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SHORT COMMUNICATIONS

EMERGENCE PATTERNS OF *COENAGRION HASTULATUM* (CHARPENTIER) IN NORTHERN GERMANY (ZYGOPTERA: COENAGRIONIDAE)

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The emergence patterns were followed closely at a pond E of Braunschweig. The emergence period lasted 24 days and the EM50 was reached after 11 days. Due to its emergence phenology, *C. hastulatum* is classified as a summer species. The date of emergence was negatively correlated with head width in ♀♀ but not in ♂♂. In ♂♂, a negative correlation occurred between the date of emergence and the body mass at emergence. These findings are contrasting previous studies and are discussed with respect to sexual differences. The results are compared with the emergence patterns of other odonates.

INTRODUCTION

On account of their emergence phenology, the temperate zone dragonflies are classified as spring- or summer species (CORBET, 1962). Species that emerge early in the year usually have a short emergence period and a close synchronisation. These are termed "spring species". In others, emergence is often poorly synchronized and it is spread over a long period. They have been termed "summer species" (CORBET, 1954). Recently SUHLING (1995) demonstrated that the local temperature regime defines the spring- or summer emergence pattern, in *Onychogomphus uncatus* (Charp.) (Gomphidae) at two adjacent streams in southern France. Based on the work of GARDNER (1954), CORBET et al. (1960) suggested *Coenagrion hastulatum* to be a summer species.

Whereas *C. hastulatum* is widespread and common in northern Europe (OLSVIK & DOLMEN, 1992) it is rare in central Europe. The preferred habitats in central Europe are acid sphagnum ponds (BELLMANN, 1993). The biology of *C.*

hastulatum is poorly known. GARDNER (1954), NORLING (1984) and JOHANSSON & NORLING (1994) investigated its life history, with special emphasis on northern populations. Additionally, JOHANSSON (1996) conducted experiments on larval ecology. Until present, the emergence patterns have not been described.

The aim of this investigation was the study of *C. hastulatum* emergence patterns within a single emergence period. We provide data on emergence, weight, headwidth and sex ratio. Some findings on sexual differences in changes of body mass and headwidth in correlation with the emergence date are also presented.

STUDY SITE AND METHODS

The study pond, Eckernkamp, is situated 18 km E of Braunschweig, in the district of Helmstedt (52°18'20"N, 10°46'20"E). It is surrounded by an annular ditch. The aquatic vegetation consists mainly of *Stratiotes aloides* which covered 70% of the water surface at the time of the study. Other autochthonous coenagrionid species are *Pyrrhosoma nymphula* (Sulz.), *Coenagrion puella* (L.) and *C. pulchellum* (Vander L.). In total, 18 autochthonous odonate species occur at the Eckernkamp.

The study was conducted during May and June 1996. On May 5 we set up at the bank 5 gauze-cages, covering a surface of 8 m². The cages were made of four wooden posts, covered with mosquitonet. The net ended 2 cm over the water surface. This, because the net is also accepted by damselflies as an emergence substrate.

The emerged adults were collected daily in the afternoon, when the emergence had stopped. Each damselfly was kept separately in a plastic box with a perch, to harden overnight. The next day we weighed them, and the head width was measured, using a Zeiss-Stemi SR dissecting microscope. Ultimately, the insects were released at the pond.

RESULTS

Emergence began on May 16 and continued until June 8, 1996. A total of 219 adults emerged (121 ♂, 98 ♀). The sex ratio at emergence was male-biased (55.25% ♂), but did not differ significantly from unity (χ^2-test, ns).

Figure 1 shows the cumulative percentage of the daily emergence during the period from 16th May until 8th June. The last few individuals emerged after a short interval on 8th June. EM_{50} was reached on the 11th day of emergence (26 May). The first male and the first female emerged both on the same day, on 16 May (Fig. 2). Emergence continued until 8 June. An obvious feature of the histograms is the large daily fluctuation in the number of emerging individuals. There were two emergence peaks in the population.

Males did not emerge significantly earlier than females, although more males than females emerged during the first four days. Comparing the numbers per sex and day, during 10 out of 17 days of the emergence period more males than females emerged. The mean head width and body weight during emergence are shown in Table 1.

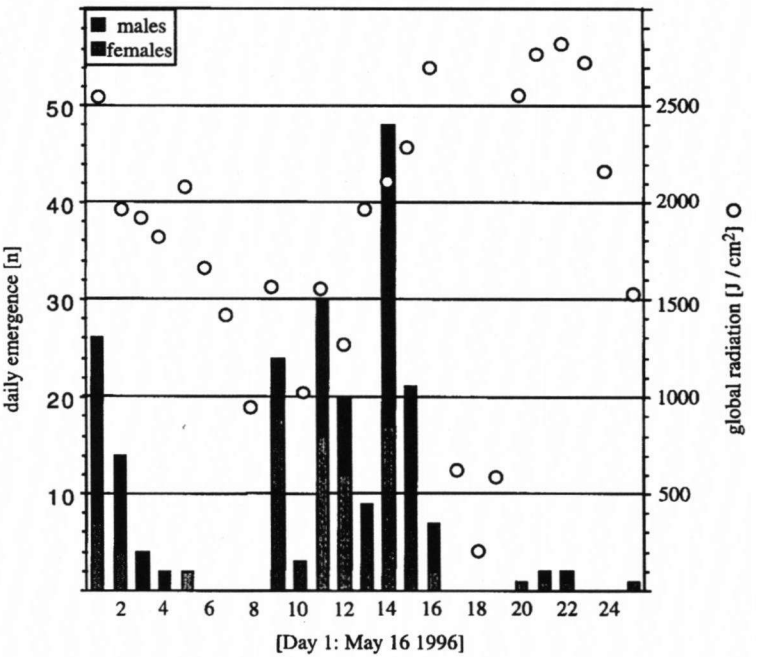

Fig. 1. Daily emergence of *Coenagrion hastulatum* at the study site in northern Germany. The black parts of the bars indicate males, the shaded ones the number of females. The circles indicate the global radiation (DEUTSCHER WETTERDIENST, 1996).

