

**THE OCCURRENCE AND ACTIVITY OF SPERM IN MATURE  
FEMALE *ENALLAGMA CYATHIGERUM* (CHARPENTIER)  
(ZYGOPTERA: COENAGRIONIDAE)**

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Examination of 28 mature female *E. cyathigerum*, caught immediately after presumed oviposition or early in the day, has shown that 96% carried some stored sperm and that 54% had full sperm loads. Further copulations, therefore, start with well-filled sperm stores in such females. Spermathecal sperm is highly active and disperses rapidly in saline, whereas sperm from the bursa is inactive and remains as a solid plug for at least an hour after removal.

## INTRODUCTION

Males of *Calopteryx maculata* and some other zygopterans remove previously deposited sperm from the female tract during copulation before they deposit their own sperm (WAAGE, 1979, 1982). *Enallagma cyathigerum* is thought to do the same, but it was not known if females carry sperm from previous copulations in this species (MILLER & MILLER, 1981). Most females caught either just after oviposition or early in the day are shown here to carry substantial sperm loads, and this supports the contention that sperm found adhering to the penis and the ovipositor of stage-I copulating individuals had been removed from female tracts by males.

## OBSERVATIONS AND DISCUSSION

Female *Enallagma cyathigerum* were observed ovipositing while submerged among beds of *Elodea canadensis* Michx. and *Potamogeton pectinatus* L. at a habitat previously described (MILLER & MILLER, 1981). After oviposition females returned to the surface, but they did so only during periods of sunshine when males flew abundantly over the water. In the absence of

emergent vegetation they were either blown to the water's edge or they were rescued by males which clasped them and dragged them along the water surface, or raised them into the air. Commonly several males were seen to compete for a resurfacing female. On reaching a perch the male invited copulation which commonly followed.

Twenty females were caught within 1 minute of surfacing and their egg and sperm loads were estimated after dissection. Sperm load was estimated from measurements of the distension of the bursa and spermatheca, taking the most swollen examples to be 100% full (cf. WAAGE, 1980). Nine females contained no mature eggs; 7 contained a few, and 4 contained full egg loads, indicating that oviposition had not occurred in a fifth of the sample. Sixteen females had a 90-100% full bursal sperm load; 3 contained 50-75%, and 1 contained less than 50% of a load in the bursa. Likewise 16 females contained 75-100% of a full spermathecal load, 4 contained about 50% and 1 contained less than 50%. Thus all females examined contained some live sperm, and 16 carried nearly full loads. Of the four which carried full egg loads, two also had full sperm loads, and the other two had full bursae but only partly filled spermathecae. The results therefore indicate that the amount of sperm used during one bout of oviposition was too small a fraction of the total to be measured.

A further batch of 19 females was collected at 09.00 hr on a dull day before daily activity had started. Of these 11 had unripe ovaries and were teneral; the remaining 8 had full batches of mature eggs, and in 6 the bursae and spermathecae were filled with sperm. In the 7th the bursa was full and the spermatheca contained a small amount of sperm, while the 8th had no detectable sperm. Thus of all 28 mature females examined, 96% contained a substantial amount of sperm and 54% carried full loads. Further copulations in such females therefore start with much sperm already present, and it is probably some of this sperm which is ejected by males and which was found on examination to be adhering to the penis and ovipositor (MILLER & MILLER, 1981).

The state of the sperm contained in females was examined by gently squashing out the contents of 10 bursae and 10 spermathecae on a slide in saline. In every case spermathecal sperm displayed a high degree of activity and swam rapidly on the slide. It tended to form pin-cushion-like clumps round granules which were also released, and it clustered round the micropyles of mature eggs. Sperm from the bursae, on the other hand, was much less active and it remained as a solid plug for at least an hour with very little activity of the individual sperm being seen except round the margin. Division of the plug into smaller masses did not activate the sperm, nor did contact with eggs or with spermathecal sperm. Sperm contained within an intact bursa did not appear to be active whereas that in a spermatheca could sometimes be seen to beat strongly, the high sperm density causing the

flagellar waves to become mechanically coupled.

The plug-like nature of bursal sperm probably facilitates its withdrawal from the female by the hooked processes on the penis. Spermathecal sperm on the other hand might not so readily be withdrawn en masse. Moreover in *E. cyathigerum* no part of the penis is capable of entering the spermatheca, and for spermathecal sperm to be removed by a copulating male, the sperm must first be expelled into the bursa or vagina by spermathecal contractions. The long copulation time of this species (ca. 20 min) may partly be concerned with this activity. In contrast, *Calopteryx* spp. have a relatively short copulation duration (1-5 min), and they possess barbed horns which can enter the spermathecae and extract sperm (WAAGE, 1979, 1982).

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