L & R Flying Service, Welsh, LA for their role in this research.

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EFFECTS OF INDIGENOUS *TOXORHYNCHITES RUTILUS RUTILUS* ON *AEDES AEGYPTI* BREEDING IN TIRE DUMPS

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ABSTRACT. A study in Jacksonville, Florida showed that a dense natural population of the predator, *Toxorhynchites rutilus rutilus*, significantly reduced a natural population of *Aedes aegypti* in a tire dump, when compared with 2 other tire dumps with very low levels of *Toxorhynchites*. Production of prey pupae and adults was virtually eliminated by mean levels of 1 to 5 predator larvae per tire during a 10-week study. In these studies the predator was most effective in tires located under trees, and least effective in open areas.

INTRODUCTION

Much has been written recently on the possible use of *Toxorhynchites*, a predatory genus of mosquitoes, as biocontrol agents against mosquito species that breed in natural and artificial containers (Brown 1973, Steffan 1975, Lubega et al. 1975, D. A. Focks, personal communication). Some studies have been reported on the bionomics of laboratory-reared *Toxorhynchites* when released in the field (Focks et al. 1980, Gerberg and Visser 1978, Hu 1955), and their effect on container-breeding mosquitoes (Bonnet and Hu 1951, Gerberg and Visser 1978, Payne 1934, Peterson 1956). However, only limited observations have been reported on the effects that natural populations of *Toxorhynchites* have on other mosquito species in the field. Trpis (1972) found that in East Africa *Toxorhynchites brevipalpus* Theobald did not effectively control *Aedes aegypti* (Linn.) early in the rainy season due to its long developmental period, but that it was very effective in bringing *Ae. aegypti* under control later in the season. He suggested the release of laboratory-reared *Tx. brevipalpus* at the onset of the first rains to overcome this lag in biocontrol. Focks et al. (1980) found that natural populations of *Toxorhynchites rutilus rutilus* (Coq.) on an island near the west coast of Florida reduced the numbers of *Ae. aegypti* larvae (in automobile tires they had placed on the island) from more than 100 to less than 5/tire during late summer and early fall. Their data also indicated a definite time lag in effective control by the predator.

To characterize further the interaction of *Toxorhynchites* and *Ae. aegypti* and to determine the effect natural populations of this predator have on this important vector of disease, we conducted a cooperative study at selected tire dumps in Jacksonville, Florida.

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MATERIALS AND METHODS

Three study sites were chosen in the Jacksonville Mosquito Control District; all contained discarded automobile tires and were breeding habitats for mosquito larvae, predominantly *Ae. aegypti.* These sites were separated from each other by distances of 5.3 to 23.8 km.

1. Jacksonville Speedway (JS; Fig. 1). This site was located between Interstate Highway 95 and U.S. Highway 17 just south of Pecan Park Road. The 0.5-mi. (1.1 km) elevated dirt track was isolated from residential areas by a distance of ca. 1 km. The site was poorly drained with standing water present in the surrounding area, especially during rainy weather. Old automobile tires were piled along the east side of the track (ca. 0.5 km long × 10 m wide × 0.5–3.0 m high) as a safety barrier for cars which careen from the track during races. It was difficult to estimate the number of tires, but there were probably in excess of 100,000; almost all the tires served as breeding sites for *Ae. aegypti.* Wax myrtle shaded the tires only on the extreme outer (easternmost) edge of the pile, leaving most of the tires in the open.
2. Kings Road Site (KR; Fig. 2). This site, located near Kings Road, consisted of an unauthorized dump in a light industrial area. The site had accumulated mixed refuse including ca. 200 old truck tires, all had breeding mosquitoes, predominantly *Ae. aegypti.* Mixed hardwood and pines located on the east and west borders provided partial shade for a few of the tires; all other tires were in the open. During the tenth week of the study the owners began land clearing for a new warehouse and all the tires and trees were hauled away.
3. Picketville Road Site (PR; Fig. 3). This site was located between Interstate Highway 295 and Picketville Road near the Cedar River. It consisted of an unauthorized dump that had accumulated a variety of refuse, but old automobile and truck tires (ca. 150) predominated. The site was almost completely shaded by a canopy of pine trees and water oak, with grass and a few small shrubs as undergrowth. All tires at this location were breeding sites for *Ae. aegypti.*

