URBAN DISTRIBUTION OF *AEDES TRISERIATUS* IN NORTHERN INDIANA[1]

S. M. HANSON, M. SONG AND G. B. CRAIG, JR.

Vector Biology Laboratories, Department of Biology, University of Notre Dame, Notre Dame, IN 46556

ABSTRACT. Ovitraps were used to determine the distribution of *Aedes triseriatus* among forty-eight 1.2 km^2 quadrants in urban South Bend and Mishawaka, Indiana. Oviposition paddles from 96 ovitraps were collected for 13 weeks from June to September, 1986. A total of 82,974 eggs was collected. Eggs were present in each quadrant at least once and were found in most quadrants on 6 or more collection dates. Ninety-two percent of the ovitraps were positive at least once, indicating ubiquitous distribution throughout the urban area. The eggs collected were 80–90% *Ae. triseriatus*, the remainder being *Ae. Hendersoni*. Effectiveness of large (3,100 ml) and small (350 ml) ovitraps was compared. The large ovitraps exceeded the small by 319% for eggs/positive ovitrap and 486% in numbers of positive ovitraps.

INTRODUCTION

Aedes (Protomacleaya) triseriatus (Say) is the most commonly reported mosquito inhabitant of tree holes in the United States east of the Great Plains. This species is the primary vector of LaCrosse encephalitis (LAC) virus in the USA (Thompson et al. 1972). *Aedes triseriatus* is often considered to be a rural, sylvan species associated with forests and woodlots. Its rural distribution is well-documented (Sinsko and Craig 1978, Novak et al. 1981, Nasci 1982). Our major objective was to determine the urban distribution of *Ae. triseriatus* in the cities of South Bend and Mishawaka, St. Joseph County, Indiana. South Bend and Mishawaka have populations of 107,117 and 41,100 inhabitants, respectively (Anonymous 1986).

Monitoring *Ae. triseriatus* populations was difficult before the advent of ovitraps. Since this species is diurnal, it is seldom found in light traps. Females are reluctant to enter the small aperture in animal-baited traps. Landing-biting counts, carbon dioxide (CO_2) traps, and larval surveys are expensive and impractical at best. Thus, *Ae. triseriatus* demographics were little-known until recently. The modified Fay ovitrap (Loor and DeFoliart 1969) is an inexpensive, accurate, and efficient tool for *Ae. triseriatus* survey. This consists of a beverage can painted shiny-black, half-filled with water, and containing a balsa-wood paddle on which eggs are deposited.

A preliminary study by Leiser (1981) demonstrated the wide distribution of *Ae. triseriatus* in South Bend. The present project used a different distribution system than that of Leiser, supplied additional data, determined the percentage of *Ae. (Pro.) hendersoni* (Cockerell) present, and compared the effectiveness of two different ovitraps.

Surveillance of tree hole mosquitoes is commonly done using ovitraps constructed from 350 ml beverage cans. Recently, workers in Ohio have shown that larger containers are more efficient for sampling *Ae. triseriatus* populations (Berry 1985). This study measured the relative sampling effectiveness of 350 ml and 3,100 ml containers.

MATERIALS AND METHODS

Urban distribution. A grid of forty-eight 1.2 km^2 quadrants was superimposed upon a map of the two cities (Fig. 1). From June 16 to 19, two 3,100 ml ovitraps were placed at least 300 m apart in each quadrant. In addition to the urban ovitraps, two 3,100 ml ovitraps were placed in a woodlot near South Bend to compare the urban egg count with that of a relatively rural site. The 3,100 ml ovitraps were 18 cm high × 16 cm diam and open at the top. The cans were sprayed inside and out with gloss black enamel paint. A 5 mm hole was drilled in the side approximately 5 cm from the bottom to prevent overflowing. Two soaked 5 × 15 cm balsa-wood paddles were attached to the inside of the ovitrap with paper clips and positioned so that the bottom edge of the paddle touched the bottom of the ovitrap. The ovitraps were placed on the ground under trees or bushes, except for ovitraps #23, 26, 29, 30, 42, 50, 59, 60 and 92; these were 30, 21, 190, 59, 163, 195, 242, 31 and 100 cm above the ground, respectively. The ovitraps were filled with water up to the 5 mm hole, and approximately 2 g of dry maple leaf litter was added to each as an attractant (Loor and DeFoliart 1969).

The ovitraps were serviced weekly for nine weeks beginning on June 26, then biweekly for the following four weeks. Servicing included collecting the paddles, adding fresh paddles,

[1] Work supported in part by St. Joseph Co. (Indiana) Health Department Mosquito Abatement Program and NIH Grant No. AI-02753.

