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Nocturnal roosting sites of *Calopteryx splendens*: a marking study (Odonata: Calopterygidae)

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Abstract

In summer 2001 a population of imaginal *Calopteryx splendens* was investigated with regard to its nocturnal roosting site preferences. A fluorescent substance was applied to the abdomen for re-finding marked specimens at night using UV-illumination. During the study the distance of the nocturnal roosting sites to the river significantly decreased, and in July nearly all individuals were found at the edge of the river. Height of roosting sites between 0.5 to 1.0 m from the ground was preferred regardless of weather conditions. At night the body of the odonates was mainly oriented towards the east; furthermore, *C. splendens* significantly preferred the western bank as a nocturnal roosting site. This orientation ensures a quick warming up of the body in the morning.

Keywords: Odonata, dragonfly, Zygoptera, territories, marking, behaviour, nocturnal roosting, mark-and-recapture

Zusammenfassung

Nächtliche Ruheplätze von *Calopteryx splendens*: Eine Markierungsstudie (Odonata: Calopterygidae) – Im Sommer 2001 wurde eine Population von Imagines der Gebänderten Prachtlibelle (*Calopteryx splendens*) bezüglich ihrer Präferenz für nächtliche Ruheplätze untersucht. Dazu wurde eine fluoreszierende Substanz auf das Abdomen der Tiere aufgetragen, um das Wiederfinden markierter Individuen mit Schwarzlicht bei Nacht zu ermöglichen. Im Verlaufe der Studie verringerte sich der Abstand der nächtlichen Ruhesitze zum Fluss signifikant. Im Juli waren die Tiere fast ausschließlich an der Uferkante zu finden. Die Höhe der nächtlichen Sitzwarten war unabhängig von den Wetterbedingungen und lag zwischen 50 cm und 1 m. Die Tiere richteten ihren Körper nachts überwiegend nach Osten aus. Außerdem bevorzugte *Calopteryx splendens* signifikant das Westufer als Ort für den nächtlichen Aufenthalt. Diese räumliche Orientierung ermöglicht ein beschleunigtes Aufwärmen der Körper nach dem Sonnenaufgang.

1. Introduction

Mark and recapture investigations on insects have mostly been performed at daytime. Marking for re-finding at night has only been used in a few cases due to the higher effort required for these methods (Wheye & Ehrlich 1985, Heller & von Helversen 1990, Janßen & Plachter 1998, Hunger & Röske 2001). For habitat selection and the complex demands of a species in regard to its habitat, however, nocturnal roosting sites may be of importance and may affect the occurrence or lack of a species.

Only very few investigations on Odonata have been performed with reference to their nocturnal roosting sites (REHFELDT & NEUBAUER 1995; KETELAAR & PONTENAGEL 2000, HUNGER & RÖSKE 2001). Most data provided in the literature rather refer to occasional records. Therefore, we investigated in a more comprehensive survey a population of *Calopteryx splendens* (HARRIS, 1776) with the aim to obtain reliable information as to where this species is located during the night and how far it flies from its daytime territories at a river to its nocturnal roosting sites.

2. Study site and methods

The investigation on nocturnal behaviour and roosting sites was carried out between 7 June and 2 August 2001 at the brook Pließnitz at the southern border of the former lignite mining site Berzdorf, ca 5 km S of Görlitz, Saxony, Germany. The brook had been transposed to the periphery of the opencast mine in the 1960s to reduce ground water influx to the mine. Lignite mining in Berzdorf was discontinued in December 1997 due to economical reasons; in ponds on the mining site and in the spoil dumps on its periphery, 49 odonate species have been recorded (XYLANDER & STEPHAN 1998, 2001).

About 320 m of the banks of the brook – harbouring a moderate-sized population of *Calopteryx splendens* (abundance class 3 according to BUCHWALD 1989) – were chosen as an investigation site. The banks showed a typical »double-U«-profile; both were steep and had rich vegetation. Beside the banks there was a flat area with ruderal vegetation followed by a rather steep slope.

Within the investigation period, 1872 individuals (1184 males, 688 females) of *C. splendens* were captured on both banks and individually marked on one of their wings using a black waterproof fine-liner pen (Staedler Lumocolor 318 F). Furthermore, a yellow- or orange-coloured luminous paint (Jenzi, »Tagesleuchtfarbe«, Art. No. 8112) was applied to the abdomen of the individuals (cf. GEPPERT et al. 2002).

Marked specimens acted »normally«; they were frequently observed during territorial and mating flights at the river as well as during mating with unmarked individuals.

