INFLUENCE OF TREE TRUNKS ON THE SPATIAL DISTRIBUTION OF *TOXORHYNCHITES R. RUTILUS* OVIPOSITIONS IN A COASTAL OAK/PALM HAMMOCK IN FLORIDA[1]

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ABSTRACT. The number of *Toxorhynchites r. rutilus* eggs occurring in 20 ground-level oviposition traps was monitored daily for 14 days in an area of coastal oak/palm hammock forest in Florida. Ten of these ovitraps (modified 2-liter plastic soda bottles) were placed in contact with tree trunks, the others at least 2 m from the base of the nearest tree. There was no significant difference in the mean number of eggs observed in egg-positive ovitraps for either type of trap site. However, ovitraps abutting trees were egg-positive significantly more often than expected. This result is discussed in terms of the initial oviposition-site searching behavior of female *Toxorhynchites*.

INTRODUCTION

One of the major impediments to the wider use of the predacious mosquito genus *Toxorhynchites* as biological control agents of mosquito vectors seems to be the reluctance or inability of females to locate and oviposit into the same small water-filled containers as target species when released in urban environments. From the distribution of *Toxorhynchites rutilus rutilus* (Coq.) ovipositions after an urban adult release, Focks et al. (1983) suggested that the oviposition-site search behavior probably included an initial location of and orientation to vegetation. In the same vein, Bailey et al. (1983) showed that *Tx. r. rutilus* was effective at controlling populations of *Aedes aegypti* (Linn.) breeding in a tire dump situated under trees but not in one in the open, despite releases of 1,000 adult *Toxorhynchites* a week. They attributed this effect to a preference for the shade afforded by the trees, rather than the trees themselves. Similar preferences for shady, sylvan environments have been reported from other species of *Toxorhynchites* (Corbet 1964, Lounibos 1979, O'Malley et al. 1989), and it seems that oviposition is largely confined to these areas. In dense seasonal-deciduous rainforest in Trinidad, West Indies, ovipositions by *Toxorhynchites moctezuma* (Dyar and Knab) into artificial ovitraps were strongly influenced by the vegetation immediately surrounding the trap (Jordan and Hubbard 1991). About 10 times as many eggs were observed in those ovitraps sited within the crotch of the buttressed roots of trees as in those placed on the ground some distance from trees. The statistical significance of the above results, however, were suspect, as the data violated certain model assumptions (Jordan and Hubbard 1991). Therefore, to shed more light on this aspect of *Toxorhynchites* behavior, the following experiment was performed specifically to identify any arboreal influence on oviposition-site selection by *Tx. r. rutilus* in their natural, forested environment.

MATERIALS AND METHODS

The study was conducted during September 1990 in a small area of coastal oak/palm hammock forest on the grounds of the Florida Medical Entomology Laboratory, Vero Beach, FL (Fig. 1). Ovitraps were made from 2-liter plastic soda bottles. By cutting off the top half, and painting the remainder matte black, an effective ovitrap for *Toxorhynchites* was created. Traps were placed in shallow holes in the ground at an angle of about 45° to the horizontal, an orientation which provided for overflow and some shelter from rainsplash during precipitation (Fig. 2). Twenty such ovitraps were arranged along a 200-m transect through the hammock. Ten of the traps were selected at random and sited directly adjacent, i.e., in contact with the trunks of trees. The other 10 were situated so that each was no closer than 2 m to the nearest tree trunk. All traps were originally filled with 500 ml of oak-leaf infusion water, prepared by soaking dried oak-leaf litter in distilled water (ca. 120 g leaves per liter of water) for 2 wk prior to the experiment. The traps were topped up by rainfall or distilled water if necessary. Every ovitrap was inspected daily for 14 consecutive days, and any *Toxorhynchites* eggs within were recorded and removed from the water surface with a small glass spoon. The ovitraps were examined at the same time and in the same order each day. All eggs were brought back to the laboratory in water-filled vials, labeled with date and site of oviposition, and reared through

[1] This is University of Florida, Institute of Food and Agricultural Sciences, Journal Series No. R-01356.

