SEASONAL INCIDENCE AND VERTICAL DISTRIBUTION PATTERNS OF OVIPOSITION BY *AEDES AEGYPTI* IN AN URBAN ENVIRONMENT IN TRINIDAD, W. I.

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ABSTRACT. The oviposition patterns of *Aedes aegypti* were investigated using modified ovitraps placed along 4 vertical transects and monitored weekly for 52 wk in St. Augustine, Trinidad, W.I. From the 832 ovitraps exposed at ground level, 1.2, 3.0 and 4.6-m elevations, 43% (361) were found containing 20,114 *Ae. aegypti* eggs. During the wet season, 52.7% of the eggs were collected whereas during the dry season only 47.3% were collected. Egg populations were highest at the 1.2-m elevation. The implications of these results are discussed.

INTRODUCTION

Much information is available on the vertical oviposition and distribution patterns of mosquitoes occupying equatorial forests (Haddow et al. 1947, Mattingly 1949, Corbet 1961) and savannahs (Snow and Wilkes 1972, Snow 1975, Gillies and Wilkes 1976). But until recently little attention has been paid to this problem in urban areas. Few studies have been conducted on the vertical distribution of the urban vector of yellow fever and dengue, *Aedes aegypti* (Linn.).

In Africa, Mattingly (1957) found vertical tree holes were least favored by *Ae. aegypti,* and Kellett and Omardeen (1957) found significant numbers of *Ae. aegypti* occupying tree hole habitats from ground level to 34 ft (10.4 m) in Arima, Trinidad. Similarly, De Caires (1947) and Tinker (1974) reported large numbers of *Ae. aegypti* larvae in roof gutters during routine house to house inspections in British Guiana (Guyana) and Suriname, respectively. It has been suggested that the movement of *Ae. aegypti* mosquitoes above ground level may have resulted from insecticide pressure, that is, the absence of untreated containers (Tinker 1974).

This study was undertaken over a 1-year period to determine the seasonal and vertical oviposition preferences of *Ae. aegypti* using modified ovitraps in St. Augustine, Trinidad.

MATERIALS AND METHODS

Study area: This study was conducted in St. Augustine (10° 38′N; 61° 25′W), a medium size town of approximately 30 ha, 18,000 people, 12,000 houses) extending between the Eastern Main Road and the Churchill-Roosevelt Highway, 18 km east of Port of Spain, Trinidad. St. Augustine is surrounded by many small townships and to the east by the University of the West Indies. In the study area the terrain is generally flat and most houses are not raised above the ground, conforming to a typical block plan. The space separating houses varied from 5 to 10 m with either solid concrete or chain-link fences demarking the lots. Larval surveys were conducted every 8–10 wk by the Insect Vector Control Division workers, and during the study the Breteau index was 10.6 in the wet season and 5.9 in the dry season (D. D. Chadee, unpublished data). Common larval habitats for *Ae. aegypti* in St. Augustine included steel drums, cans, vases, gutters, tires and elevated domestic water-storage tanks. The vegetation is similar to that described in St. Joseph by Chadee and Corbet (1987).

Meteorology: Air temperature and RH were measured in a standard meteorological screen, and rainfall was recorded daily throughout the year at the Piarco Meteorological Station, located about 6 km east of St. Augustine. Trinidad experiences two distinct seasons: the "wet" season from May to November and the "dry" season from December to May.

Oviposition: Oviposition was monitored using modified ovitraps (Fay and Eliason 1966) as described by Corbet and Chadee (1990) except that 350 ml of tap-water was added instead of yeast slurry. Four ovitraps were placed at each of 4 sites (designated A–D) in St. Augustine. At each site ovitraps were placed at ground level, 1.2, 3.0 and 4.6-m heights. All ovitraps were placed under the eaves of houses and serviced weekly as described by Chadee (1988).

Ovitraps were exposed for 1 wk for each of 52 wk from December 7, 1987, to December 9, 1988. Each week paddles (labeled with the site number and height) were removed and replaced by egg-free paddles, the water in each ovitrap discarded, ovipot scrubbed to remove any eggs laid or attached to the insides of the ovitraps and 350 ml of fresh tap water added. The handling of paddles and identification of eggs after collection was as described by Chadee and Corbet (1987).

Oviposition patterns were analyzed separately for the dry season (observations from December 1–13, 1988, and December 9, 1987, to May 25, 1988), for the wet season (May 25 to November 30 1988) and for both seasons combined. During this study oviposition activity was recorded as the *occurrence* of eggs, and as the *number laid*, each week according to heights. Data were transformed into a (5 × 4) contingency table and analyzed using a G-test (Sokal and Rohlf 1980). In addition, the numbers of eggs laid were transformed ($\sqrt{1 + x}$) and an analysis of variance (ANOVA) performed (Sokal and Rohlf 1980).

