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NOTES ON OVIPOSITION AND EMBRYONIC DEVELOPMENT OF *ENALLAGMA EBRIUM* (HAGEN) AND *E. VERNALE* GLOYD IN QUEBEC (ZYGOPTERA: COENAGRIONIDAE)

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Captured individuals mated and oviposited in the laboratory. Eggs were placed under constant temperature conditions. In the 2 spp. the egg development is influenced by temperature, and it is best described by the sigmoid curve. The lower threshold of development is provided for each sp. along with day-degrees necessary to reach hatching.

INTRODUCTION

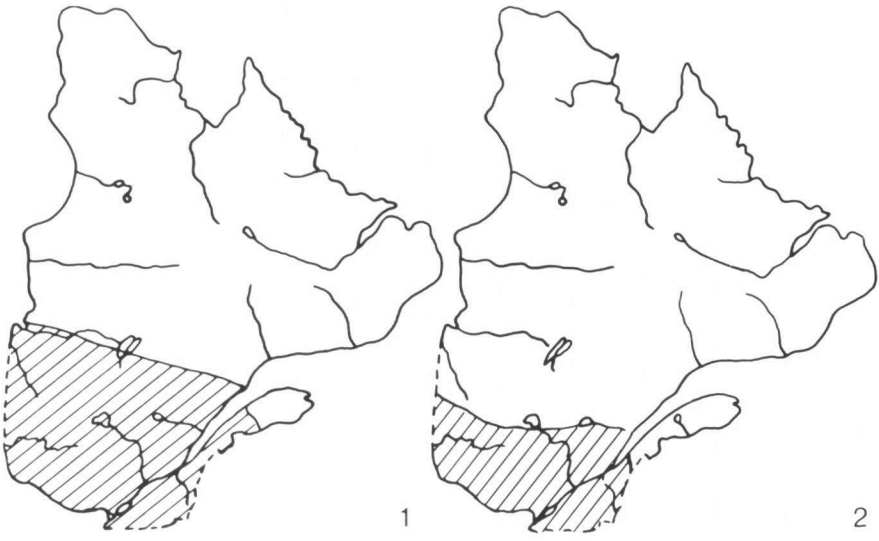
In 1966 a project on the Odonata of the Province of Quebec was initiated and it has evolved towards three main objectives. At the onset, the main emphasis was placed on the completion of the faunistic survey of Quebec (FERNET & PILON, 1968a, 1968b, 1968c, 1969, 1970a, 1970b, 1970c; FERNET et al., 1968; HARPER et al., 1975; PILON et al., 1978). With the development of a rearing technique (PELLERIN & PILON, 1975) and a better knowledge of the odonate fauna of the area where the biological station of the Université de Montréal is situated (LEBUIS & PILON, 1976; PILON & LEBUIS, 1976), emphasis was shifted to the description of larval stages and to the analysis of growth parameters of various Zygoptera (LEBEUF & PILON, 1977; PELLERIN & PILON, 1977; RIVARD & PILON, 1977, 1978). Recently, investigations on the ocular structures of Zygoptera (LAVOIE et al., 1975) were initiated and will be continued in future years.

This study presents observations and data obtained from rearings of *Enallagma ebrium* (Hagen) and *E. vernale* Gloyd, mainly related to oviposition and to the influence of temperature on egg development under laboratory conditions.

Different studies by WALKER (1953), ROBERT (1963), FERNET & PILON (1969, 1970a, 1970b), LEBUIS & PILON (1976) and PILON & LEBUIS (1976) indicated that *E. ebrium* can be

found as far north as the Rupert House (James Bay) - Godbout (North Shore) axis, as far east as the Matapedia Valley in the Gaspé Peninsula and in all southern Quebec (Fig. 1).

According to these authors, *E. vernale* is more restricted in its distribution since it can be found in all southern Quebec and as far north as the Abitibi (La Ferme) - North Shore (Port-au-Persil) axis (Fig. 2). Its eastern distribution is not well known although it seems to be absent from the Gaspé Peninsula (FERNET & PILON, 1970a).



Figs. 1-2. Distribution in Quebec of *Enallagma ebrium* (1) and *E. vernale* (2).

WALKER (1953) and ROBERT (1963) mentioned that *E. ebrium* is mainly found along marshy streams and ponds, along lakeshores where aquatic vegetation is present. FERNET & PILON (1970b) stated that in the Saguenay area this species was principally observed along the shore of eutrophic lakes and to a lesser degree along marshy ponds and dystrophic lakes. In the region of study, PILON & LEBUIS (1976) reported that this species is mainly seen along dystrophic lakes, dystrophic ponds, flooded banks and along marshy streams.