Fig. 1. Typical structure of a coastal oak/palm hammock within the study area; Vero Beach, FL.

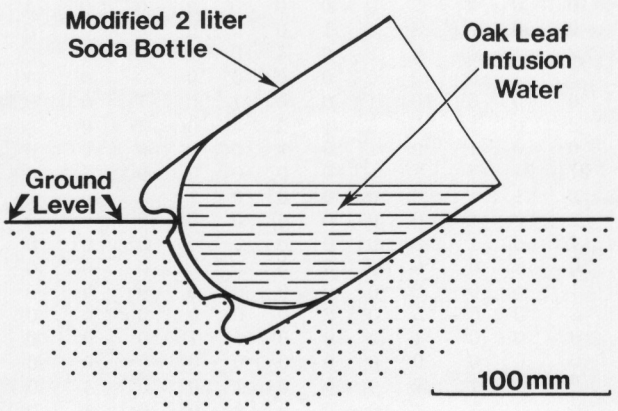

Fig. 2. Cross section through an ovitrap (a modified plastic 2-liter soda bottle) *in situ* showing half-buried orientation.

to the adult stage for identification. Finally, reflected light readings were taken at each ovitrap site at 3 different times of the day: at 0800, 1200 and 1600 h and under both clear and fully overcast cloud conditions, to ascertain whether there was any difference in the quantity of shade at the 2 types of site.

RESULTS

The 14 days of data from each ovitrap are shown in Table 1. Out of 280 ovitrap inspections, 72 were positive for *Toxorhynchites* eggs, and all were subsequently identified as *Tx. r. rutilus*. A runs test among days for each of the ovitraps showed that the occurrence of these egg-positive observations was random in all but ovitraps 5 and 11. Forty-nine of the egg-positive observations came from ovitraps situated adjacent to tree trunks, the remaining 23 from ovitraps at least 2 m from tree trunks. These frequencies were compared (by chi-square test) to those frequencies expected from a population of randomly searching females (which would produce equivalent egg-positive frequencies in both categories of ovitrap-site). The observed frequencies represented highly significant departures ($\chi^2 = 9.39$; 1 df; $P < 0.005$) from expectation, and indicated that ovitraps adjacent to tree trunks were positive for eggs more often and those at least 2 m from tree trunks less often than would have been expected by the null hypothesis.

Table 2. Result of ANOVA on square-root transformed data of number of *Toxorhynchites r. rutilus* eggs recorded from each egg-positive observation during the 14-day monitoring period.

Distance from tree	n	Back-transformed (squared) mean number of eggs per trap per day and 95% CL of mean			ANOVA	
		$\bar{Y}$	Upper	Lower	F	p
≥2 m	23	2.28	1.40	3.37	0.43	>0.5
Adjacent	49	2.71	1.18	3.58		

Taking just the egg-positive observations, there was no significant difference between the mean number of eggs per ovitrap per day oviposited into ovitraps in the open and those abutting trees ($F = 0.28$; $P = 0.60$; ANOVA). These data were rendered homoscedastic prior to ANOVA by applying a square-root transformation (Sokal and Rohlf 1980). Back-transformed means are given in Table 2 together with 95% confidence limits.

The light intensity readings taken at each ovitrap site revealed no significant differences in the amount of shade between tree sites and open sites at any time of day or cloud cover.

DISCUSSION

These results can be interpreted in 2 ways: first, that the *Tx. r. rutilus* females based their

Table 1. Number of *Toxorhynchites r. rutilus* eggs occurring at each daily inspection of each ovitrap in coastal oak/palm hammock in Florida.

