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NOTES ON THE REPRODUCTIVE BEHAVIOUR OF *ENALLAGMA CYATHIGERUM* (CHARPENTIER) (ZYGOPTERA: COENAGRIONIDAE)

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The observations were carried out (1977-1979) at 3 localities in British Columbia, Canada. Reproductive activity began as early as 09.30. Sperm translocation, always in tandem, was always followed immediately by copula. Copula was intermittent, lasting 23-58 min., followed by exploratory oviposition for 10-27 min. Effective oviposition was both in tandem at the surface and unaccompanied, with the female submerged and the male guarding. Guarding lasted 7-35 min. Host plants included healthy tissue of *Callitriche verna* L., *Nuphar polysepalum* Engelm., *Sparganium minimum* Fries and *Scirpus* sp. The submerged female oviposited with head down while backing up the stem. Submerged oviposition lasted as long as 90 min, a record submergence interval in the Odonata.

INTRODUCTION

Periodic observations of mating and oviposition in *Enallagma cyathigerum* were made from 1977 to 1979 at three widely separate localities in British Columbia, Canada: Weston Lake, Saltspring Island; Pete's Pond, Tahsis; and Loon Lake, Ainsworth.

OBSERVATIONS AND DISCUSSION

In the dense forest at Loon Lake, most initial daily matings probably occurred along exposed patches of gravel roadbed, as males were found swarming there during the early morning, with pairs in tandem noted as early as 09.30. Most females probably fly to the water already in tandem, as noted by PARR & PALMER (1971) and GARRISON (1978). Of 29 females

observed surfacing following submerged oviposition, 22 were seized by males before they were able to fly to shore. Males were attracted not only to surfacing females, but also to severed, floating wings, including the large, banded wings of *Libellula forensis* Hagen.

Males were also sexually aggressive towards perched females of *Ischnura perparva* Selys, though pronounced abdominal lifting and severe wing warning by these tiny females seemed to prevent tandem seizure. This lack of ability by male *E. cyathigerum* to discriminate size has also been noted by PAULSON (1974), who found males responding sexually to female *Ischnura denticollis* (Burmeister).

The times from tandem seizure to achieving the wheel position were 7, 9, and 10 min. in three complete observations. Flights were common, and followed a zig zag pattern, attracting large numbers of single males. Similar erratic flight patterns have also been noted in tandem pairs of *E. civile* (Hagen) (BICK & BICK, 1963) and *E. aspersum* (Hagen) (BICK & HORNUFF, 1966) when uncooperative females were seized from the surface, following submerged oviposition. Prior to copula, tandem pairs of *E. cyathigerum* used vertical perches, such as the upturned lips of lily pads, *Nuphar polysepalum* Engelm., where unimpeded movements of the female's abdomen was permitted. However, whether perched or in flight, females initially held their abdomens in a drooping fashion, making no attempt to copulate until sperm translocation, which was noted in four pairs, and which was followed immediately by mating in each case. Translocation thus appeared to stimulate the female to mate. In contrast, females of *E. pollutum* (Hagen) and *E. signatum* (Hagen) actively probe with their abdomens to complete the wheel position, this action appearing to act as a releaser for males to translocate sperm (TENNESSEN, 1975).

In four observations, copula included 2 to 4 tandem interruptions, each interruption lasting 1 to 8 min, during which flights were common. Including these interruptions, mating lasted 27 and 41 min at 24°C, 23 min at 28° and 58 min at 29°C. Excluding interruptions, total durations of the wheel position were 24, 36, 19 and 45 min respectively. ROBERT (1958), however, does not mention such interruptions, stating only that "la copulation dure 10 à 20 min".

In six sightings, the exploratory period lasted 10 to 27 min, during which pairs, still in tandem, made frequent flights. Upon landing at the edge of a lily pad, a female tested the suitability of the pad for oviposition by arching the abdomen and touching the ovipositor to the upper surface, and, occasionally, the lower surface of the pad.

Only young, healthy tissue, such as the peduncles of new buds, and the petioles of curled, partially emersed pads was used for oviposition, contrasting with the observation by ROBERT (1958) of oviposition "sur les

débris secs des Scirpes, flottant sur l'eau". Surface oviposition was noted only in *Callitriche verna* L., with the female submerging only her abdomen, and ovipositing while still in tandem. However, in host plants such as *Nuphar polysepalum*, *Sparganium minimum* Fries and *Scirpus* sp., females submerged completely, head first, while the males remained on the surface. One female oviposited in both the above manners; first for 8 min in *C. verna*, and then below the surface in *S. minimum*.

On the thick petioles of *N. polysepalum*, submerged females oviposited in a head-down position, with the abdomen in a shallow arch, and deposited most eggs in regular patterns of wavy to zig zag lines, while backing up the stems, this behaviour also noted by ROBERT (1958). One female laid 231 eggs in 28 min, and another, 358 eggs in 77 min, at water temperatures of 22 and 21°C, respectively. Egg complement was determined by keeping the submerged females under continuous observation, and then later counting oviposition scars.

Females submerged for 28, 41, 54, 62, 63, 73, 77, 85, and 90 min (mean 63.7 min) on *N. polysepalum*; and 67, 79 and 87 min (mean 77.7 min) on *S. minimum*. Means for both the above host plants are close to the 65 min submergence of a single female on *Nymphea* (ROBERT, 1958), a duration recognized as a maximum submergence in the Odonata by CORBET (1962). The present study maintains *E. cyathigerum* in the position of longest submergence duration, increasing the record to 90 min.

Even in related species, submergence durations are markedly shorter, including 13-25 min for *E. aspersum* (BICK & HORNUFF, 1966); 6-29 min, for *E. carunculatum* Morse (LOGAN, 1971); 15-31 min for *E. exsulans* (Hagen) (BICK & HORNUFF, 1966); and 2-40 min for *E. civile* (BICK & BICK, 1963).

Two females were seen to surface and then resubmerge to continue ovipositing, a behaviour also noted by ROBERT (1958). One female resubmerged twice on adjacent *Scirpus* stalks, ovipositing for 15, 16, and finally, 36 min. A second female surfaced after ovipositing for 83 min on *N. polysepalum*, then resubmerged to oviposit for an additional 2 min.

Females in the act of submerging tended to attract large numbers of single males, and, when interference from these males was intense, the tandem male occasionally pulled the partially submerged female back to the surface and into flight. Usually, however, males released their grip just before their heads submerged and then remained on guard at the surface. However, guarding, which included wing warnings and short flights, was rather ineffective, so that often a number of single males would briefly share the same lily-pad with the guard, especially when the female remained in view below the surface. In one such case, single males repeatedly struck the water surface, attempting to grasp a barely submerged, ovipositing female. On *N. polysepalum*, guarding

lasted 7 to 35 min (mean 22.1 min) in 8 observations, but on *S. minimum*, females preferred barely emersed leaves, offering no foothold for the males, so that only a single 3 min hovering was observed. The one hour guarding period reported by ROBERT (1958) may have been unusually prolonged by a rain shower that occurred during the observation.

Nine of 29 females taken into tandem following surfacing at Loon Lake were released prior to a second oviposition, indicating that perhaps only a small percentage of females successfully mate and oviposit twice in one day. In fact, more than one mating per day seems to be rare for females of the genus, as only one mating per day is recorded for *E. praevarum* (JOHNSON, 1964), for *E. aspersum* and *E. exsulans* (BICK & HORNUFF, 1966), while two consecutive matings per day were very infrequent in *E. civile* (BICK & BICK, 1963).

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