SCIENTIFIC NOTE

DIFFERENTIAL PREDATION OF THE PLANARIAN *DUGESIA TIGRINA* ON TWO MOSQUITO SPECIES UNDER LABORATORY CONDITIONS

ADRIANO S. MELO AND CARLOS FERNANDO S. ANDRADE

Departamento de Zoologia, IB, Universidade Estadual de Campinas, Campinas, SP, 13083-970, Brazil

ABSTRACT. Two experiments were performed on the predation of the planarian *Dugesia tigrina* (Girard) upon 2 mosquito prey species, *Aedes albopictus* and *Culex quinquefasciatus*. Bioassays were carried out in sectioned tires with 2 liters of water. In the 1st experiment, predation was evaluated using 4, 8, and 12 mature planarians against 40 2nd-stage larvae of each mosquito species alone. In the 2nd experiment, the same 3 predator densities were used with a pool composed of 20 2nd-stage larvae of each mosquito species. In the 1st experiment, final corrected mortality of *Ae. albopictus* reached 89.1, 98.8, and 99.6% and final corrected mortality of *Cx. quinquefasciatus* reached 29.4, 48.0, and 53.0%, respectively, with 4, 8, and 12 planarians. In the 2nd experiment and when subjected to the density of 4 planarians, *Ae. albopictus* was more susceptible to predation, with a selectivity index of 0.87, whereas this index was 0.13 for *Cx. quinquefasciatus*. Predation was more intensive during the 1st 4 days of the experiments, when most larvae were in the 2nd and 3rd stages. We observed that *Cx. quinquefasciatus* larvae were faster than *Ae. albopictus* in reacting to planarian contacts, resulting in more success in escaping from the predator attacks.

KEY WORDS Mosquito control, biological control, planarian, mosquito, differential predation

The mosquitoes *Aedes albopictus* (Skuse) and *Culex quinquefasciatus* Say are 2 of the most abundant biting species occurring in the urban environment in southeastern Brazil. Moreover, these 2 species are vectors of several diseases, both in Brazil (Consoli and Oliveira 1994) and in others regions of the world (Gratz 1999). A promising tool in mosquito management programs is the use of traps with abiotic or biotic lethal agents. The planarian *Dugesia tigrina* (Girard) is an effective predator of mosquito larvae. Evaluations both under laboratory and field conditions have reported reductions in mosquito collections up to 95% (George et al. 1983, Melo et al. 1996). Planarians are suitable agents for biological control programs because of advantages such as low cost of production (Legner and Tsai 1978), maintenance (Callahan and Morris 1989) and dispersion in the field (Darby et al. 1988). Moreover, planarians have high tolerance to several pesticides including, insect growth regulators (Nelson et al. 1994) and *Bacillus thuringiensis* var. *israelensis* (Perich et al. 1990).

Perich and Boobar (1990) evaluated the effects of *Dugesia dorotocephala* (Woodworth) predation on nontarget organisms for 17 aquatic species, and only 3 species were significantly affected: the aquatic oligochaeta *Aeolosoma* sp., the copepod *Cyclops* sp., and *Toxorhynchites amboinensis* (Doleschall) larvae. In the same work *D. dorotocephala* showed no preference for *Aedes aegypti* (L.) larvae when compared to the 3 nontarget species.

However, our field observations in trap tires led us to suspect a preferential predation on different species of mosquito larvae. Such preference could be of fundamental importance when using lethal traps. Planarians might control preferentially syntopic-occurring larval species. In order to confirm this observation we performed a laboratory experiment to evaluate differential predation on *Ae. albopictus* and *Cx. quinquefasciatus*.

Dugesia tigrina were collected on aquatic plants in a lake at Bragança Paulista City, São Paulo State, Brazil. An initial planarian stock was raised in a modified Legner and Tsai (1978) device with an aquarium aerator substituting for the aquatic plants. Mosquito larvae were obtained from a 1-year-old laboratory culture of *Ae. albopictus* and field collections of *Cx. quinquefasciatus* egg rafts.

Bioassays were performed in ⅓ sections of discarded tires as used for trapping and monitoring *Aedes* spp. infestation in the university campus (Melo et al. 1996). The tire sections were internally coated with transparent plastic sheets and filled with 2 liters of distilled water. The plastic was fixed to the borders of the tires with plastic clips, to allow water removal for observation and larvae counting over a white tray background. During the experiments, larvae were provided with appropriate amounts of laboratory mouse food. The tire sections were covered with fine mesh muslin to retain emerging adults.

