

CANNIBALISM AND CARNIVORY IN *TOXORHYNCHITES SPLENDENS* (DIPTERA: CULICIDAE)

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Abstract. Laboratory reared larvae of *Toxorhynchites splendens*, which were previously starved for 24 hours, cannibalized eggs of their own kind or preyed upon the eggs of other species (*Aedes aegypti* and *Anopheles stephensi*) present on the surface of water in small containers. Second and third instars consumed eggs faster than first and fourth instars. The first instar consumed larvae of its own kind faster than the other instars, in the absence of other prey. However, when prey larvae were provided, there was a significant fall in the rate of cannibalism.

INTRODUCTION

The cannibalistic behavior of the larvae of the genus *Toxorhynchites*, which is known to affect the stable prey-predator equilibrium and yield of adults in mass-rearing, is considered to be an important behavioral trait of the species (Trpis, 1973; Trimble and Carbet, 1975; Furumizo and Rudnick, 1978; Focks and Boston, 1979; Lounibos, 1979; Steffan *et al.*, 1980; Steffan and Evenhuis, 1981; Annis and Rusmiarto, 1988; Linley, 1988; Linley and Duzak, 1989). Egg cannibalism and carnivory in *Toxorhynchites* have been reported by many workers (Trpis, 1973; Kazana *et al.*, 1983; Gerberg, 1985; Linley and Duzak, 1989). Newkirk (1947) reported immature mortality of 82-90% in *Toxorhynchites splendens* larvae under natural conditions and attributed it to its cannibalistic behavior. The present study was aimed to investigate cannibalism exhibited by the larvae of *Tx. splendens* in relation to the availability of other prey species.

MATERIALS AND METHODS

Cannibalism in the laboratory reared larvae of *Tx. splendens*, which were previously starved for 24 hours, was investigated both in the presence and absence of larvae of other prey species. Experiments were carried out in enamel trays (0.015 m²) containing 500 ml of tap water. Each experiment consisted of 10 replicates. In order to study the impact of the density of the larvae of prey species

on the rate of cannibalism, two prey regimes were used, ie prey in less numbers (10-20 larvae/predator) and prey in larger numbers (40-80 larvae/predator). Number of larvae of *Tx. splendens* used in each set of experiment were 4 and 6 per container. The number of larvae of *Tx. splendens* that remained alive after 24 hours were recorded. Controls were maintained to see natural mortality in the predator.

The larvae of *Tx. splendens* were starved for 24 hours and egg cannibalism was studied by providing 50 freshly laid eggs of its own kind to larvae present individually in 50 ml beakers (12 cm²) containing tap water. Egg predation was studied in the similar way by providing 500 eggs of prey species (ie *Aedes aegypti* and *Anopheles stephensi*). Ten replicates were maintained for each experiment. In order to ensure that there was no hatching of the first instars from the eggs during the trial period of 3 hours, one control beaker containing eggs, but no larva, was set up for each experiment. The number of eggs remained uneaten were counted after 3 hours of exposure.

RESULTS AND DISCUSSION

Results of cannibalism in the larvae of *Tx. splendens* at different predator-prey densities and in the absence of prey are given in Table 1. Throughout the experiments no mortality in the larvae of *Tx. splendens* was observed in controls. Results showed that first instar consumed larvae of its own-kind faster than the other instars in the absence of prey. On an average, 40-60% of the first instars

Table 1

Larval cannibalism in *Tx. splendens* as a function of predator and prey density.

Predator instar	Predator density	% Cannibalism		
		Prey density		
		Nil	Low	High
1	4	60.00	5.36	1.79
	6	44.44	15.56	18.89
2	4	10.00	21.67	10.00
	6	20.00	22.92	16.67
3	4	10.00	5.00	11.67
	6	6.67	7.78	0.00
4	4	0.00	10.00	1.67
	6	23.33	2.22	3.85

Table 2

Egg cannibalism and carnivory by instars of *Tx. splendens* previously starved for 24 hour.

Predator instar	% Egg consumed		
	<i>Tx. splendens</i>	<i>Ae. aegypti</i>	<i>An. stephensi</i>
1	2.60	0.80	1.20
2	13.80	18.00	17.20
3	29.40	4.80	14.00
4	4.80	0.80	0.00

were eaten by their own mates in the absence of prey. However, when prey larvae were provided, there was a significant fall in the rate of cannibalism. The rate of cannibalism observed in the other instars in the absence of prey ranged between 6 and 23%. Cannibalism among second instars was not deterred by increase in prey density. In many occasions it was observed that the larvae were eating only the rear portion of the siblings. This is in accordance with the earlier observations made by many workers (Green, 1905; Jenkins and Carpenter, 1946; Steffan and Evenhuis, 1981), who have reported that the backward swimming of *Toxorhynchites* larvae made them highly cannibalistic, because it was observed that when they met one another head on, they did not show intraspecific predation.

The rate of egg consumption in the larvae of *Tx. splendens* is given in Table 2. Second and third instars consumed eggs of their own-kind faster than first and fourth instars. The rates of cannibalism were 13.8% and 29.4% respectively which amounted to 7 and 15 eggs out of 50 provided initially; whereas, first and fourth instars though starved for 24 hours consumed significantly lesser number of eggs offered during the 3 hour experimental period. The egg stage of *Tx. splendens* lasts 48-96 hours in comparison to 48 hour and 48-60 hours in *Tx. brevipalpis* and *Tx. amboinensis* as reported earlier (Linley, 1988; Linley and Duzak, 1989). Given the number of eggs eaten by single second and third instars of *Tx. splendens* in the 3 hour experimental period, it can be surmised that most of the eggs would be consumed before they hatch out, unless alternate prey is available.

Results of predation on the eggs of prey species (*Ae. aegypti* and *An. stephensi*) are given in Table 2. Predation by first and fourth instars of *Tx. splendens* was negligible on the eggs of these two species. In contrast, the second instar consumed about 86 and 90 of the 500 eggs of *An. stephensi* and *Ae. aegypti* initially provided. The third instar consumed 70 and 24 eggs respectively. From the results it is inferred that second and third instars of *Tx. splendens* predated on eggs faster than the first and fourth instars. *Tx. splendens* showed a propensity for egg predation and could detect, seize and ingest eggs floating on the water surface. *Tx. splendens* eggs were found to float away from the edges, adhered together in clumps. Larvae were also observed to remain away from the edge. They were often seen with their bodies parallel to the water surface, with heads and mouthparts touching (or) very close to the interface. The present study shows that the rate of cannibalism can be affected by prey density. Also the present study highlighted the reasons for the presence of one or two *Tx. splendens* larvae per container in the field. This spatial distribution of the predator reduces intraspecific competition and increases effective control of prey species by the predator. Therefore, it is suggested that for effective and sustainable use of this predator, individual larvae should be released in as many containers as possible. This wide spatial distribution would facilitate establishment of *Tx. splendens* population by reduced cannibalism.

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