According to GLOYD (1943) *E. vernale* is found in woodland pools, ponds and small lakes. WALKER (1953) added marshy inlets on the shore of large lakes. In more recent studies, FERNET & PILON (1970b) and PILON & LEBUIS (1976) reported that this species mainly inhabits eutrophic and dystrophic lakes but can also be observed along streams and flooded banks.

LABORATORY METHODS

This study was undertaken during the summers of 1973 and 1974 at the Station de Biologie de l'Université de Montréal (46°N, 74°W). Adults in copulation were captured in the field and brought to the laboratory. After copulation, females were placed on aquatic plants such as *Eriocaulon septangulare* With. and *Nuphar variegatum* Engelm for endophytic oviposition.

Eggs were collected after oviposition periods and immediately placed under constant temperature environments of 12.5, 15, 17.5, 20, 22.5, 25, 30 and 32.5°C. These environments are maintained by means of Hotpack incubators model 352620 and 352700 with a range of 2-50°C (± 0.5°). Photoperiods of 14 hrs per day were maintained with Sylvania F.5T12-D fluorescent tubes connected to Canadian General Electric Time Switch type TSA-47.

Hatching of the eggs was recorded every eight hours during the whole experiment. Egg measurements were made with a stereoscope Wild M-5 equipped with a micrometer Wild Censor (graduation fine 0.01 mm) on 100 eggs of each species.

RESULTS OF LABORATORY REARINGS

OVIPOSITION AND HATCHING

LEBEUF & PILON (1977) and PELLERIN & PILON (1975) reported that *E. boreale* Selys and *Lestes eurinus* Say were mating readily under laboratory conditions. *E. ebrium* and *E. vernale*, however, were never observed in copulation under such conditions.

E. ebrium oviposited readily in submerged stems of aquatic plants but never in the tissue of floating aquatic plants as reported in the field by WALKER (1953). *E. vernale*, on the other hand, must be placed on submerged stems to induce oviposition (Fig. 3).

Eggs of *E. ebrium* are cylindrical measuring 1.10 mm (± 0.05) in length and 0.20 (± 0.05 mm) in width. The posterior extremity is rounded while the anterior end is tapered and flushed with the epidermis of the plant. Eggs of *E. vernale* are also cylindrical with same length and width as those of the other species (Fig. 4A). In both species eggs are laid singly, and the female's ovipositor is displaced laterally, forward and backward, thus accounting for the zigzag lay out of the eggs. When oviposition is terminated, a discoloration of the female can often be observed especially after long periods spent in water. This was also reported by BICK & HORNUFF (1966).

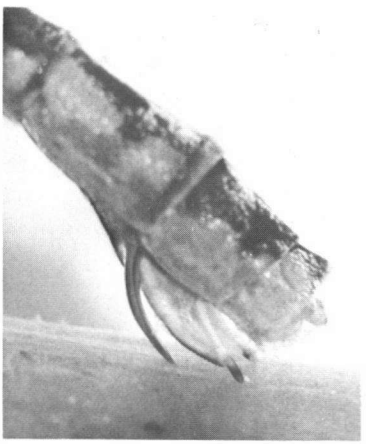


Fig. 3. Tip of abdomen of an ovipositing *Enallagma vernale*.

The maximum period spent in water by one female of *E. vernale* was five hours. However, in both species, the oviposition periods were normally much shorter but variable, between 25 and 120 minutes. In both species, the average number of eggs laid by a female was about 300 eggs with a range of 195 to 400 eggs.

Upon hatching, eggs gave birth to prolarvae (Fig. 4C). The prolarval stage was of very short duration; in *E. vernale* it lasted for 6-7 min (Fig. 4B). Once