The study was begun on June 21, 1981. Five tires at each site were selected at random and numbered, and every week for 10 weeks the contents of each numbered tire were removed, the number of *Toxorhynchites* larvae and prey (all other mosquito species) larvae and pupae were counted, and the contents were then replaced in the original tires. During the fifth week we also placed a CDC miniature light trap baited with CO_2 at each site 1 night per week, and the following day the trapped *Ae. aegypti* adults were removed and counted. Other species that were collected in the light trap were not considered in the test, as most do not nor-

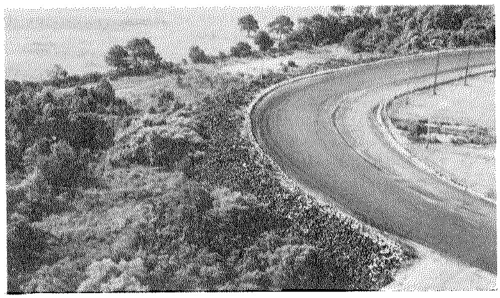

Fig. 1. Jacksonville Speedway (JS) study site showing tires placed as a safety barrier around track.

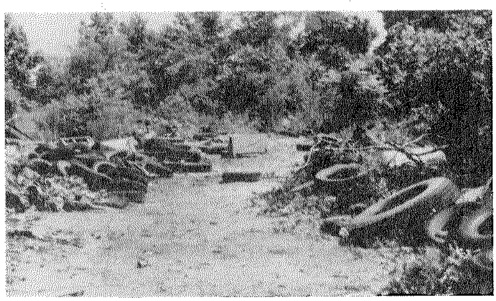

Fig. 2. Kings Road (KR) study site showing discarded tires in an open area.

Fig. 3. Picketville Road (PR) study site showing discarded tires shaded by large trees.

mally breed in automobile tires. We also attempted to establish a *Tx. r. rutilus* population at JS by releasing ca. 1000 adults/week during the first 6 weeks of the study.

RESULTS AND DISCUSSION

During the first week of the study the average number of predatory (*Tx. r. rutilus*) larvae per tire was 0 for JS, 0.6 for KR, and 3.6 for PR (Fig. 4). During the remainder of the study the highest number of predator larvae/tire observed at PR was 5.4 during week 3, but the numbers were much higher at this site than at the other 2 sites throughout the 10-week study. Thus, the PR site supported a very high natural population of *Toxorhynchites,* while predators were found at the other 2 sites only occasionally.

Figure 5 shows the effect these natural populations of *Toxorhynchites* had on the prey larvae. During the first week JS had an average of 42 prey larvae/tire, KR had 68/tire and PR had 50/tire. Collections from other tires at each site showed that more than 90% of the larvae were *Ae. aegypti,* with a few *Culex quinquefasciatus* Say, and a few *Aedes triseriatus* (Say). Therefore, data are presented as total prey larvae and pupae throughout. Figure 5 also shows that during weeks 6–10 the number of prey larvae/tire at PR was only ca. half or less that observed during the first week, whereas, the larval populations at the other 2 sites both reached their highest peaks during week 8.

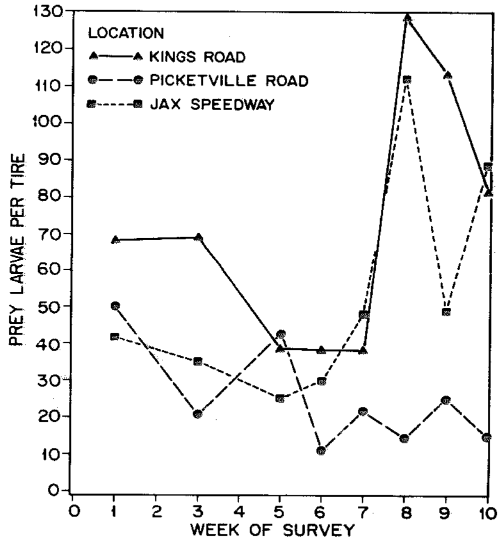

Fig. 5. Mean number of prey larvae per tire for 10 weeks at 3 locations from June 21 through August 29, 1981.

