PREY STAGE PREFERENCE OF THE PREDATOR, *TOXORHYNCHITES RUTILUS RUTILUS* ON *AEDES AEGYPTI*

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ABSTRACT. To determine if 4th-instar *Toxorhynchites rutilus rutilus* (Coquillett) preferentially consumes one stage of *Aedes aegypti* (L.), equal numbers of 1st-instar, 4th-instar, and pupae prey were placed in 3.78-liter containers with one 4th-instar predator. Predators ate significantly more 4th-instar prey than pupae or 1st instars; but they killed, without eating, significantly more pupae than 4th instars, with no 1st-instar killing observed.

Toxorhynchites rutilus rutilus (Coquillett) is a large nonbiting mosquito indigenous to Florida, Georgia, and coastal South Carolina (Carpenter and LaCasse 1955). It is predaceous during the larval stage, breeding in artificial and natural containers, and preying upon other container inhabitants. One such inhabitant is the yellow fever mosquito, *Aedes aegypti* (L.). Consequently, *Tx. r. rutilus* is being investigated as a possible biological control agent for this and other container-breeding mosquitoes. The purposes of the present experiment were (1) to determine if *Tx. r. rutilus* larvae prefer one stage of *Ae. aegypti* prey and (2) to obtain estimates of the number of prey each stage consumed. Also, concurrent observations were made on the killing behavior exhibited by the last larval instar of *Tx. r. rutilus*. The killing of prey without consumption is characteristic of *Toxorhynchites* spp., and although this behavior is poorly understood, it may be a way of protecting the predator during the defenseless pupal stage (Trpis 1972, Corbet 1963, Corbet and Griffiths 1963). These data are being used to help predict and understand the effects of *Tx. r. rutilus* on *Ae. aegypti* populations through the use of mathematical models.

MATERIALS AND METHODS

Predator and prey immatures used in this experiment were reared according to the procedure described in detail by Focks and Boston (1979). Briefly, predators were reared in 50 × 40 × 10 cm trays with a 16 hr photophase and at 25.5±1.0°C. Each tray was set with 7 liters of well water, a slurry of 3 g of dried liver and hydrolyzed yeast powder mixture (3:2), and 0.15 ml (ca. 10,000) of *Ae. aegypti* eggs. To this tray was added ca. 330 *Tx. r. rutilus* eggs. On the same day (day 0) a second tray was set containing 3 liters of well water, a similar slurry of food, and prey eggs. The larvae from this second tray were added to the predator tray on day 5 or 6.

Fourth-instar prey were reared at 29.5±1.0°C in similar containers with 3 liters of well water, a slurry of 3 g of liver and yeast mixture, and ca. 10,000 *Ae. aegypti* eggs. On day 2, prey were fed 4 g of liver and yeast. Fourth-instar prey were harvested on day 3 and pupae on day 6. Prey to be used as 1st instars were hatched in well water under reduced atmospheric pressure 24 hr prior to use; they were not provided with any food.

One teneral 4th-instar predator was placed in each of ten 3.79 liter buckets containing well water and fifty prey of each stage. The following day the number of prey of each stage killed and abandoned, and the number of prey consumed was recorded; remaining prey were removed and replaced with new ones daily until the predator pupated.

RESULTS AND DISCUSSION

Table 1 presents a summary of the data on the predatory activity of the 4th-stage

Table 1. Predation and killing behavior of individual 4th-instar *Tx. r. rutilus* when offered 3 stages of *Ae. aegypti* prey in 3.79-liter containers (10 replications).