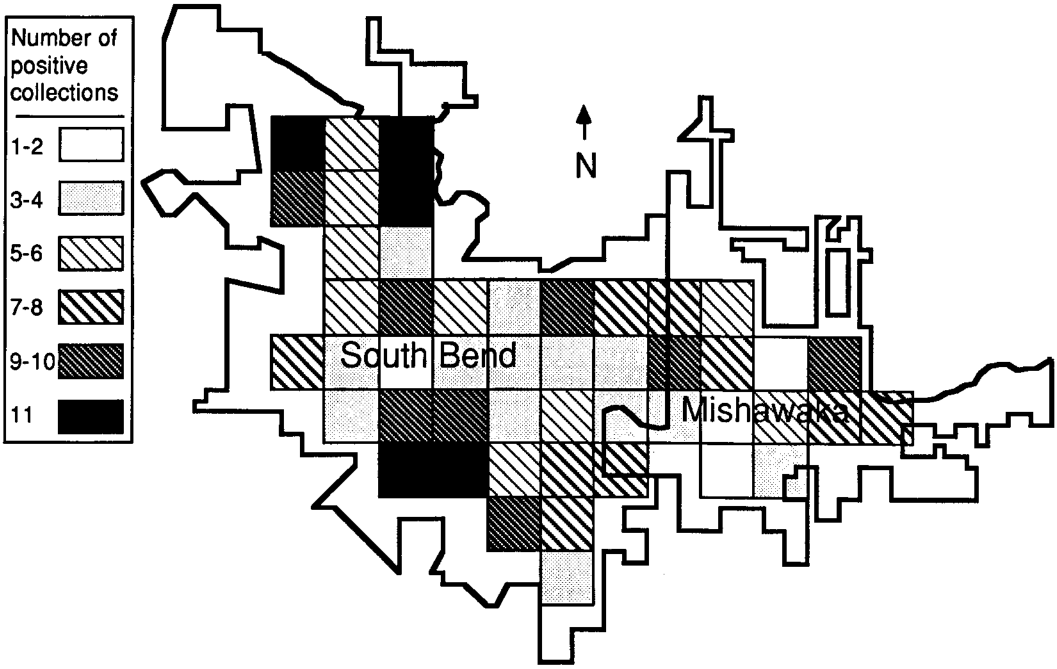

Fig. 1. Map of urban area and ovitrap quadrants. Each quadrant is 1.2 km^2. Shading indicates number of positive collections.

and adding water when necessary. Each paddle was examined for eggs; the eggs/trap were counted, and the eggs from 20 randomly-chosen ovitraps with eggs were hatched in nutrient broth (different ovitraps were chosen each week). When the larvae reached the fourth instar, they were identified, and the percentage of *Ae. hendersoni* was determined. The criteria for separating the two species were body color and size and shape of anal papillae.

Total numbers of eggs/week, eggs/trap/day for each week, percentage of ovitraps with eggs for each week, and cumulative percentage of ovitraps with eggs at least once were calculated. Total numbers of eggs in each woodlot ovitrap and selected urban ovitraps were also tabulated for the season.

Effectiveness of two different ovitraps. A 350 ml ovitrap (height 12 cm, diam 6.5 cm) was placed between 1 and 2 m from a 3,100 ml ovitrap at 50 of the urban sites described above. The 350 ml ovitraps were prepared with the same paint, holes and balsa-wood strips as the 3,100 ml ovitraps. In addition, the positions of the two ovitraps at each site were exchanged during service. Eggs on each balsa-wood strip were counted. Total numbers of eggs/week, eggs/positive trap for each week, and percentage of ovitraps with eggs for each week were calculated for both types of ovitraps. Percentage difference between the two ovitrap types in eggs/positive ovitrap/week and percentage difference between the two ovitrap types in percent positive ovitraps were then calculated.

RESULTS

Urban distribution. The data in Table 1 show the distribution of ovitraps with eggs (positive ovitraps) in the two cities during each sample period. The time between sample dates is a sample period. The first sample period is between the dates on which the ovitraps were distributed (June 16 to 19) and the first sample date. Table 1 shows that the cumulative percentage of positive ovitraps was 92% at the end of the study.

Figure 1 illustrates the number of sample dates when at least one ovitrap in a given quadrant was positive. It shows that each quadrant was positive for eggs at least once, and most quadrants were positive for eggs on six or more sample dates. Figure 2 is taken from Leiser (1981) and is used with permission. It shows that 66% of the sample districts were positive for eggs at least once during the summer of 1980.