RESULTS

Meteorology: The mean monthly air temperature and RH were similar to that previously described by Chadee and Corbet (1987). The mean monthly RH was parallel with precipation; the minimum of 70–74% was recorded in March, April and May and more than 80% during June to December 1988 and part of December 1987. Mean monthly air temperatures were lowest in December (both 1987 and 1988) and highest in May but remained relatively constant from June to November 1988.

From December 9, 1987, to December 13, 1988, 2,290 mm of rain was recorded. Months with the highest rainfall were June, July, August, September, October and November (1988) when 1,808 mm (78.9% of the years total) was recorded. October produced the highest monthly rainfall for 1988 (488 mm or 21.3%). From January to May there was little rain.

Oviposition: Seasonal patterns of oviposition at all 4 heights are shown in Table 1. Populations remained low throughout the dry season (39.3% of traps positive for eggs), but after the start of the rains in May, the egg populations increased toward peak abundance in the mid-rainy season (July, August, September and October).

From the 832 ovitraps exposed along the 4 vertical transects, a total of 361 (43% of occurrences) ovitraps were found containing 20,114 *Ae. aegypti* eggs. Seasonal differences in oviposition patterns were observed, with 47.3% (9,516 eggs, 157 positive ovitraps, mean 60.6 eggs/positive ovitrap) of all eggs collected during the dry season and 52.7% (10,598 eggs, 204 positive ovitraps, mean 52.0 eggs/positive ovitrap) during the wet season (Table 1).

When the number of oviposition occurrences and eggs collected were compared (G-test) among the 4 vertical transects, no significant differences ($P > 0.05$) were found, thus indicating that similar populations of *Ae. aegypti* were present at the ovitrapping transects (see Table 2). However, when the data collected at the 4 elevations were further tested using an analysis of variance (two-way ANOVA), the results

Table 1. Vertical oviposition preferences of *Aedes aegypti* from ovitraps in St. Augustine, Trinidad (1987–88).

Level (m)	Dry season[1]				Wet season[2]				Whole year[3]			
	No. positive ovitraps	% positive	No. eggs laid	% total eggs	No. positive ovitraps	% positive	No. eggs laid	% total eggs	No. positive ovitraps	% positive	No. eggs laid	% total eggs
0	55	55.0	2,391	25.1	84	77.8	3,669	34.0	139	66.8	6,060	30.1
1.2	81	81.0	6,848	72.0	103	95.4	6,787	64.0	184	88.5	13,635	67.8
3.0	10	10.0	50	0.5	11	10.2	122	1.2	21	10.1	172	0.9
4.6	11	11.0	227	2.4	6	5.5	20	0.2	17	8.2	247	1.2
Totals	157	39.3	9,516	100.0	204	47.2	10,598	100.0	361	43.4	20,114	100.0

[1] Dry season 400 ovitraps exposed (100 for each level).
[2] Wet season 432 ovitraps exposed (108 for each level).
[3] Whole year 832 ovitraps exposed (208 for each level).

Table 2. Number of eggs laid by *Aedes aegypti* at 4 heights located in 4 houses in St. Augustine, Trinidad (1987–88).

Heights (m)	Site A	Site B	Site C	Site D	Total
0	1,296	1,947	1,256	1,561	6,060
1.2	2,465	4,918	2,709	3,543	13,635
3.0	91	61	12	8	172
4.6	93	91	12	51	247
Totals	3,945	7,017	3,989	5,163	20,114

Site differences (F = 2.77; d.f.4; $P > 0.05$) (ANOVA); height differences (F = 53.18; d.f.4; $P < 0.001$) (ANOVA); differences between 0 and 1.2 m data (G = 25.00; d.f.1; $P < 0.001$).

showed no significant differences (F = 2.77; d.f. 3; $P > 0.05$) between sites but significant differences (F = 53.18; d.f. 3; $P < 0.001$) between heights. The results also showed that ovitraps located at ground level and 1.2 m were the 2 most preferred heights used by gravid *Ae. aegypti* (Table 1). Consequently, when the data from ground level and 1.2 m were transformed into a 2 × 2 contingency table and compared using a G-test, the results showed significantly ($P < 0.001$) more eggs were collected at 1.2 m than at ground level (G = 25.0; d.f. 1, $P < 0.001$).

DISCUSSION

The results of this study clearly demonstrate that *Ae. aegypti* mosquitoes preferred oviposition sites 1.2 m above ground in Trinidad. In addition, significant numbers were also laid at ground level whereas very few were laid at the 3.0 and 4.6-m elevations. Patterns of oviposition were similar in both the wet and dry seasons in Trinidad. Interestingly, the preferred ovipositing container of *Ae. aegypti* in Trinidad is the drum (70%), the height of which is about 1 m. These results suggest that placement of ovitraps at ground level as proposed by various authors (Fay and Eliason 1966, Hoffmann and Killingsworth 1967, Jakob and Bevier 1969, Thaggard and Eliason 1969) may not be the most appropriate option. Consequently, the results of this study suggest that personnel conducting ovitrapping programs need no longer confine ovitrap placement to ground level but may use available options up to 1.2 m. Therefore, the placement above ground level may eliminate the problem of interference by animals often found when traps are placed at ground level (Jakob and Bevier 1969).