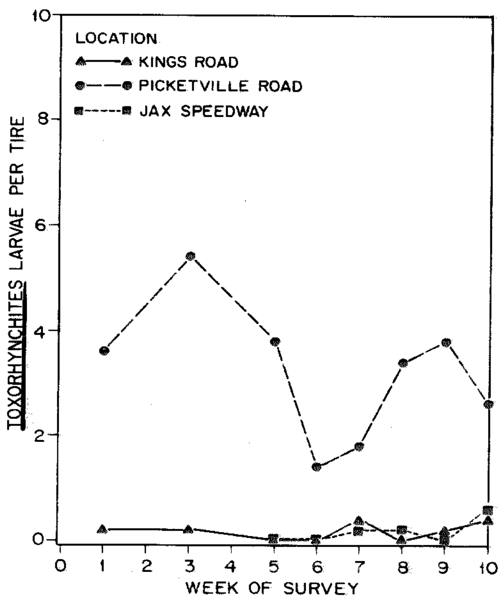

Fig. 4. Mean number of *Toxorhynchites rutilus rutilus* larvae per tire for 10 weeks at 3 locations from June 21 through August 29, 1981.

The reduction of prey pupae at PR over time was even more obvious (Fig. 6). After week 5 the number of prey pupae at PR declined steadily, and by week 10 none were found in the test tires. During the course of the study the number of prey pupae at the other 2 sites fluctuated from 1 to 15/tire; however, there was no indication of sustained reduction as was shown at PR.

There was also an obvious difference in the numbers of adult *Ae. aegypti* trapped at the 3 sites. Figure 7 shows that although the number of captured adults was relatively low at all 3 sites during weeks 5 and 6, when the trapping first began, the captures peaked at both JS and KR during week 7 and at JS again during week 10. (No captures were made during week 10 at KR due to a failure of the fan in the trap at that site.) The captures at PR, however, declined steadily during the last 4 weeks to almost 0 during week 10.

Thus, although the mean number of prey larvae at the site with the greatest predator population (PR) was never reduced to below 10/tire, the lowest prey levels occurred during the last half of the study when prey density at

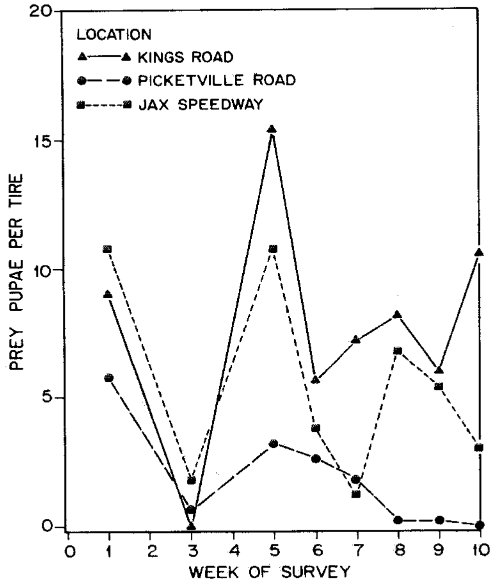

Fig. 6. Mean number of prey pupae per tire for 10 weeks at 3 locations from June 21 through August 29, 1981.