Recapture – more appropriately »re-finding«, as the information was often obtained without catching the individuals – of marked *C. splendens* began at dawn. Two persons investigated the banks and the neighbouring vegetation. On a few days nocturnal surveys were performed directly from the bed of the river. For detection of fluorescence-ink-marked specimens during the night, two UV-torches powered by a 12 V/7.0 A h-lead accumulator were used. The smaller one (8 W/12 V) illuminated marked individuals up to a distance of 2 m, the larger one (15 W/12 V) up to 4 m.

3. Results

On 13 nocturnal surveys 210 individuals of *Calopteryx splendens* (144 males, 66 females) were re-found on the banks of the Pließnitz, 125 of which were marked with the luminous paint; others were found by chance as they were located in direct vicinity to fluorescing specimens. The recapture rate was 6.6 %. The longest period of an individual re-found after marking was 16 d; most specimens, however, were found 0 – 48 h after marking. Male and female imagines did not show significant differences regarding their preferences of nocturnal roosting sites.

3.1. Distance from the brook

During the investigation the mean distance of the nocturnal roosting site to the brook decreased (Fig. 1). From 7 June to 19 July 2001, *C. splendens* was found dispersed on the meadows of the banks at a distance between 0 to 10 m with a preference for up to 2 m from the edges of the river. After 20 July, 98.5 % of the recorded *C. splendens* roosted directly at the river edge at night. The differences in habitat preference between the two periods were highly significant (χ^2 Test, $p < 0.001$).

The temperature within the period of investigation correlated with the distance to the river. From 7 June until 3 July 2001, temperatures were 10 – 16 °C; during this period the mean distance of roosting sites to the river varied between 0.3 to 3.8 m (the only exception was on 25 June, on which all specimens were recorded directly at the river). With an increase of temperature up to 17 – 21 °C after 5 July, imagines preferred roosting sites close to the water edge (0 – 0.4 m). On 11 July, the night temperature declined to 11 °C; during this night, *C. splendens* was recorded at a mean distance of 0.8 m.

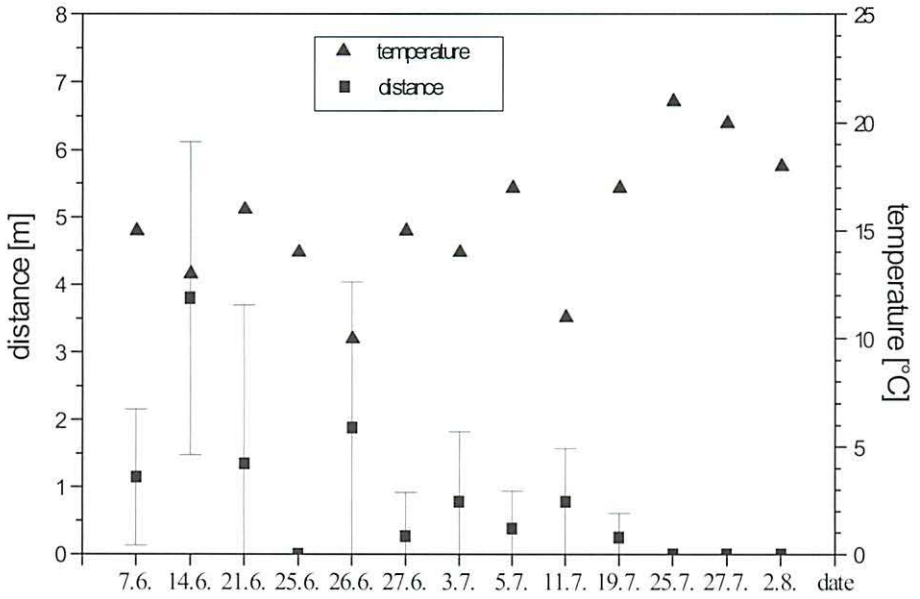

Fig. 1 Distance of nocturnal roosting sites of *Calopteryx splendens* ($n = 210$; mean and s.d.) from the Pließnitz River and air temperature between 7 June and 2 August 2001.

3.2. Height of nocturnal roosting sites

The preferred height of the nocturnal roosting sites was 0.5 – 1.0 m, encompassing 62.4 % of the individuals recorded at night (Fig. 2). At 1.0 – 1.5 m, 23.3 % of the individuals occurred and at 0.25 – 0.5 m only 14.3 %. Weather conditions had no effect on the height of the roosting sites. Even during rainy or stormy weather, *C. splendens* did not hide in the vegetation closer to the ground.