The study was performed in 2 steps. In the 1st experiment, predatory efficiency was assayed on 40 2nd-stage larvae of each mosquito species alone and in the 2nd experiment, predatory efficiency was assayed with a mixture of 20 2nd-stage larvae of each species. The 2 experiments were subjected to 4, 8, and 12 mature planarians (13–17 mm long). Sets without planarians were controls. In the 1st experiment, the number of living larvae and pupal
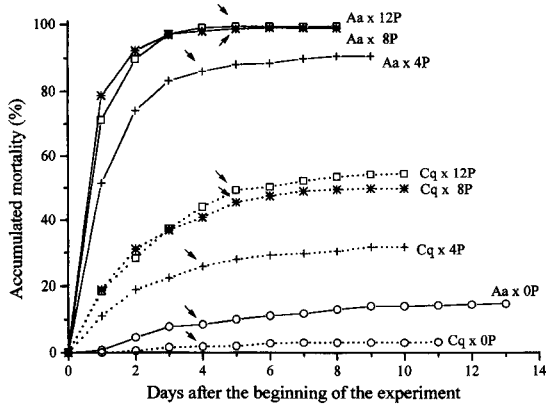
Fig. 1. Daily documented mortality for *Aedes albopictus* and *Culex quinquefasciatus* in control and in treatments with 4, 8, and 12 planarians. The arrows indicate the day when the 1st pupae appeared. Cq, *Cx. quinquefasciatus*; Aa, *Ae. albopictus*. 0P, 4P, 8P, and 12P indicate control and treatments with 4, 8, and 12 planarians, respectively.

exuviae were counted daily until all adults had emerged. In the 2nd experiment, only pupal exuviae were assessed daily and identified, showing how many individuals of each species became adults. Each experiment was carried out in 10 replicates, totaling 120 experimental units.

The analysis of the 1st experiment was carried out by linear regression of the control and treatment final mortality transformed by logit scale using $\log_{10}$ and addition or subtraction of 0.5 when the mortalities were 0 or 100%, respectively. The independent variable, planarian number, was transformed by $\log_{10}(x + 1)$. An a posteriori Student's t-test was carried out on regression coefficients obtained from the 2 species (Sokal and Rohlf 1995). In the 2nd experiment, mean of corrected final mortality (Abbott 1987) was used to calculate a selectivity index conditioned to when at least 1 individual of each species was able to survive (Manly et al. 1972).

The mean daily accumulated mortality for each species and treatment in the 1st experiment are shown in Figure 1. Mean final mortalities for *Ae. albopictus* in control and treatments with 4, 8, and 12 planarians were 14.7, 90.7, 99.0, and 99.7%, respectively. For *Cx. quinquefasciatus*, mean final mortalities were 3.2, 31.7, 49.7, and 54.5%, respectively, in control and treatments with 4, 8, and 12 planarians. Predation was more intensive during the 1st 4 days when most larvae were in the 2nd and 3rd stages. For both species, the regression coefficient obtained using the final mortality against successively greater planarian abundance was significantly different from zero, meaning an increase in predation with successively greater planarian densities (*Cx. quinquefasciatus*, $b = 1.66$, $P < 0.0001$; *Ae. albopictus*, $b = 2.92$, $P < 0.0001$). The predation rate upon *Ae. albopictus*, as measured by

the regression coefficient, was significantly greater than that for *Cx. quinquefasciatus* ($t = 5.59$, $P < 0.001$).

Preferential predation was, at least in part, confirmed by the 2nd experiment because the selectivity indexes were 0.87 for *Ae. albopictus* and 0.13 for *Cx. quinquefasciatus* in the treatment with 4 planarians. In the treatments with 8 and 12 planarians, no adult of *Ae. albopictus* was obtained, making unfeasible the calculation of the selectivity index. In contrast, the corrected mortalities for *Cx. quinquefasciatus* in these 2 treatments were 60 and 73%, respectively.

Higher predation rates during the 1st 4 days confirm the results of Meyer and Learned (1981) and indicate preferential predation by *D. tigrina* upon mosquito larvae in the 2nd and 3rd stages. In fact, direct observations with the white tray as background indicated greater ability for 4th-stage larvae and pupae to escape from the planarian attacks when compared to 2nd- and 3rd-stage larvae. All observed predation was caused by direct planarian–larva contact and no larvae were seen trapped and killed by planarian mucous left on the container surfaces, as reported elsewhere (Legner and Yu 1975, Meyer and Learned 1981).

The differential predation observed for these 2 mosquito species disagrees with the results of Perich and Boobar (1990), who found no difference for *Ae. aegypti* compared with 3 other prey species. We observed higher agility of larvae of *Cx. quinquefasciatus* compared to larvae of *Ae. albopictus* and in several observed encounters with the planarians, the larvae of the former species were able to escape after a brief contact. Larvae of *Ae. albopictus* are slower in their response to contact, allowing more time for the planarians to manipulate them and generate a greater contact surface with mucous secretions.

Intense predation of *D. tigrina* upon *Ae. albopictus* larvae confirms the results of a previous field evaluation where *D. tigrina* was responsible for controlling up to 95% of the larval population in trap tires (Melo et al. 1996). Both evaluated mosquito species may occasionally succeed each other in breeding sites such as cemetery flowers pots and attract-and-kill trap tires. Decomposing flowers and leaves may turn the water into a more suitable environment for *Cx. quinquefasciatus* because of the increase of organic matter, whereas rain flooding may reduce this resource. Our results indicate that *D. tigrina* can have good control efficacy upon *Ae. albopictus* larvae even if *Cx. quinquefasciatus* colonizes such breeding sites.

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