

EFFECTS OF A SUB-LETHAL DOSE OF RESMETHRIN ON REPRODUCTION OF *TOXORHYNCHITES RUTILUS RUTILUS*

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ABSTRACT. In laboratory tests, exposure of *Toxorhynchites rutilus rutilus* to resmethrin at the established LD-90 dose for *Aedes aegypti* did not reduce the daily adult survival or egg hatch. Average fecundity was reduced from 5.6 to 2.3 eggs/female/day during the first three or four days of oviposition. The potential reduction in fecundity of released predators that subsequently become exposed to routine applications of insecticides in an integrated control program would be minimized by adulticiding prior to predator release.

INTRODUCTION

Toxorhynchites rutilus rutilus (Coquillett) is an autogenous species of mosquito whose larvae are predaceous on inhabitants of artificial and natural containers. A deterministic computer model detailing the interaction of the container-breeding vector of dengue fever, *Aedes aegypti* (L.), and the predatory larva of *Tx. r. rutilus* indicated that a significant reduction in the density of *Ae. aegypti* is possible with an integrated control strategy employing regular releases of gravid, laboratory-reared predators and adulticide treatments (Focks et al. 1978). This sylvan species is very effective in shaded automobile tire dumps (Bailey et al. 1983), and is currently being used operationally by the Duval County Mosquito Control District (Jacksonville, FL) for control in this type of habitat. However, its preference for tree holes as oviposition sites reduces its ability to locate artificial containers other than tires at ground level and therefore affects its usefulness in situations in which the target species is predominantly in such containers (Focks et al. 1983a). However, *Toxorhynchitesamboinensis* (Doleschall) will oviposit in commonly found artificial containers located on the ground (Focks et al. 1983b), and in the summer of 1983, the predictions of the model concerning integration of predator releases and pesticide applications were verified in field studies with this species (unpublished data).

Because the genus *Toxorhynchites* does show promise as a biological control agent in certain important, albeit restricted, situations, we have evaluated the susceptibilities of *Tx. r. rutilus* and *Tx. amboinensis* to several commonly used mosquito adulticides. One pyrethroid and 4 organophosphorus (OP) insecticides were evaluated as contact aerosols in wind tunnel tests against adults of *Ae. aegypti* and both species of *Toxorhynchites* (Focks et al. 1979, Djam and Focks 1983). The results indicated that *Ae. aegypti* is not substantially more susceptible (average 1.7 ×) than either predator species to the

OP compounds tested. However, when resmethrin was tested against these species, *Tx. amboinensis* was 2.7 times more susceptible than *Ae. aegypti* (uncolonized New Orleans stock; LD-90 = 0.0052 g/liter), and in marked contrast, *Ae. aegypti* (colonized laboratory stock; LD-90 = 0.0001 g/liter) was 16 times more susceptible than *Tx. r. rutilus* to this compound. Because *Tx. amboinensis* and *Ae. aegypti* are so nearly equal in susceptibility to the most commonly used adulticides, the period of application of insecticide in an integrated program is necessarily limited to just immediately prior to predator liberation. The present study was designed to determine the impact of sub-lethal exposure on subsequent longevity, fecundity and egg hatch on *Tx. r. rutilus* if resmethrin were used without regard to the date of predator release.

MATERIALS AND METHODS

Both species of mosquitoes were reared and maintained by methods described earlier (Focks and Boston 1979). The *Tx. r. rutilus* females were ca. 6 days old when treated; this age corresponded to that of laboratory-reared predators which are normally held in the insectary during the preoviposition period of 4 to 6 days to ensure the release of gravid females. *Aedes aegypti* females were ca. 5 days old when exposed. On the day of treatment, 20 predator females were dissected to determine the insemination rate.

The synthetic pyrethroid used was technical resmethrin diluted in acetone; the compound was applied as an aerosol spray in a wind tunnel described by Mount et al. (1976). This device consisted of a cylindrical tube 15.5 cm in diam. through which a column of air (ca. 23°C and 50% RH) was blown at a rate of 1.8 m/sec. Ten adult predators (or 25 *Ae. aegypti*) were confined in cardboard exposure cages (8.6 cm diam. × 5.0 cm high) with 16-mesh galvanized wire screen ends; the cages were held in the center of the wind tunnel tube and exposed to an

atomized 0.25 ml solution containing 0.010 mg/ml of resmethrin at a pressure of 10.3 kPa.

Immediately following exposure the mosquitoes were anesthetized with carbon dioxide and transferred to acrylic plastic cages (ca. $0.5 \times 0.5 \times 0.5$ m) and provided with cotton balls soaked with 50% honey. Black, 0.5-liter jars containing ca. 150 ml of water were provided for oviposition; the cages were held at ca. 23°C. On each of the subsequent 14 days during each replicate, the dead *Tx. r. rutilus* and the eggs laid during the previous 24-hr period were counted and removed; the hatch of 50 eggs was observed 3 days after oviposition.

The test consisted of 2 replicates; each replicate consisted of 3 cages of ca. 50 *Tx. r. rutilus* females each that were observed daily for 14 days after treatment. One cage contained acetone-treated controls and 2 cages contained resmethrin-treated females. A cage of 40 exposed *Ae. aegypti* was examined for 24-hr mortality only.