It is now evident that neither the height (present study) nor the light criteria (Chadee 1991) found to be most appropriate for ovitrap placement in Trinidad conform to those suggested by previous workers (Fay and Eliason 1966, Hoffmann and Killingsworth 1967, Jakob and Bevier 1969, Thaggard and Eliason 1969).

ACKNOWLEDGMENTS

I thank Jasmin Chadee and R. Ganesh and R. Sedino for field and laboratory assistance. Special thanks are due to J. M. Sutherland for assistance in the field and for reviewing the manuscript. In addition, I thank S. Mahabir from the Caribbean Epidemiology Centre for statistical advice.

REFERENCES CITED

Chadee, D. D. 1988. Effects of "closed" houses on the *Aedes aegypti* eradication programme in Trinidad. Med. Vet. Entomol. 2:193–198.

Chadee, D. D. 1991. Oviposition site preferences of *Aedes aegypti* (L.) along horizontal transects in Trinidad, W.I. Med. Vet. Entomol. 5: In press.

Chadee, D. D. and P. S. Corbet. 1987. Seasonal incidence and diel patterns of oviposition in the field of the mosquito, *Aedes aegypti* (L.) (Diptera: Culicidae) in Trinidad, West Indies: a preliminary study. Ann. Trop. Med. Parasitol. 81:151–161.

Corbet, P. S. 1961. Entomological studies from a high tower in Mpanga Forest, Uganda. IV. Mosquito breeding at different levels in and above the forest. Trans. R. Entomol. Soc. Lond. 113:301–314.

Corbet, P. S. and D. D. Chadee. 1990. Incidence and diel oviposition periodicity of *Aedes aegypti* (Diptera: Culicidae) in the field of Trinidad, W. I., with relation to the solar aspect. Ann. Trop. Med. Parasitol. 84:63–78.

De Caires, P. F. 1947. *Aedes aegypti* control in the absence of piped potable water supply. Am. J. Trop. Med. 27:733–743.

Fay, R. W. and D. A. Eliason. 1966. A preferred oviposition site as a surveillance method for *Aedes aegypti*. Mosq. News 26:531–535.

Gilles, M. T. and T. J. Wilkes. 1976. The range of attraction of animal baits and carbon dioxide for mosquitoes. Studies in a freshwater area of West Africa. Bull. Entomol. Res. 61:389–404.

Haddow, A. J., J. D. Gillett and R. B. Hington. 1947. The mosquitoes of Bwamba County, Uganda. V. The vertical distribution and biting cycle of mosquitoes in a rain-forest, with further observations on microclimate. Bull. Entomol. Res. 37:301–330.

Hoffmann, B. L. and B. F. Killingsworth. 1967. The egg-laying habits of *Aedes aegypti* (Linnaeus) in central Texas. Mosq. News 27:466–469.

Jakob, W. L. and G. A. Bevier. 1969. Application of ovitraps in the U.S. *Aedes aegypti* eradication program. Mosq. News 29:55–62.

Kellett, F. R. S. and T. A. Omardeen. 1957. Tree hole breeding of *Aedes aegypti* (Linn.) in Arima, Trinidad. W. I. Med. J. 6:179–188.

Mattingly, P. F. 1949. Studies on West African forest mosquitoes. I. The seasonal distribution, biting cycle and vertical distribution of four of the principal species. Bull. Entomol. Res. 40:149–169.

Mattingly, P. F. 1957. Genetical aspects of the *Aedes aegypti* problem I. Taxonomy and bionomics. Ann. Trop. Med. Parasitol. 51:392–408.

Snow, W. F. 1975. The vertical distribution of flying mosquitoes (Diptera: Culicidae) in West African savanna. Bull. Entomol. Res. 65:269–277.

Snow, W. F. and T. J. Wilkes. 1972. The vertical distribution, and age, of mosquito populations in West African savanna. Trans. R. Soc. Trop. Med. Hyg. 66:536–537.

Sokal, R. R. and F. J. Rohlf. 1980. Biometry. 2nd Ed. Freeman, New York.

Thaggard, C. W. and D. A. Eliason. 1969. Field evaluation of components for an *Aedes aegypti* (L.) oviposition trap. Mosq. News 29:608–612.

Tinker, M. E. 1974. *Aedes aegypti* larval habitats in Surinam. Pan Am. Health Org. Bull. 8:293–301.