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EGG DEVELOPMENT AND EARLY INSTARS IN *CORDULEGASTER BOLTONII IMMACULIFRONS* SELYS: A FIELD STUDY (ANISOPTERA: CORDULEGASTRIDAE)

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Egg development lasted between 24 and more than 43 days (85% hatched). The mean head width and abdominal length of the 9 earliest instars are given. A method for odon. life history studies under natural conditions is presented.

INTRODUCTION

There are two common types of approaches for exploring the development and growth of odonates. One involves regular sampling, the other rearing of larvae in the laboratory. Studies of the second type are especially common and can demonstrate the effect of factors such as temperature (e.g. LUTZ & ROGERS, 1991) or photoperiod (e.g. INGRAM & JENNER, 1976) on development rates. However, natural conditions can only partly be simulated in the laboratory. Field studies by themselves are also common, but usually lack information on the early larval stages (e.g. FOLSOM & MANUEL, 1983).

Little is known about early instar larvae of *Cordulegaster* species (see VERSCHUREN, 1991). The aim of this work was to rear *C. boltonii immaculifrons* under natural conditions from eggs.

STUDY SITE

Investigations were carried out at the Canal de Vergières (CdV), an irrigation canal in the Crau (southern France). Current velocity varied between 1.2 m/s and a few cm/s near the edge. The yearly fluctuation of water temperature ranged between 18.1- 22.0°C in July 1991 (n=15) and between 12.7 - 13.3°C in January 1992 (n=9); however, the daily amplitude could be considerable, and a difference of 7.1°C (from 15°C to 22.1°C) in 24 hours was recorded on 1 July 1991. The oxygen content was near the saturation point throughout the year, and pH ranged between 7.8 and 8.0. Detailed information on the locality was provided by REHFELDT et al. (1991).

METHODS

A female of *Cordulegaster boltonii immaculifrons* was observed ovipositing on the bank into sandy sediment (2 July 1991). In order to study the development in the field, this sediment, which contained 26 eggs, was put into a cage and exposed in the CdV. The cage was a plastic box (frame 24 × 12 × 12 cm), covered with gauze (0.5 mm mesh). It was attached to the stream bottom with pieces of wire mesh that were fixed to both sides of the box and weighted down in the water with flat stones.

Monitoring of egg development was started one week after oviposition. Eggs were examined using a binocular microscope at 50 × magnification and measured to an accuracy of 0.02 mm. For larvae bigger than 0.6 mm head width, a magnification of 20 × was used and measurements made to the nearest 0.05 mm. Measurements of head width above the eyes according to the recommendation of DYAR (1890) and length of the abdomen from the first segment to the end of the anal pyramid were taken. Increase of water temperature during these examinations was limited to 3°C. Larvae in the cages were not fed additionally. In several experiments it was confirmed that nutrition as well as current velocity, temperature, and oxygen content were within the natural range (SCHÜTTE, 1992). The larvae were left in the cages until June 1992 after which they were set free.

RESULTS

The size of the eggs directly after oviposition was 0.8 × 0.55 mm (sd 0.01 mm, n = 12). They were short ovals, each with a small micropylar stalk, were coloured reddish brown, and had no jelly. The 22nd day after oviposition was the first date when the eyes of an embryo could be detected. The first larvae hatched after 24 days, but there were still eggs with no visible eyes. A prolarva was not observed. On the 43rd day, 76% (n=20) of larvae had hatched (first instar: head width 0.40 mm, sd 0.01 mm), but 30% (n=8) had already reached the second instar (hw 0.55 mm, sd 0.002 mm) (Fig. 1) The head width of the third instar was 0.69 mm (sd 0.02 mm), first reached by a

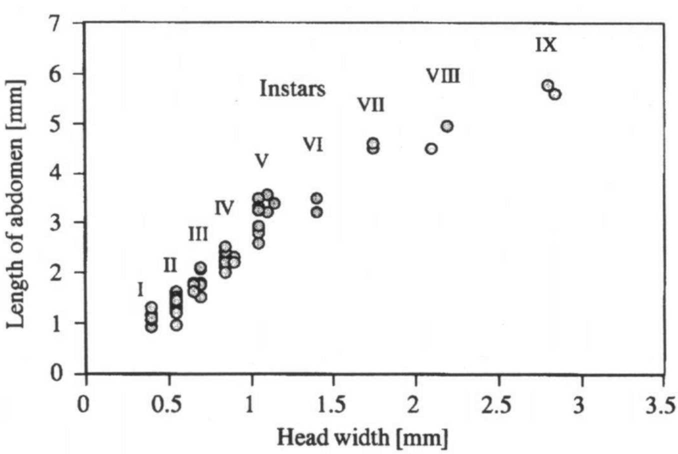

Fig. 1. Length of abdomen and head width (in mm) of the first 9 instars of *Cordulegaster boltonii immaculifrons* in southern France.