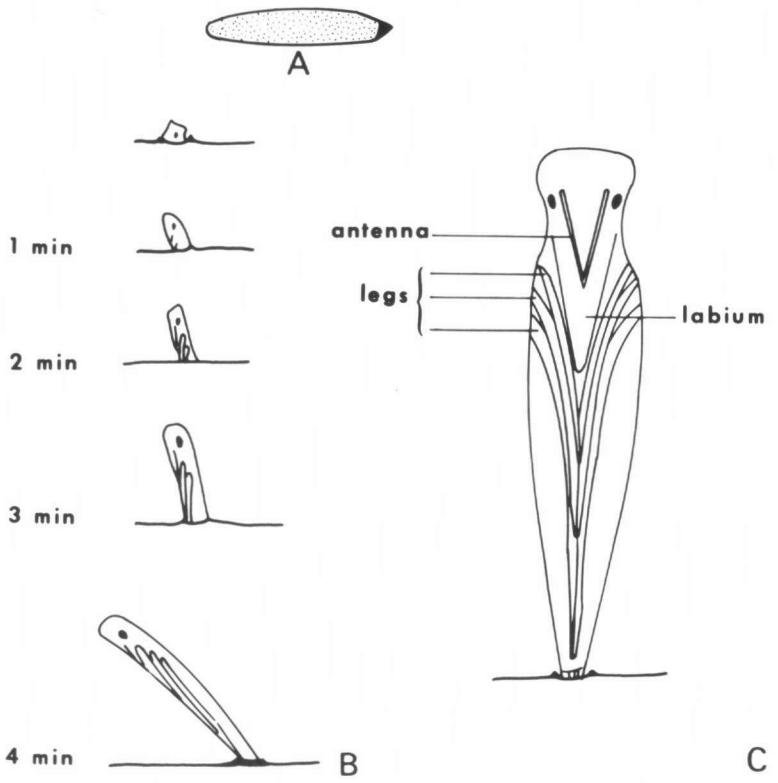


Fig. 4. *Enallagma vernale*: (A) egg; — (B) hatching sequence; — (C) prolarva, ventral face.

the egg shell was broken, the prolarva started to wriggle and slowly escaped from the shell and the surrounding plant tissue. About 4 minutes later, it was completely out of the egg shell but still attached by its posterior end to the plant tissue. A short time later, following wriggling movements, the thorax of the prolarva was arched while the head was bent. Then, the envelope split along a median line to free the thorax at first. As the envelope split forward, the head, antennae and labium were also freed followed slowly by the thoracic legs. Finally, after violent wrigglings, the larva escaped completely from the envelope which stayed attached to the plant tissue. CORBET et al. (1960) have given the probable adaptive reasons for this strange stage in the life of all Odonata.

INFLUENCE OF TEMPERATURE ON EGG DEVELOPMENT

A total of 3430 eggs of *E. ebrium* (of which 2750 succeeded to hatch) and 1211 eggs of *E. vernale* (of which 1045 hatched) were used for the experiment.

Table I

Development and mortality of eggs of *Enallagma ebrium* and *E. vernale* at various constant temperatures

	E. ebrium					*E. vernale*				
° C	No. of eggs	No. of eggs hatched	% mortality	Mean hatching time (days)	Range (days)	No. of eggs	No. of eggs hatched	% mortality	Mean hatching time(days)	Range (days)
12.5	131	0	100	—	—	—	—	—	—	—
15.0	238	138	42.0	56.38	*52.7-72.5*	53	14	73.6	54.79	*51.2-60.0*
17.5	195	110	43.6	41.55	*37.2-53.7*	—	—	—	—	—
20.0	690	388	43.8	25.60	*22.5-42.9*	47	21	55.3	29.34	*28.0-32.0*
22.5	50	50	0	24.08	*21.7-26.0*	—	—	—	—	—
25.0	1010	985	2.5	14.20	*12.2-18.7*	765	726	5.1	16.88	*14.0-22.0*
27.5	404	398	1.5	12.48	*11.0-14.2*	94	54	42.4	12.38	*11.2-14.2*
30.0	274	260	5.1	9.34	*8.7-10.7*	47	41	12.8	9.80	*9.2-10.7*
32.5	438	421	3.98	10.02	*7.7-14.0*	205	189	7.8	12.33	*9.7-14.0*

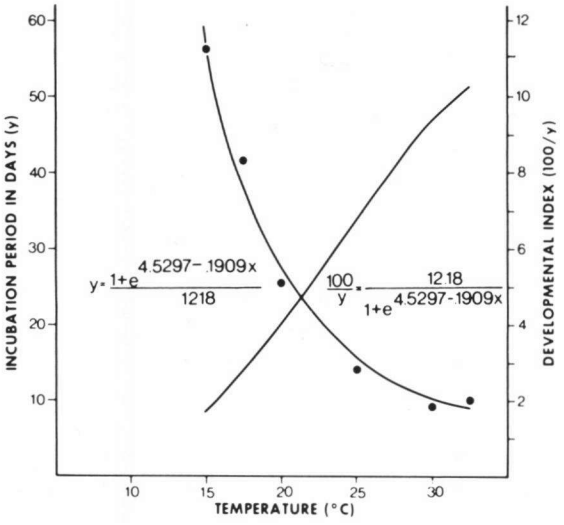


Fig. 5. *Enallagma ebrium*: duration of the period from oviposition to hatching at constant temperatures, and the reciprocals of these values plotted against temperature.