A total of 82,974 eggs was collected from the urban 3,100 ml ovitraps over the course of this study. Figure 3 illustrates the eggs/day during each sample period. The data from the August 31 and September 7 sample dates and the Sep-

Table 1. Positive ovitraps throughout the summer.

Sample date no.	% positive ovitraps	Cumulative % positive ovitraps
1	49	49
2	23	64
3	42	67
4	30	72
5	33	76
6	37	80
7	38	83
8	34	89
9	44	90
10	42	90
11	42	91
12	48	92
13	20	92

tember 11 and 21 sample dates were combined, because half the ovitraps were serviced on each of those sample dates. The total number of eggs collected in each of the two rural ovitraps was 14,075 eggs and 18,803 eggs, much higher than the egg collection in any urban ovitrap except # 8. The total egg production in ovitrap #8 was 15,412 eggs.

Table 2 compares egg production in different urban habitats. The "Woodlot" category includes three ovitraps which were placed in cemetaries, an ovitrap on a wooded college campus, and an ovitrap placed on a wooded golf course in addition to those ovitraps in woodlots. The "Business" category is comprised of all ovitraps on commercial properties, such as factories, stores, restaurants, etc. The "Residence" category consists of all ovitraps placed on residential properties, including three ovitraps positioned on church premises. Seasonal totals of ovitraps in different urban habitats were compared using a Mann-Whitney U-test. The number of eggs/day of the "Woodlot" ovitraps was significantly different ($P < 0.05$) from that of the "Business" and "Residence" ovitraps. The number of eggs/day of the "Business" and "Residence" ovitraps did not differ ($P > 0.05$) significantly from one another.

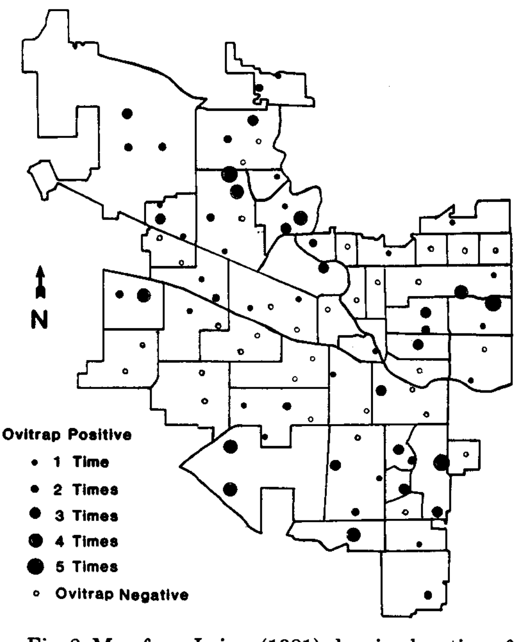

Fig. 2. Map from Leiser (1981) showing location of ovitraps positive for *Ae. triseriatus* in South Bend.

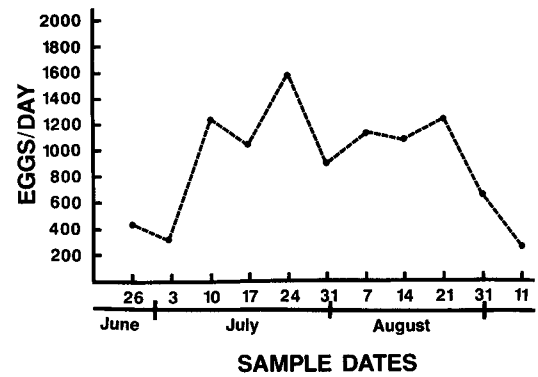

Fig. 3. Total egg count in each sample period. These data represent the seasonal total egg production.

Effectiveness of two different ovitraps. Figures 4 and 5 compare the number of eggs/positive ovitrap and percentage of positive 350 ml ovitraps with that of the 3,100 ml ovitraps for all the sample periods of this comparison experiment. The 3,100 ml ovitraps in these figures are only the 50 ovitraps with 350 ml ovitraps adjacent to them. The data for the two different ovitraps were compared in a Mann-Whitney U-test and found to be significantly different ($P < 0.01$) in eggs/positive ovitrap (Fig. 4) and percent positive ovitraps (Fig. 5). The 3,100 ml ovitraps had 319% more eggs//positive trap than the 350 ml ovitraps. There were 486% more positive 3,100 ml ovitraps than 350 ml ovitraps.

Table 2. A comparison of egg production in different urban habitats.

Type of habitat	Number of traps	No. eggs/trap Mean[1]	SD
Woodlot	21	2,352a	3,877
Business	31	458b	753
Residence	44	332b	502

[1] Means followed by the same letter are not significantly different (Mann-Whitney U-test, $P < 0.05$).