Trap no.	Distance from tree	No. of eggs recorded at each inspection														No. of positive traps
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	≥2 m	0	1	0	0	0	0	0	0	0	0	1	0	0	0	2
2	≥2 m	0	0	2	2	0	0	0	0	2	0	0	0	0	0	3
3	≥2 m	0	0	2	8	4	1	0	0	0	0	0	0	3	0	5
4	Adjacent	2	1	0	0	2	0	4	0	1	2	1	0	1	0	8
5	≥2 m	2	1	0	0	0	0	0	0	0	0	0	0	0	0	2
6	≥2 m	0	0	3	16	1	0	0	1	0	1	0	0	0	0	5
7	Adjacent	2	0	1	5	6	1	2	4	0	3	0	0	0	3	9
8	≥2 m	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2
9	Adjacent	27	24	7	2	5	0	0	0	0	0	3	0	4	0	7
10	Adjacent	2	1	1	0	0	0	0	0	1	3	0	0	0	0	5
11	Adjacent	2	2	1	0	0	0	0	0	0	0	0	0	0	0	3
12	≥2 m	7	0	1	0	0	0	0	0	0	0	0	0	0	0	2
13	≥2 m	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1
14	Adjacent	1	0	0	2	0	0	0	0	0	0	0	0	0	0	2
15	Adjacent	2	0	0	5	0	2	0	0	0	0	0	0	0	0	3
16	Adjacent	0	0	0	1	2	0	0	0	1	0	0	0	0	0	3
17	≥2 m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Adjacent	2	4	1	7	0	0	0	1	0	0	4	0	0	0	6
19	Adjacent	0	0	3	1	0	0	0	0	0	0	3	0	0	0	3
20	≥2 m	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Total																72

ovipositional commitment on the proximity of the site to the nearest tree trunk. Several authors have demonstrated that there are a number of factors associated with oviposition sites which can strongly influence the ovipositional decisions made by female *Toxorhynchites*. The color of the site (Trimble 1979, Hilburn et al. 1983), presence of water (Benzon et al. 1988) and water chemistry (Benzon et al. 1988, Linley 1988) all appear to be important cues that females consider before ovipositing. In this study, however, these factors were identical for each ovitrap, only their proximity to trees was different. It would seem unlikely that females would reject a suitable (water-filled) oviposition site, once it had been located, on the basis of how close it was to the trunk of a tree. The results above imply that this is true, because on average, *Tx. r. rutilus* females deposited equal numbers of eggs in both open and tree ovitraps, suggesting that they found them equally suitable as larval environments.

The second and perhaps more likely explanation for these observations is that traps adjacent to trees were located more often or with greater ease than those not associated with trees. The chances of searching females visiting each type of ovitrap location would be radically different if their oviposition-site searching behavior began with an initial orientation to the trunks of trees, followed by the more familiar routine of looping flight and oviposition. This would mean that ovitraps beside trees would be encountered more often, and those away from trees less often, producing the results of the present study.

Since there was no difference in light intensity between the 2 types of site, it appeared that shade was not a property of the oviposition sites that was considered by females at this level in their search behavior. Nonetheless it has been well established in the literature that *Toxorhynchites* mosquitoes possess ovipositional habitat preferences for shade (Corbet 1964, Lounibos 1979, O'Malley et al. 1989). One may propose, therefore, a hypothetical oviposition-site search pattern as follows: locate shade (if they have left it); locate a tree trunk; locate hole or crevice in vicinity of trunk; check for water presence and water chemistry within; and finally, oviposit.

While these behavioral traits have yet to be observed directly, such responses would be obvious steps toward females locating naturally occurring oviposition sites (flooded tree holes and rot holes). In an urban situation this behavior may preclude them from locating the most suitable larval habitats (and effecting vector control), because there are fewer trees in urban areas and water filled containers occur in a wide variety of places, not just in proximity to trees.

ACKNOWLEDGMENTS

I am grateful to J. R. Rey, G. F. O'Meara and 2 anonymous referees for extremely helpful comments on this paper.

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