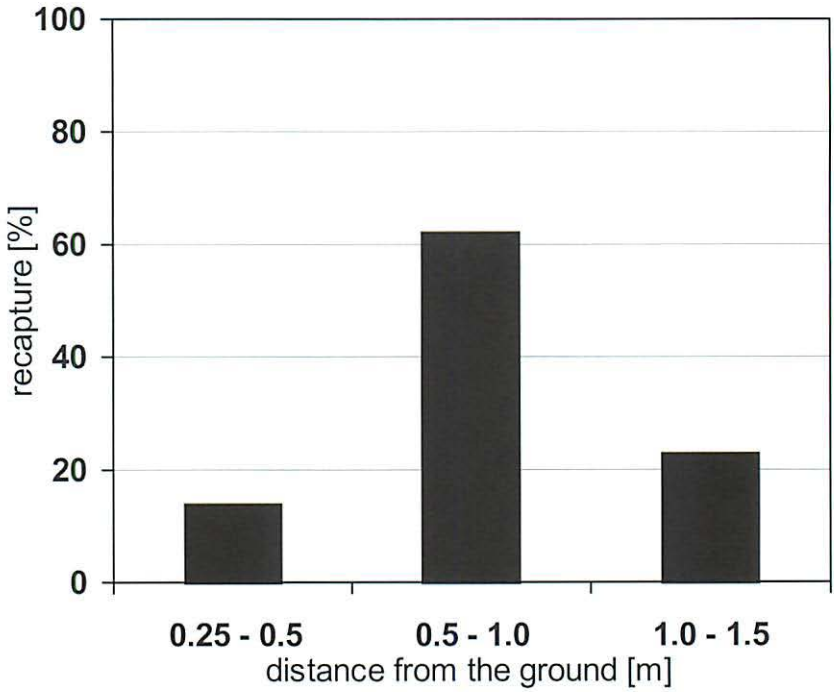

Fig. 2 Height above the ground of nocturnal roosting positions of *Calopteryx splendens*.

3.3. Orientation

Of the 210 individuals re-found at night, 56 (26.7 %) were oriented with their body tip facing eastwards, 43 (20.5 %) towards the south and 38 (18 %) towards the north. Less than 4 % were oriented towards the west (Fig. 3). Intermediate positions (e.g. NE or SE) were chosen less often than the main directions. There were differences between the sexes; males were mainly oriented towards the east, females towards the south.

3.4. Preference for the riverbank

C. splendens significantly preferred the western bank of the river as its nocturnal roosting site. 182 specimens were recorded at the westerns banks, only 28 at the eastern banks. This preference was significant (Wilcoxon-test; $p = 0.021$). The banks at which specimens had been previously marked were of importance; a high fluctuation from one riverbank to the other, however, had been recorded during daytime surveys. On four of eight nocturnal investigations, no individual was recorded at all at the eastern banks. These four nights were windless. Therefore, wind drift as factor of translocation to the western banks can be excluded; the temperature on those days was 18 – 21 °C, the sky was clear.

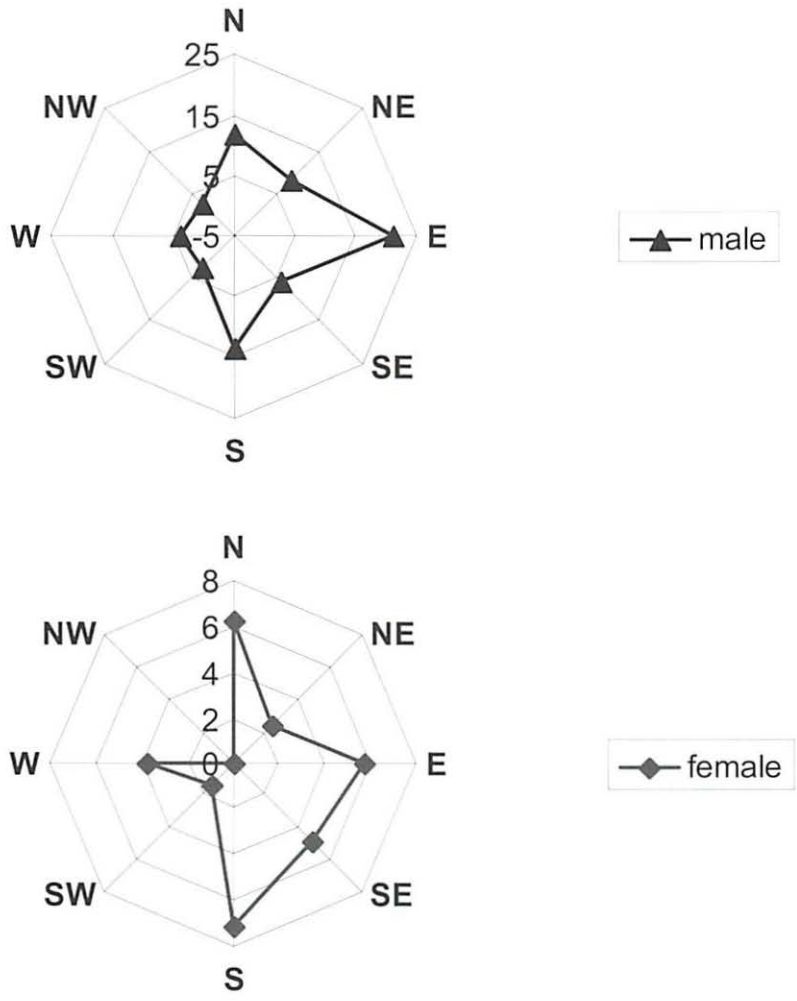

Fig. 3 Body orientation of male and female *Calopteryx splendens* recorded nocturnally at the Pließnitz River (percentage of all individuals re-found).

