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SHORT COMMUNICATIONS

FEEDING RATE OF LARVAE OF *ENALLAGMA CYATHIGERUM* (CHARPENTIER) IN THE PRESENCE OF CONSPECIFICS AND PREDATORS (ZYGOPTERA: COENAGRIONIDAE)

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In the laboratory, larvae of *E. cyathigerum* show no significant depression of feeding rate when exposed to an active predator, or to equal-sized or smaller conspecifics, detectable by sight alone, or to an active predator detectable visually, hydrodynamically and chemically. In this respect *E. cyathigerum* differs from another coenagrionid, *Ischnura elegans*, studied recently by P.A. HEADS (1986, *Ecol. Ent.* 11: 369-377).

INTRODUCTION

Dragonfly larvae are obligate predators with opportunistic feeding habits (CORBET, 1962). Although larvae of different species and of different age cohorts of the same species may be spatially or temporally segregated within a waterbody, it appears that they sometimes overlap or even share occupancy of a microhabitat (e.g. CROWLEY & JOHNSON, 1982a, 1982b). They also coexist with various invertebrate and vertebrate predators.

Two elements of community structure to receive attention recently are interference competition (e.g. JOHNSON et al., 1985; ROWE, 1985; BAKER, 1980; HARVEY & CORBET, 1986) and predator avoidance (MERRILL & JOHNSON, 1984; HEADS, 1986). In respect of interference competition, as manifest in the laboratory, some species exhibit it (e.g. ROWE, 1980; HARVEY & CORBET, 1986) whereas others do not (BAKER, 1981). One species, *Ischnura elegans* (Vander L.), shows predator avoidance and depression of feeding rate in the laboratory in the presence of an active predator (adult *Notonecta glauca* L.)

but only if the predator is detectable hydrodynamically and chemically, as distinct from merely visually (HEADS, 1986).

Our aim in the experiments described here was to contribute to this subject by repeating certain aspects of the work by HEADS (1986) on *I. elegans*, but using *Enallagma cyathigerum* (Charp.), likewise a coenagrionid and a sit-and--wait type predator.

MATERIAL AND METHODS

Larvae of *E. cyathigerum* were collected by handnet from Rohallion Loch, Perthshire (56°32'N, 3°32'W; NO 048 387) on 6 October 1986. They were identified using characters described by CHOWDHURY & CORBET (1987). Larvae 15-17 mm body length (excluding antennae and caudal lamellae), i.e. those in penultimate and final instars, were held after collection, each in a separate container, in a cabinet (photoperiod 12 h, temperature 15 ± 1° C, thus avoiding an abrupt change from prevailing natural conditions) for up to 30 days and provided on alternate days with 2 instar-III larvae of *Aedes aegypti* (L.). Two days before being used in an experiment larvae were acclimatized in the laboratory at 18-20° C. During acclimatization and experimental treatment, larvae experience an unregulated, artificial photoperiod.

Experimental containers were white, translucent, rectangular plastic cartons (20 x 14 cm, height 15 cm) each containing 1 l of tapwater (depth 4 cm). Prey were larvae of the mosquito, *Aedes aegypti* (L.) in instars III or IV (body length: 4-6 and 6-7 mm; weight: 0.5-1.8 and 1.8-4.9 mg). Predators were adults of the hemipteran, *Notonecta glauca* L. All organisms were placed in experimental containers 10-15 min before each experiment began. All experiments were conducted during daylight. Experimental observations lasted for 30 min, the observer keeping well away from the container so as to avoid disturbing the occupants visually. The water in containers had been allowed to equilibrate to laboratory temperature by being kept in a large, open dish overnight. Once a larva of *E. cyathigerum* had been used in an experiment it was not used again so as to eliminate any possibility of its behaviour having been modified by the treatment. Experiments were designed to answer 3 questions in respect of *E. cyathigerum*:

Series 1 — Is feeding rate affected by the presence of an active predator or of an equal-sized or smaller conspecific when these are detectable only visually?

Series 2 — Is feeding rate affected by the presence of an active predator when this is detectable visually, hydrodynamically and chemically?

Series 3 — Is feeding rate affected by the presence of an active predator when the dragonfly larva, in order to reach its prey, has to expose itself to possible attack by the predator?

Arrangements peculier to each Series are described below.