Stage of prey	No. offered	Daily mean[a] Consumed	Daily mean[a] Killed	Daily mean prey destroyed[a]	Avg. total/development time[a] Consumed	Avg. total/development time[a] Killed	Total mean prey destroyed[a]
1st Instar	50	5.9 ± 1.9	0	5.9 ± 1.9	40.4 ± 15.1	0	40.4 ± 15.1
4th Instar	50	18.2 ± 9.2	1.9 ± 2.2	20.5 ± 8.0	117.1 ± 45.9	15.7 ± 21.6	132.8 ± 42.4
Pupae	50	12.2 ± 2.5	11.2 ± 3.9	23.4 ± 5.0	79.7 ± 10.9	73.7 ± 23.6	153.4 ± 28.1
Total	150	36.7	13.1	49.8	237.2	89.4	326.3

[a] All means are significantly different at the k = 500 level (approx. *a* = .01) according to Duncan's Bayesian K-ratio LSD rule except daily mean consumption in which means are significantly different at the k = 100 level (approx. *a* = .05); means are given ± standard deviation.

Tx. r. rutilus larva when offered 50 each of 3 stages of prey. Consumption of 4th-instar prey (18.2/day) was highest with rates for 1st instar and pupa only 32 and 65%, respectively, of that for the 4th-instar prey. The trends for the rates of killing prey immatures without their consumption were very different from those observed for consumption. No 1st instars were observed to have been killed and the rate of killing of 4th instars (1.9/day) was only 17% of the pupae (11.2/day). Duncan's Bayesian k-ratio rule showed that the values in Table 1 were all significantly different. Previous work has shown that 4th-stage larvae of *Tx. r. rutilus* when offered a single stage of prey in identical containers and under similar conditions consumed 93.3 1st instars, 9.8 4th instars, and 7.0 pupae of *Ae. aegypti* per day. The estimates of prey consumption presented here are derived from regression equations developed by Padgett and Focks (1980).

It may be helpful in understanding the differences in rates of killing and consuming among the 3 stages of prey offered to consider differences in the behavior of the prey and predator. At the densities of prey offered in these experiments, it appears that the predator does not actively search out prey but relies on collisions between the 2 species to provide opportunities for prey capture. Because 4th-instar prey are more active than the sessile pupa and because 4th-instar prey habitually "graze" on the bodies of predators, more 4th instars than pupae are eaten. The low consumption of 1st-stage prey can be understood in terms of the adaptive significance of the predator "keying in" on the stage or size offering the highest "energy return per capture" to "energy required to capture" ratio. If the energy required to capture the larger stages is comparable to that required for 1st instars, the predator would be expected to exhibit a strategy which preferentially consumes more large prey. Once a predator has "keyed" onto the 1st instar, enormous numbers can be captured and eaten; laboratory tests involving high

densities of only 1st instar prey demonstrated that 1 *Tx. r. rutilus* 4th-instar could consume ca. 100 prey/day (Padgett and Focks 1980).

Current thinking suggests that the intraspecific killing behavior exhibited by the nearly grown 4th-instar predator serves subsequently to protect the defenseless pupa. Larger prey are also attacked, perhaps because they are approximately the same size as 3rd-instar predators which would develop into threatening size during the long pupal stadia of the predator and consume or kill the pupae. Higher rates of killing are observed for the pupae because of their greater effective concentration due to their habit of remaining suspended for indefinite periods of time at the surface of the water. (The killing of early instar prey does not occur because they pose no threat to the predator pupa.) This hypothesis does not suggest that the different rates at which late-instar prey and pupae are killed or eaten are due to a preference of the predator for one stage or the other for food, they may be simply a function of the frequency with which the predator and prey encounter one another.

Figure 1 presents the mean daily consumption of each stage of prey by the 4th-instar predator. This figure indicates that rates of 1st and 4th instar consumption tend to oscillate with decreasing amplitude over time; the rate of pupal consumption was not so well defined over time. The decline in consumption following each peak may reflect the time required to digest the previous day's capture. First instar and pupa consumption rates were significantly correlated with 4th-instar rates with Pearson correlation coefficients of 0.70 and 0.76, respectively.