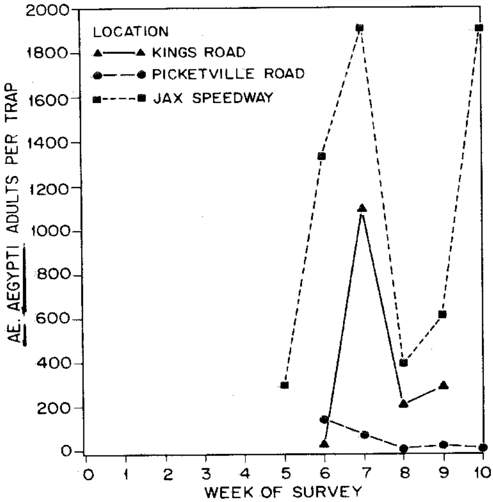

Fig. 7. Number of *Aedes aegypti* adults captured per trap at 3 locations from June 21 through August 29, 1981.

the other 2 sites was 2 to 8 times greater. Most of the prey at PR were recently hatched first and second stage larvae from eggs that hatched after periodic rains reflooded the tires. The abundance of predator larvae at that site prevented those prey from developing into pupae, thus effectively reducing the adult *Ae. aegypti* population.

An analysis of the data showed a highly significant negative correlation between the density of prey larvae and pupae and number of predator larvae. The Pearson correlation coefficients for prey larvae and prey pupae were $\alpha = -0.26$ and $\alpha = -0.27$, respectively ($P \leq 0.01$). Similarly, the number of predators observed was negatively correlated with the sum of the adults captured at each test site ($\alpha = -0.21$; $P = 0.02$). Although the correlation between predator density and adult weekly captures was only -0.56 ($P = 0.03$), this weak correlation can probably be attributed to the limited number of observations, i.e., only 1 adult sample/week at each site.

These data demonstrate the potential effectiveness of natural populations of *Tx. r. rutilus* in reducing populations of other mosquito species, especially *Ae. aegypti,* that utilize discarded automobile tires as a larval habitat. Also, observations made during the study show that shade may have been a major factor influencing the efficiency of the predator. Even after releasing ca. 1000 adults/week at JS during the first 6 weeks of the study, only 4 predator larvae were found at that site in 10 weeks (1 during week 7 and 3 in the same tire during week 10). This tire was located in partial shade, while all others in the test were in the open. A more extensive survey of the site during the tenth week revealed that while an occasional tire harbored predator larvae, each positive tire was located on the outer edge of the pile where it was shaded by the wax myrtle growing on the perimeter (Fig. 1). It was impossible to estimate the percentage of predator-positive tires; however, we did not observe any predators in tires located in the open. At KR the observations were similar in that few of the tires were shaded and only 8 predators were observed throughout the 10 week period.

The habitat at PR, however, was totally different, in that the site was almost totally shaded. *Tx. r. rutilus* is normally a woodland species, preferring to oviposit in rot cavities in large trees. We have found through past research (unpublished data) that this species will oviposit in a variety of artificial containers, but it generally prefers tires when they are located in wooded areas or otherwise shaded from direct sunlight. Thus, it seems that *Tx. r. rutilus* was effective in controlling *Ae. aegypti* at PR, but not at the other 2 study sites, because of the availability of protective shade and/or vegetation.

Therefore, it is likely that *Tx. r. rutilus* may be used effectively to control mosquitoes breeding in tire dumps located in wooded areas. There is recent evidence, however, that some of the exotic species of *Toxorhynchites* such as *Tx. amboinensis* (Doleschall) and *Tx. brevipalpis*, will oviposit in artificial containers in the open (Focks et al. 1982).

The observations made in this study suggest that *Toxorhynchites* should be released early in the season in order to establish predator populations before the vector or pest species of mosquitoes reach high density levels in the field. These data and others (Trpis 1972, Focks et al. 1980) show that natural populations of *Toxorhynchites* can exert considerable control on prey mosquitoes. However, due to their extended developmental period, the control is slow in developing because the predator has to go through several generations before their numbers are high enough to be effective. If large numbers of the predator are released early, this lag in control can probably be prevented.

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ANNOUNCEMENT

SUPPLEMENT TO "MOSQUITOES OF NORTH AMERICA, NORTH OF MEXICO" BY R. F. DARSIE, JR. AND R. A. WARD

Reprints of an 11 page supplement (published in *Mosquito Systematics)* to the AMCA publication, "Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico," are available gratis from the undersigned. Mailing can be expedited by enclosing an address label with your request.

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