RESULTS

The 24-hr posttreatment mortality for the treated groups averaged 95% and 3%, respectively, for *Ae. aegypti* and *Tx. r. rutilus* exposed to resmethrin; for each replicate, 4% of the *Tx. r. rutilus* mosquitoes exposed to only acetone died. The insemination rate for *Tx. r. rutilus* averaged 84% for the 2 replicates.

Figure 1 depicts the average percentage of predator females alive during the 14 days subsequent to exposure. The average daily survival (proportion remaining alive from one day until the next) for the treated and control mosquitoes was 0.954 and 0.945, respectively; these rates are not significantly different (analysis of variance (ANOVA), $P > 0.50$). It can be seen from Fig. 1 that there was no increase in mortality during the first few days following exposure.

Figure 2 presents the percentage hatch in eggs collected from the 2 groups over time. While hatch declines at a rate of ca. 1.6% per day in both groups, the hatch rates for the 2 groups did not differ significantly (paired *t*-test, $P < 0.01$).

Figure 3 displays graphically the impact of the 0.010 mg/ml aerosol of resmethrin on the daily egg production in *Tx. r. rutilus*. It appears that the reduction in fecundity due to the insecticide was confined to 3 or 4 days after treatment. The 14-day average for the number of eggs/female per day was 2.42 and 1.91 for the control and treated groups, respectively and these rates are significantly different (ANOVA, $P = 0.01$). The averages for the first 7 days were 3.50 and 2.37, respectively, for the same groups. Fecundity in the acetone-treated con-

trol group was very similar to estimates made earlier for *Tx. r. rutilus* (Focks et al. 1979) that had not been exposed to acetone.

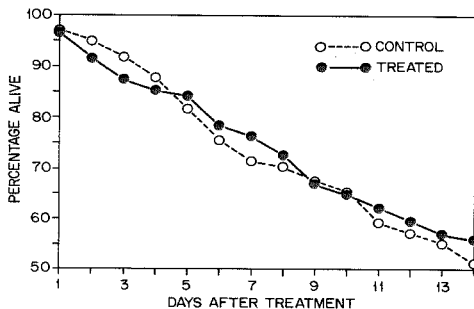


Fig. 1. The average percentage of *Toxorhynchites rutilus* females remaining alive following exposure to acetone or a sublethal dose of resmethrin when ca. 6 days old.

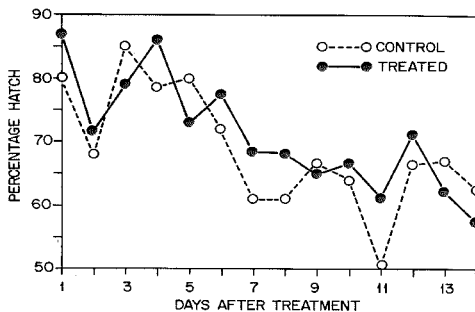


Fig. 2. The average hatch of eggs collected from *Toxorhynchites r. rutilus* females that had been exposed to acetone or a sublethal dose of resmethrin.

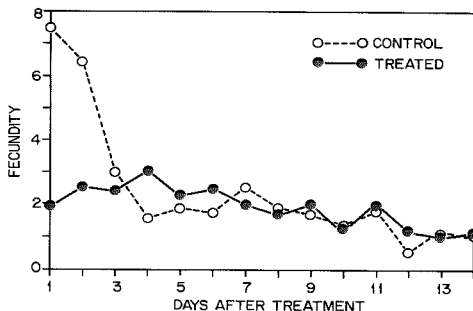


Fig. 3. The average daily fecundity of *Toxorhynchites r. rutilus* females that had been treated with acetone or a sublethal dose of resmethrin.

DISCUSSION

This study demonstrates that treating *Tx. r. rutilus* females with the LD-90 dose of resmethrin for *Ae. aegypti* does not impair daily survival or egg hatch, but it does adversely affect fecundity. This may have rather important ramifications in integrated control efforts. Because *Tx. r. rutilus* females are more fecund during the first few days of their reproductive lives, the reduction in early egg production caused by exposure to insecticide could have a large impact on the total number of eggs laid by a female during her lifetime. For example, in the field, where the daily survival is ca. 80% (Focks et al. 1983a), the average lifespan is only 5 or 6 days. Multiplying the daily fecundities in Fig. 3 by the expected number of females alive yields estimates for life-long egg production of 13.2 and 7.0 eggs/female for untreated and treated females, respectively. Thus, if the behavior of *Toxorhynchites* adults results in exposures similar to those received by *Ae. aegypti*, reductions in predator fecundity could be anticipated. In addition to the impact of the fecundity of *Tx. r. rutilus* by resmethrin, the variation in actual dose of insecticide obtained in target areas due to such factors such as distance, vegetation, terrain and ground-based meteorology would be another very good reason to limit insecticide applications to immediately prior to predator release. This degree of variation could exceed the difference in the susceptibilities of the target and predator species. Therefore, in spite of a 16-fold difference in susceptibility between *Ae. aegypti* and *Tx. r. rutilus* to the insecticide resmethrin, integrating the use of this compound with *Tx. r. rutilus* releases may require certain adjustments, such as limiting insecticide application to immediately prior to predator release. If this practice were routinely followed, only those predators which had already been in the field for

several days would be exposed, and the effect on fecundity would be minimized.

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