Series 1 — Four treatments were compared. They were identical in that each experimental container held a cylindrical, clear-glass beaker (250 ml capacity) containing 100 ml tap water, one *E. cyathigerum* larva (15-17 mm long) and a plastic drinking straw to provide a perch for the dragonfly larva; two more drinking straws were placed against the outside of the beaker to encourage the other occupant of the container to perch near the dragonfly larva occupying the beaker; 10 instar-III prey larvae were gently pipetted into the beaker at the beginning of each experiment which was replicated 12 times. The four treatments differed according to what was placed inside the experimental container (though not in the beaker):

(A) A mobile predator: an adult *N. glauca*.
(B) A same-sized "competitor": an *E. cyathigerum* larvae 15-17 mm long.
(C) A smaller "competitor": an *E. cyathigerum* larva 10-11 mm long.
(D) Nothing.

For each experiment the experimental containers were placed in a row in which the positions of the four treatments had been randomized.

Series 2 — Two treatments were compared. They were identical in that each experimental container held a transparent, open-ended, plastic cylinder (length 14.0 cm, diameter 3.5 cm) each end of which was covered with white nylon gauze (internal mesh aperture 1.6 mm) secured by an elastic band. The cylinder was completely immersed at the beginning of each experiment; in each experimental container were placed one *E. cyathigerum* larva (15-17 mm long) and two plastic drinking straws as perches for the larva; 20 instar-III prey larvae were gently pipetted into the container at the beginning of each experiment which was replicated 12 times. The two treatments differed according to what was placed inside the cylinder:

(A) A mobile predator: an adult *N. glauca.*

(B) Nothing.

For each experiment the positions of the two treatments were randomized.

Series 3 — Two treatments were compared. They were identical in these respects: the experimental container had in one corner a plastic drinking straw and a strand of an aquatic plant (*Myriophyllum*), an *E. cyathigerum* larva (15-17 mm long) which had been released close to these perches and encouraged to cling to them and a rectangular piece (4.5x3.5 cm) of black, plastic Netlon (a grid of coated wires intersecting at right angles to enclose a rectangular space (5x6 mm), hung against a long wall of the container at its midpoint; a beam of light was focused on the corner occupied by the dragonfly larva; 10 instar-IV prey larvae were gently pipetted into the diagonally opposite corner of the container at the beginning of each experiment which was replicated 5 times. It was assumed that the prey larvae would avoid the illuminated corner of the container so that the dragonfly larva would have to cross the container to feed. The two treatments differed according to what else was placed inside the container:

(A) A mobile predator: an adult *N. glauca.*

(B) Nothing.

RESULTS

Series 1 — The results appear in Table I. For each of the 12 replicates the ratio between the number of prey eaten in treatments A, B, C or (B+C)/2 and the number of prey consumed in treatment D (i.e. A/D, B/D, C/D or (B+C)/2D was obtained and then the mean of each ratio was calculated using the formula: $D_{mean} = (x - y)/(x + y)$ where x is the number of prey eaten in A, B, C or (B+C)/2 and y is the number of prey eaten in D. Then t' was compared to Student's t for 11 degrees of freedom. The values of t' for each treatment (i.e. A, 0.51; B, 0.02; C, 0.20; (B+C)/2, 0.26) were well below 1 which showed the differences to be non-significant.

Series 2 — The results appear in Table I. The value of t' (i.e. 0.09) calculated in the same way was well below 1 which likewise showed the differences to be non-significant.

Series 3 — In both treatments feeding rate was depressed, perhaps because of inhibition by the strong illumination; so the hypothesis could not be tested.

Table I

Prey consumption by *E. cyathigerum* under different treatments

Replicate	Number of prey larvae eaten in 30 min under treatment[1]:					
	Series 1				Series 2	
	A	B	C	D	A	B
1	7	0	10	9	9	8
2	10	10	10	10	7	7
3	9	8	10	8	5	7
4	9	0	1	10	7	7
5	6	4	8	5	7	9
6	8	4	7	1	9	10
7	7	5	8	0	7	7
8	4	8	8	8	2	3
9	4	6	6	6	8	5
10	2	4	3	4	5	6
11	5	4	2	5	2	4
12	6	6	6	2	2	2
Totals	77	59	79	68	70	75
Average	6.42	4.90	6.58	5.67	5.83	6.25
Range	2-10	0-10	1-10	0-10	2-9	2-10

[1] For treatment see text.