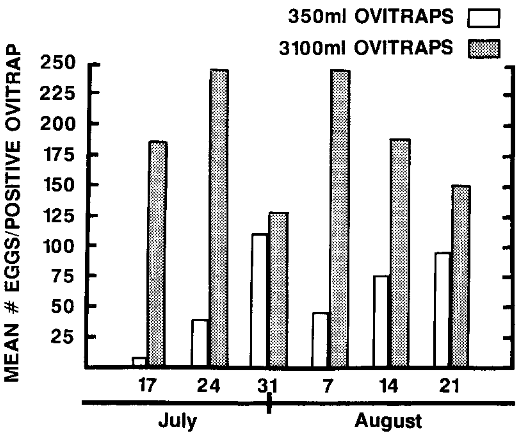

Fig. 4. Comparison of mean number of eggs in 350 ml and 3,100 ml containers.

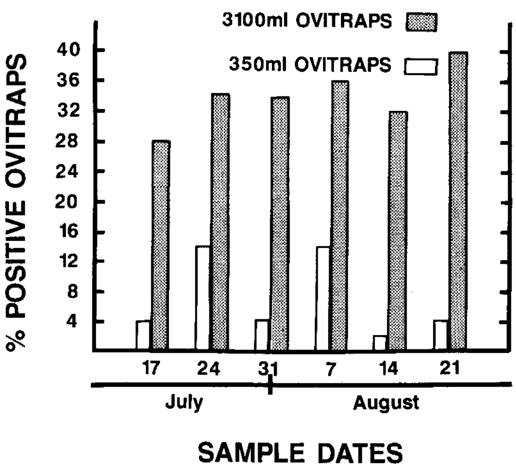

Fig. 5. Comparison of percent positive ovitraps for 350 ml and 3,100 ml containers.

DISCUSSION

Urban distribution. Table 1 and Fig. 1 show that *Ae. triseriatus* was well-distributed in the urban areas throughout the summer. The final cumulative figure, 92% positive ovitraps (Table 1), unquestionably demonstrates the virtual ubiquity of *Ae. triseriatus* in these two cities. Figure 3 shows that *Ae. triseriatus* is present throughout the summer in large numbers in this urban area. A positive ovitrap is definite evidence of at least the temporary presence of *Ae. triseriatus*, but a negative ovitrap does not prove its absence. In addition, the distribution of resting *Ae. triseriatus* does not correspond exactly to the distribution of egg-laying *Ae. triseriatus* (Beier, et al. 1982). The ovitrap only indicates egg-laying. Thus, there could be biting mosquitoes in an area with no positive ovitraps.

Figures 1 and 2 indicate *Ae. triseriatus* was present in significant numbers throughout the urban area during the summers of 1986 and 1980, respectively. The fact that it was prevalent during both studies suggests its presence is not transient. Fewer positive ovitraps were collected by Leiser in 1980 (cumulative figures: Leiser—59%, this study—92%). According to the results of this study, the difference might be attributable to the 3,100 ml ovitraps used in the present study, whereas Leiser used 350 ml ovitraps. Rainfall and mosquito population levels also influence ovitrap data. Rainfall influences the number of oviposition sites available to mosquitoes. The number of available oviposition sites is probably inversely related to the number of eggs laid in ovitraps. Rainfall data for the months of May through September of 1980 and 1986 indicate that rainfall was slightly above average during both summers (National Oceanic and Atmospheric Administration Local Climatological Data: 1980 and 1986). Therefore, rainfall does not seem to be the factor causing the difference in ovitrap data. Light trap records from St. Joseph County, Indiana in 1980 record 171,134 mosquitoes collected, including 546 *Ae. triseriatus/hendersoni*. The same light traps in 1986 collected 75,670 mosquitoes, including 289 *Ae. triseriatus/hendersoni*.[1] The light trap data indicate a smaller *Ae. triseriatus/hendersoni* population in 1986 compared to 1980. But the opposite is true of the ovitrap data. Thus, it seems probable that the larger ovitraps had a major effect on the difference in eggs/ovitrap.

The percentage of *Ae. hendersoni* larvae found when a portion of the eggs from each sample period were hatched varied from 27 to 0.06%. The ovitraps in this study were basal. However, *Ae. hendersoni* is a greater portion of the tree hole mosquito population in the canopy than in basal sites (Sinsko and Grimstad 1977, Novak et al. 1981, Schuler and Beier 1983). Therefore, the *Ae. hendersoni* population in this urban area is probably much larger than these basal ovitraps indicate. The eggs of *Orthopodomyia alba* Baker, another common tree hole mosquito in this area, were never observed in the ovitraps. This is not surprising, because *Or. alba* has only been reported in the canopy.[2]

---

[1] St. Joseph County Indiana Mosquito Abatement Program Report, 1980 and 1986.

