for the estimation of light intensity during twilight periods by expressing the time in terms of the current duration of Civil Twilight (cited in CORBET, 1962). Light intensity seems to affect also the flight period of tropical species, as it is reported from the crepuscular *Heliaeschna ugandica* (CORBET, 1962). PARR (1965, 1973) discussed the effect of weather parameters on the activity of *Ischnura elegans*.

The results have shown that light intensity may restrict flight activity of *Coenagrion puella*, too. As it is demonstrated in Figure 1, ca. 60 x 10^3 lux seems to be a critical value during the entire seasonal flight period of this species. If this threshold is reached in the morning, flight activity starts and continues until light intensity falls to its threshold-minimum (60 x 10^3 lux) in the late afternoon. As the declination of the sun decreases from June to the end of the seasonal flight period in September, the daily period with light intensity > 60 x 10^3 lux also decreases gradually and hence the daily flight activity.

On many clear days the temperatures at the end of the daily flight periods were the same as during the times of maximal activity. Thus, light intensity seems to be more important than temperatures for the determination of daily flight activity.

An important factor for light intensity in the field is the degree of cloudiness. On cloudless days, flight activity is highest; the limit on a calm day is reached as soon as ca. 6/8 of the sky are covered. The results have shown that by then, light intensity in most cases has reached the critical value of 60 x 10^3 lux. Of course, light intensity depends largely on the cloud type; the intensity transmitted by a thin layer of Altostratus in June may be 45 x 10^3 lux at noon. For heavy Cumulonimbus, the value may be only 4 x 10^3 lux. But both are below the critical value.

The response to light intensity can be affected also by wind intensity. On a clear summer day with light intensity values lying well above the threshold, only a fairly strong wind ($\geqslant$ 8 m s^{-1}) may restrict flight activity. The results have shown that also tolerance to lower light intensities can be influenced by wind, i.e, oviposition frequency on a cloudy day (but > 60 x 10^3 lux) may be high if the wind intensity is low; otherwise, a cloudless sky is able to compensate for a fairly strong wind. Flight activity is only restricted if both unfavourable parameters occur together or if one parameter sinks below its threshold (Fig. 2).

Thus, the response of *Coenagrion puella* to environmental conditions seems to be quite complex, and many factors are involved. Further studies are necessary on the same species in other parts of its area as well as on other species in order to obtain more information on this subject.

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