In Table I the total number of eggs used, the number of those hatched, the mean time to hatch, the range and the per cent mortality observed are given for each temperature. A larger number of eggs were used at 25°C and the individuals hatching were reared to the adult stage for a description of larval instars and an analysis of growth parameters (cf. RIVARD & PILON, 1977, 1978).

There was a complete failure of the eggs of *E. ebrium* to hatch at 12.5°C, while at 15-20°C, ap-

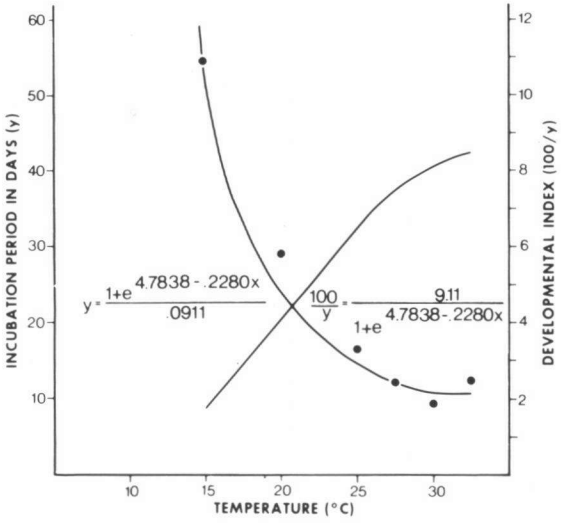


Fig. 6. *Enallagma vernale*: duration of the period from oviposition to hatching at constant temperatures, and the reciprocals of these values plotted against temperature.

proximately 43% mortality occurred in the egg populations. From 22.5 to 32.5°C mortality never exceeded 5.1%, while 22.5°C appeared to be the optimal temperature for survival, with no mortality observed (cf. Tab. I). Experiments with *E. vernale* indicated a much higher percentage of mortality except at 25 and 32.5°C.

The mean duration, from oviposition to hatching, varied from 56.4 days at 15°C to 9.8 days at 30°C for *E. ebrium*, and from 54.8 days at 15°C to 9.8 days at 30°C for *E. vernale* (cf. Tab. I), indicating an influence of temperature on egg development. According to these figures, the optimum temperature is around 30°C. The mean incubation period in relation to constant temperatures is illustrated in Figure 5 for *E. ebrium* and in Figure 6 for *E. vernale* along with the reciprocals of these values as proposed by PRADHAN (1946) and DAVIDSON (1942, 1944) to obtain a developmental index (100/y). The mathematical formula describing best the speed of development of *E. ebrium* eggs from the lowest to the highest temperatures at which complete development to hatching occurs is $100/y = 12.18/1 + e^{4.5297 - 0.1909x}$ ($P < 0.01$). The lower threshold of development as proposed by VARLEY et al. (1973) is 12-15°C. In the case of *E. vernale*, speed of development is best represented by the mathematical formula $100/y = 9.11/1 + e^{4.7838 - 0.2280x}$ ($P < 0.02$). The lower threshold of development is 12.71°C. RIVARD et al. (1975) found the lower threshold of development in *E. boreale* at 10°C.

From these data, it is possible to obtain the day-degrees necessary to complete development to hatching (PARENT, 1969). Eggs of *E. ebrium* would require an average of 203.22 and *E. vernale* 179.87 day-degrees to complete development to hatching.

CONCLUSION

In the Province of Quebec the distributions of *E. ebrium* and *E. vernale* largely overlap, although *E. ebrium* has a greater northern and eastern range. In the region of study, the two species are mainly coinhabiting dystrophic lakes, but each of them also has a number of specifically distinct habitats.

Under laboratory conditions, both species did not copulate readily. *E. ebrium* oviposited readily however, but not so *E. vernale*.

Observations on the influence of temperature on egg development indicate that the most favourable temperature range lies between 22.5° and 30°C. Optimum temperature for *E. ebrium* is around 27.5°C and that for *E. vernale* is 25°C. Below and above the optimum temperatures the development is retarded and the mortality increased. The lower threshold of development is 12.15°C for *E. ebrium* and 12.71°C for *E. vernale* and would require respectively 203.22 and 179.87 day-degrees to hatching.

As reported by RIVARD et al. (1975) the temperature of the surface water under natural conditions was observed to vary between 19° and 28°C; this would indicate that during most of the incubation period in the field, favourable temperatures for egg development are encountered, approaching very often the optimal values required.

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