Figure 2 presents the daily mean killing without consumption of *Ae. aegypti* 4th instar and pupa. The killing activity increases

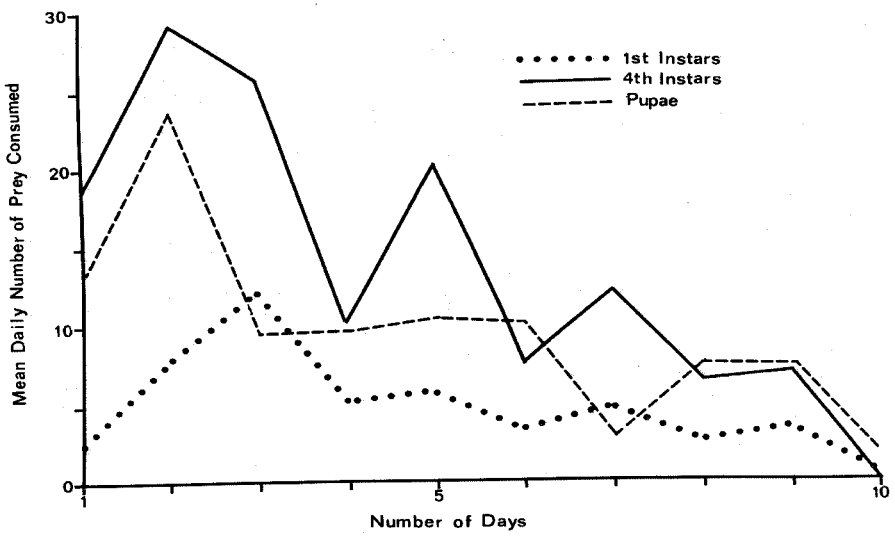

Figure 1. Daily mean consumption of *Ae. aegypti* prey of various stages by 4th-instar *Tx. r. rutilus* in 3.79-liter containers.

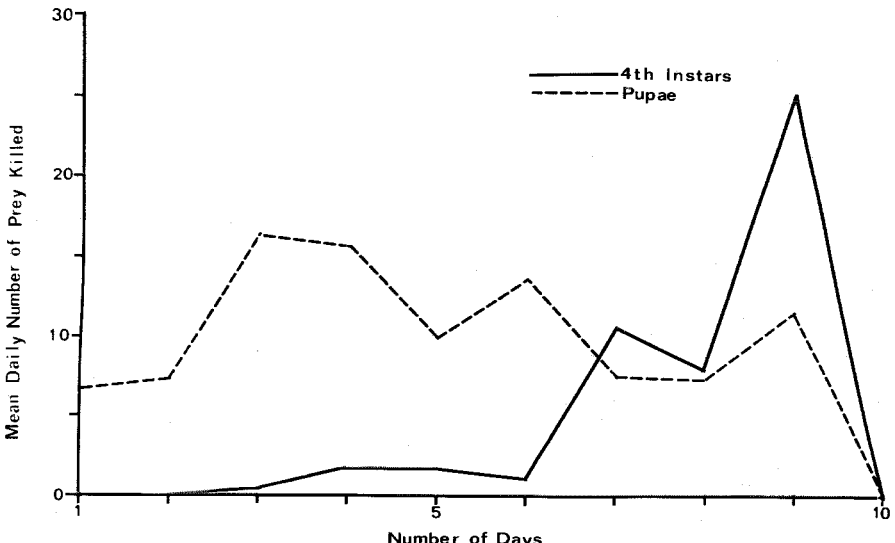

Figure 2. Daily mean killing of *Ae. aegypti* prey of various stages by 4th-instar *Tx. r. rutilus* in 3.79-liter containers.

over time as pupation approaches. The killing rates were not significantly correlated among the 3 stages of prey offered.

From a control perspective, these results are encouraging. The total number destroyed daily either by consumption or killing alone was 49.8 immatures with a total destruction of 326.3 immatures per 4th stadium. In the context of control, it is fortunate that the predator destroys more pupae than 4th instars and more later than earlier stages—fortunate because density dependent natural mortality will reduce recruitment into the later larval stages, and pupal production is most highly correlated with subsequent adult densities.

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