4. Discussion

Calopteryx splendens is considered to be a species inhabiting flowing waters. Imagines rarely disperse further than 10 to 200 m (ZAHNER 1960); other authors (STETTMER 1995, SCHUTTE et al. 1997) mention a dispersal distance of 300 – 400 m from the site of metamorphosis. Only 1 – 5 % disperse further than 1 km (STETTMER 1996). This could be confirmed during this investigation; all imagines had moved less than 10 m between the locations of marking and re-finding.

A preference for nocturnal roosting sites close to the reproduction habitats has also been shown for other rheobiont zygopterans (STERNBERG 1994, HUNGER & RÖSKE 2001). *Coenagrion mercuriale* (Charpentier) was mainly found 0 – 5 m from its habitat rivers (HUNGER & RÖSKE 2001), while other zygopterans like *C. hastulatum* (Charpentier) may fly longer distances to their nocturnal roosting sites (KETELAAR & PONTENAGEL 2000). *Calopteryx haemorrhoidalis* (Van der Linden) spent the night at distances between 6 and 100 m (HEYMER 1973; NEUBAUER & REHFELDT 1995). BEUKEMA (2002) could not estimate the distance, because *C. haemorrhoidalis* at his study site rested on higher trees more than 10 m away from the water.

The distance of the nocturnal roosting sites of *C. splendens* to the river changed within the period of investigation. This may be due to the fact that imagines during maturation are mainly interested in prey, which they predominantly find on the meadows beyond the river banks. The early period of capture in this investigation was just after the start of the emerging period. After maturation, however, individuals are mainly interested in reproduction and, therefore, protect their territories close to the rivers. Thus, they decrease the migration distances. The higher the nocturnal temperature was, the closer were the roosting sites of *C. splendens* to the water edge. Temperature effects the development of *C. splendens* (VARLEY et al. 1980). The increase of air temperature and the proceeding state of maturation may have been synergistically responsible for the transposition of the nocturnal roosting sites from the meadows to the water edge.

Whether the imagines of *C. splendens* hang vertically on the substrate or sit horizontally seems to depend on habitat structure (there were no significant preferences noticed in the present study). SCHMIDT (1926) observed imagines only in hanging positions. Other zygopterans (Coenagrionidae) also take an upright position at night (ASKEW 1982). *C. splendens* was found at the Pließnitz at a height of 0.5 to 1.0 m, independent of weather conditions. This corresponds to the findings of Zahner (1960). On the other hand, MILLER (1989) observed the libellulid *Potamarcha congener* (Rambur) roosting at night on small trees about 2.5 – 6 m above the ground.

To become active after roosting, odonates need higher temperatures than during their flight activity period. Odonata can increase their body temperature by exposing their body towards the sun. To reactivate after their nocturnal body temperature decline, the western bank (which is directly exposed to the rising sun) was most suitable. *C. splendens,* therefore, chooses roosting sites on that bank, which is exposed to the early morning sun (see HEYMER 1972). At night, *Hetaerina americana* (Fabricius) was also found on the western bank of slow-moving sections of a river (SWITZER & GRETHER 1999).

Furthermore, odonates do not arbitrarily orient their body at their roosting site. This was indicated by a preferential position facing the east, which ensures a direct exposure to the morning sun at sunrise. Warming up of the lateral body may also be advantageous (as indicated by a rather frequent orientation of the body towards the south and the north). An orientation towards the west, however, keeps the specimen hidden in the shadow of the plant serving as roosting site and was avoided. *Palpopleura lucia* (Drury) and *Acisoma panorpoides* (Rambur) also take roosting position in acute angles with the perches (HASSAN 1976). JOSEPH & LAHIRI (1989) found no particular preferred direction in the orientation of individuals in *Potamarcha congener*.

An aggregation at the roosting site with up to 150 individuals sitting in close vicinity as described by SCHMIDT (1926), ZAHNER (1960), NEUBAUER & REHFELDT (1995), was never recorded at the Pließnitz. Imagines rather preferred loose aggregations, corresponding to the observations of HEYMER (1973). Sex-specific nocturnal sites as described by SCHMIDT (1926) were also not found during this study.

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