larva 51 days after oviposition when 62 % of the larvae were still in the second instar and 33 % were still in the first instar. The fourth instar (hw 0.85 mm, sd 0.02 mm) was recorded for the first time 77 days after oviposition. In total 26 larvae had hatched.

Table I

Mean head widths (in mm) with standard deviation (sd) of larvae of *Cordulegaster boltonii immaculifrons*. – [The growth ratio is the factor of increase of head capsule width from one moult to the next]

Instar	Head width (sd) [mm]	Growth ratio	number measured (n)
1st	0.40 (0)	-	7
2nd	0.55 (0)	1.38	35
3rd	0.68 (0.026)	1.24	8
4th	0.85 (0.018)	1.25	14
5th	1.07 (0.033)	1.26	12
6th	1.40 (0)	1.31	2
7th	1.75 (0)	1.25	2
8th	2.15 (0.071)	1.23	2
9th	2.83 (0.035)	1.31	2

On 7 January 1992, 189 days after oviposition, 18 % (n = 4) had reached the fifth instar with 1.05 mm hw (sd 0.00 mm). Two larvae had already reached hw 1.4 mm. Field studies stopped on 5 June 1992, nearly one year after oviposition. Out of the 26 larvae that hatched in July 1991, 14 larvae had survived in the cages. Eight of them were still in the fifth instar and two larvae had reached 2.8 mm head width, the ninth instar (Fig.1).

The width of head capsule increased by a factor between 1.24 and 1.38 per moult with a mean value at 1.27 (Tab.1).

DISCUSSION

METHOD. – To gain information on life cycles of aquatic insects the best method seems to be rearing the young instars in the field. Possible problems arise in obtaining eggs and, in running waters, preventing the cages from clogging. In rivers with a high degree of turbidity, cages should be cleaned or changed every two or three weeks, at least in autumn and spring. To reduce clogging and to ease exchange of prey organisms, the mesh size should be as large as possible, but not larger than the diameter of the eggs or the head width of larvae.

DATA. – Eggs in the Canal de Vergières (CdV) developed without diapause. FERRERAS-ROMERO (1994) states the same for *C. boltonii* in southern Spain. NORLING (1984) found the lower limit for larval development to be 8 - 12°C. Water temperature was above 13°C in the CdV even in January (1992), therefore a diapause in egg and even in the larval stage does not seem necessary.

The eggs of *C. b. immaculifrons* have no adhesive jelly, like many gomphids (e.g. SUHLING & MÜLLER, 1996). This seems to be unnecessary, because the eggs are deposited into the sediment and in this way they are protected from being washed away into unsuitable habitats.

The hatching period of *C. b. immaculifrons* in the CdV was rather long. Normally, the eggs are deposited at the same depth in the sediment, but the sediment was disturbed during transfer into the cages. Different egg depths resulted in variation of factors influencing the time of development, e. g. temperature and oxygen content.

The number of individuals of instars 6 to 9 was rather low, therefore these could not be distinguished with certainty. However, larvae of this size are easy to find by means of Surber sampling. Consequently, it should be easy to obtain information on bigger larvae. *C. boltonii* in southern Spain is semivoltine (FERRERAS--ROMERO, 1994). D'AGUILAR et al. (1986) noted in general a development time of 3 to 4 years or more; in medium latitudes of Europe it has been estimated to be between 4 and 5 years (e.g. ROBERT, 1958; KIAUTA, 1964; DONATH, 1988). The fast development of early instars in the CdV leads to the assumption that larval development of *C. b. immaculifrons* in southern France takes between 2 to 3 years.

The mean growth ratio of 1.27 per each moult for instars 1 to 9 lies within the range of growth ratios found for other hemimetabolous insects (COLE, 1980).

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