Figure 3 presents the ratio of weight and head width (mg mm^{-1}) over the emergence period. In males the ratio decreases slightly towards the end of the emergence period. In females no significant correlation was found. Therefore we applied a Spearman-rank correlation (Tab. II). In females a significant correlation between the day of emergence and the decrease in head width was found ($rs = -0.304$; $P < 0.01$, $N = 98$). In contrast, in males there exists a negative correlation between the date of emergence and the decrease of body weight ($rs = -0.231$; $P < 0.01$; $N = 121$) (Tab. II).

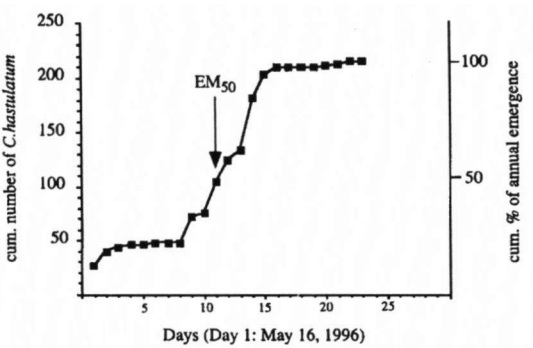

Fig. 2. Cumulative emergence curve of *Coenagrion hastulatum* at the Eckernkamp. The EM_{50} is reached after eleven days.

DISCUSSION

Coenagrion hastulatum emerged over a period of almost three weeks, from May 16 to June 8, 1996. In the preceding year emergence commenced on 6th May. The difference may be due to the long and harsh 1995/96 winter (cf. also SWEENEY, 1984). Despite the fact that the emergence period started early in the year, the emergence phenology tends towards a summer species. A typical spring species is *Pyrrhosoma nymphula* (CORBET, 1957) which emerges at the Eckernkamp pond during the same period. The emergence of *C. hastulatum* is not as closely synchronized. CORBET et al. (1961) classified *C. hastulatum* as a summer species. Here, we confirm this suggestion.

Table I

Mean weight and head width during emergence of *Coenagrion hastulatum* in 1996

Parameter	Females	Males
Mean weight ± SD [mg]	26.6±3.4	31.6±4.0
Mean head width ± SD [mm]	3.9±0.1	3.9±0.1

The odonate sex ratio is at emergence usually close to 1:1 (CORBET, 1980). In Zygoptera it is often slightly male-biased (LAWTON, 1972). The reasons for this phenomenon are still unknown. We also found a slight but not significant tendency for a male-bias.

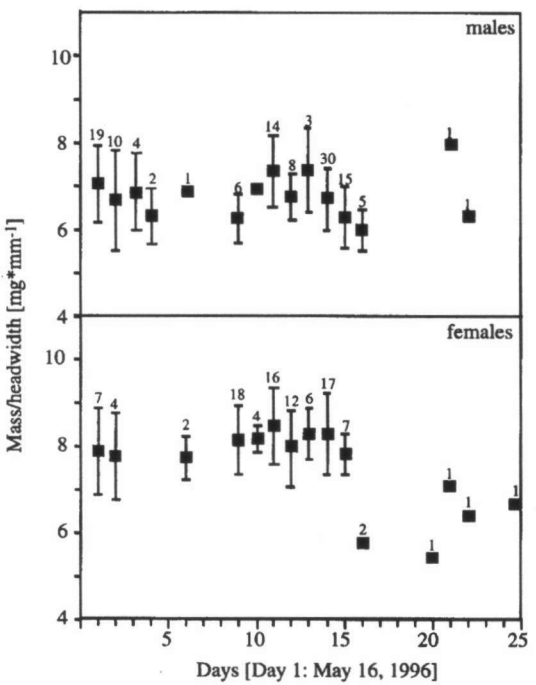

Fig. 3. The relative weight (weight/head width) in *Coenagrion hastulatum* at the Eckernkamp divided for males and females. The correlation used was a Spearman-rank correlation (♂: r_s=0.23, P=0.01; ♀: r_s=-0.08, ns). Shown are the mean, SD and N.

While in *P. nymphula* the males emerge significantly earlier than the females (GRIBBIN & THOMPSON, 1991), in *C. puella* the opposit is the case (BANKS & THOMPSON, 1985). In *C. hastulatum* the pattern is intermediate, no significant difference in the EM_{50} occurs between the sexes.

In damselflies head width and body weight are often negatively correlated with the emergence date (ANHOLT, 1990; BANKS & THOMPSON, 1985; GRIBBIN & THOMPSON, 1991), the smallest individuals emerge at the end of the season. Both

parameters are often strongly correlated (BANKS & THOMPSON, 1987b). This may be caused by food limitation (BAKER, 1989) or it is triggered by seasonal changes in larval densities (BANKS & THOMPSON, 1987a). Contrary to general experience elswhere, we noticed that in males only the mass decreased, and in females only the head width. This may be due to sexual differences in larval behaviour. BAKER et al. (1992) described sexual differences in larval damselflies and demonstrated that in last-instar larvae, the males show a higher plasticity in the choice of the emergence date.

Table II

Correlations between head width or body weight and date of emergence in male and female *Coenagrion hastulatum* (Spear-man-rank-correlation)

Sex	Head width	Body weight
♂	-0.304**	ns
♀	ns	-0.231**

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