[2] Copeland, R. S. 1987. Habitat segregation and life history patterns of the Culicidae of treeholes in northern Indiana. Ph.D. dissertation, University of Notre Dame. 286 p.

Aedes triseriatus is not detected by most mosquito abatement programs, because such programs use light traps and larval surveys to monitor mosquito populations. Unfortunately, these methods are inadequate for monitoring *Ae. triseriatus*. Thus, *Ae. triseriatus* is often overlooked and sometimes assumed to be rare. The present study indicates there may be many more *Ae. triseriatus* present in urban areas than most vector biologists realize.

When investigating LAC in Ohio, mosquito control workers found that tires were the predominant *Ae. triseriatus* breeding containers encountered in suspected transmission sites (Berry 1983). In the same study, tires produced far more *Ae. triseriatus* per container than tree holes or trash. This information, added to the data of our study, show that there is great potential for urban LAC transmission. Also, the danger of LAC could increase as the number of discarded tires in this country escalates.

These data are also important as a record of the *Ae. triseriatus* and *Ae. hendersoni* populations in an urban area where *Ae. albopictus* (Skuse) has not yet been found. If *Ae. albopictus* is discovered in this area, the 1986 data will serve as a basis for comparison.

Effectiveness of two different ovitraps. The data show that 3,100 ml containers greatly exceed the 350 ml containers in terms of number of eggs/positive ovitrap (Fig. 4) and percentage of positive ovitraps (Fig. 5). Obviously, larger containers are more efficient for sampling the urban distribution of *Ae. triseriatus*. Thus, larger containers should be used whenever possible to insure more accurate demographic data.

ACKNOWLEDGMENTS

The authors gratefully recognize Ingrid Shell for her assistance in counting the eggs. We also thank William A. Hawley and Robert S. Copeland for their expert advice.

REFERENCES CITED

Anonymous. 1986. East North Central: 1984 population and 1983 per capita income estimates for counties and incorporated places. D. E. Starsinic, (ed.). Current Population Reports, Series P-26, No. 84-ENCSC. U. S. Bureau of the Census. Washington, DC. 131 pp.

Beier, J. C., W. J. Berry and G. B. Craig, Jr. 1982. Horizontal distribution of adult *Aedes triseriatus* (Diptera: Culicidae) in relation to habitat structure, oviposition, and other mosquito species. J. Med. Entomol. 19:239–247.

Berry, R. L. 1983. *Aedes triseriatus*, man-made containers and LaCrosse encephalitis in Ohio. Proc. Ohio Mosq. Control Assoc. 13:13–17.

Berry, R. L. 1985. Ovitrap sampling for *Aedes triseriatus*. Proc. N. J. Mosq. Control Assoc. 72: 98–104.

Leiser, L. 1981. Distribution of *Aedes triseriatus* (Say) in an urban area: Comparison of two survey methods. Proc. Ind. Acad. Sci. 90:248–253.

Loor, K. A. and G. R. DeFoliart. 1969. An oviposition trap for detecting the presence of *Aedes triseriatus* (Say). Mosq. News 29:487–488.

Nasci, R. S. 1982. Activity of gravid *Aedes triseriatus* in wooded fencerows. Mosq. News 42:408–412.

Novak, R. J., J. J. Peloquin and W. Rohrer. 1981. Vertical distribution of adult mosquitoes (Diptera: Culicidae) in a northern deciduous forest in Indiana. J. Med. Entomol. 18:116–122.

Schuler, T. C. and J. C. Beier. 1983. Oviposition dynamics of two released species of *Toxorhynchites* (Diptera: Culicidae) and potential prey species. J. Med. Entomol. 20:371–376.

Sinsko, M. J. and G. B. Craig, Jr. 1978. Dynamics of an isolated population of *Aedes triseriatus* (Diptera: Culicidae) I. Population size. J. Med. Entomol. 15:89–98.

Sinsko, M. J. and P. R. Grimstad. 1977. Habitat separation by differential vertical oviposition of treehole *Aedes* in Indiana. Environ. Entomol. 6: 485–478.

Thompson, W. H., R. O. Anslow and G. R. DeFoliart. 1972. LaCrosse virus isolations from mosquitoes in Wisconsin, 1964–68. Am. J. Trop. Med. Hyg. 21:90–96.