DISCUSSION

Dragonfly larvae are known to be able to detect prey by means of their compound eyes and/or mechanoreceptors (PRITCHARD, 1965, 1966) The finding by HEADS (1986) that the feeding rate of larvae of *Ischnura elegans* is depressed in the presence of *Notonecta glauca* shows that larvae of *I. elegans* possess the sensory means for detecting this predator visually, hydrodynamically and/or chemically. It is therefore unexpected that *E. cyathigerum* did not show a corresponding response either to the predator (predator avoidance) or to conspecifics (interference competition). We must conclude that *E.cyathigerum* differs from *I. elegans* in these respects. Perhaps the microhabitats selected by larvae in nature correspond with these differences. Both in Hodson's Tarn (MACAN, 1964) and Rohallion Loch (this study) *E. cyathigerum* larvae occur predominately in swards of *Littorella uniflora* (L.) Aschers 5-10 cm high extending between depths of ca. 0.1 and >1 m. When collecting material from the *Littorella* sward in Rohallion Loch by handnet we have often encountered predatory fishes (sticklebacks: *Gasterosteus aculeatus* L.) but not other predators large enough to constitute a threat to large *E. cyathigerum* larvae. Any immunity from predation that *E. cyathigerum* larvae may enjoy by virtue of their occupancy of the *Littorella* sward is relevant to an interpretation of the results reported here. Until this is known, it must be concluded that a species which closely resembles *I. elegans* as a larva can differ markedly in its response to the same active predator.

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REFERENCES

BAKER, R.L., 1980. Use of space in relation to feeding areas by zygopteran nymphs in captivity. *Can. J. Zool.* 58: 1060-1065.

BAKER, R.L., 1981. Use of space in relation to areas of food concentration by Lestes disjunctus (Lestidae, Odonata) in captivity. *Can. J. Zool.* 59: 134-135.

CHOWDHURY, S.H. & P.S. CORBET, 1987. New external morphological characters for distinguishing larvae of Enallagma cyathigerum (Charpentier) and Ischnura elegans (Vander Linden) (Zygoptera: Coenagrionidae). *Odonatologica* 16: 375-378.

CORBET, P.S., 1962. *A biology of dragonflies.* Witherby, London.

CROWLEY, P.H. & D.M. JOHNSON, 1982a. Habitat and seasonality as niche axes in an odonate community. *Ecology* 63: 1074-1077.

CROWLEY, P.H. & D.M. JOHNSON, 1982b. Co-occurrence of Odonata in the Eastern United States. *Adv. Odonatol.* 1: 15-37.

HARVEY, I.F. & P.S. CORBET, 1986. Territorial interactions between larvae of the dragonfly Pyrrhosoma nymphula: outcome of encounters. *Anim. Behav.* 34: 1550-1561.

HEADS, P.A., 1986. The costs of reduced feeding due to predator avoidance: potential effects of growth and fitness in Ischnura elegans larvae (Odonata: Zygoptera). *Ecol. Ent.* 11: 369-377.

JOHNSON, D.M., P.H. CROWLEY, R.E. BOHANAN, C.N. WATSON & T.H. MARTIN, 1985. Competition among larval dragonflies: an in situ enclosure experiment. *Ecology* 66: 119-128.

MACAN, T.T., 1974. The Odonata of a moorland fishpond. *Int. Revue ges. Hydrobiol.* 49: 325-360.

MERRILL, R.J. & D.M. JOHNSON, 1984. Dietary niche overlap and mutual predation among coexisting larval Anisoptera. *Odonatologica* 13: 387-406.

PRITCHARD, G., 1965. Prey capture by dragonfly larvae. *Can. J. Zool.* 43: 271-289.

PRITCHARD, G., 1966. On the morphology of the compound eyes of dragonflies, with special reference to their role in prey capture. *Proc. R. ent. Soc. Lond.* A 41: 1-8.

ROWE, R.J., 1980. Territorial behaviour of a larval dragonfly Xanthocnemis zealandica (McLachlan) (Zygoptera: Coenagrionidae). *Odonatologica* 9: 285-292.

ROWE, R.J., 1985. *A taxonomic revision of the genus Xanthocnemis (Odonata: Coenagrionidae) an investigation of the larval behaviour of X. zealandica.* Ph. D. thesis, Univ. Canterbury, New Zealand.