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AN EVALUATION OF THE MOSQUITO CONTROL PROGRAM IN A SMALL MIDWESTERN URBAN COMMUNITY [1]

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Mosquito control programs for small urban communities in the midwestern United States are often modifications of programs designed for other areas such as coastal, swamp, or irrigated lands where mosquitoes pose acute problems necessitating costly measures. The use of these programs in the Midwest, where mosquitoes occur in lower densities, is often ineffective and wasteful.

This report deals with a 2-year study (1967–1968) of the mosquito control program in a small midwestern urban community located in the lower Missouri River Valley bordering the Ozark Highlands to the south and the prairie regions to the north and west. Approximately 40,000 people live in the 22.4 square miles of the city limits. The depth of the city lots averages 150 feet per lot. There are few, if any, alleyways between the properties.

In this mosquito control program, approximately $10,000 per year was allocated to the following; (1) operation of four New Jersey mosquito light traps with weekly tabulation of catch by species; (2) application of fenthion in diesel oil as a larvicide to suspected mosquito breeding sites; (3) fogging with fenthion for adult control.

MATERIALS AND METHODS. The City Health Department was responsible for the mosquito control program; however, the Department of Public Works carried out most of the actual mosquito control measures. Larval control was based on survey records of breeding sites from 1966 made by an untrained inspector. Approximately 20 percent of the money spent annually for mosquito control was used in attempted larval control. This included the larviciding crew which worked an average of 2 days per week from April 1

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to October 1. In 1967, the larval control crew spent 50 percent of its time treating large waste stabilization lagoons without preliminary determinations of mosquito breeding in these lagoons. In 1968, officials were persuaded not to larvicide three of these larger lagoons so that the actual importance of these areas as mosquito breeding sites could be determined. Three small untreated lagoons were sampled for larvae throughout the same period. Water samples were taken from each location with a ½-pint dipper. The total number of immatures per sample and the average number per dip were determined.

The mosquito control program used the remaining 80 percent of its budget for adult control, 10 percent of which went to surveillance. Equipment used for adult control consisted of a Dyna-Fog thermal aerosol fogger, model 1200 and a TIFA thermal aerosol fogger, model 40F. The foggers were calibrated to deliver a fog particle size less than 10 microns in diameter. The insecticidal formulation was composed of 1 gallon of 93 percent fenthion in 50 gallons of kerosene. The foggers were calibrated to deliver .015 pound of actual insecticide per acre as recommended by the CDC.

Test cages, similar to those used by Bellamy and Reeves (1952) ,were constructed to determine the effectiveness of the fog. This was measured by exposing caged adults to the insecticide at distances of 25, 50, 75, 100, and 125 feet from the line of fog application. Test mosquitoes (*Culex pipiens* complex) were reared from larvae collected from an untreated animal waste lagoon.

Female mosquitoes were aspirated at random from the stock culture, anesthetized with CO_2, and grouped in lots of 10. One lot was placed in each test cage.

Test mosquitoes were transported to the test site within 30 minutes after caging. Two cages of test controls were randomly selected and placed in a section of the city where no fogging was done. Cages were placed with the long axis in a horizontal position parallel to and suspended 4 feet above the ground on portable stakes. Caged mosquitoes remained at the test site from 3 to 5 hours after being exposed to the fog.

RESULTS AND DISCUSSION. Several aspects of the mosquito control program were examined. It was found that: (1) the money spent on adult surveillance could have been spent more profitably on other areas; (2) the information from the adult survey was not utilized in the control program; (3) the larval survey used by the city was neither comprehensive nor current.

More than three times the original number of reported larval breeding sites were recorded in a survey done during our study. The three oxidation lagoons surveyed in 1968 were not important areas of mosquito breeding. Only one lagoon contained larvae, and that one, not until August 1. The lagoon was larvicided and no more larvae were taken during the rest of the sampling period. The three small untreated lagoons produced a steady larval mosquito population.

Wind limits the effectiveness of thermal aerosol fogging. If the wind velocity exceeds 5 miles per hour, the fog is usually dispersed too rapidly without much lethal effect. Of the 2,196 hours that could have been used for fogging between 6 p.m. and 6 a.m., from April 1 to October 1, 1967, only 552 hours or 34 percent of the time had suitable weather for applying aerosol fog according to local climatological data. During July and August, when adult mosquito activity was greatest, weather conditions were suitable for mosquito fogging less than half (45 percent) of the available hours. Operation records showed that each machine was used 224.5 hours. However, 25 percent of the fogging was done during unsuitable weather (Table 1).

Climatological data for 1968 showed that of 2,568 hours, only 528 hours or 29 percent of the time from April through October was suitable for fogging. Twenty-nine percent and 23 percent of the evening hours were acceptable for fogging during July and August, respectively. Only 270 hours, 39 percent of the 686.5 hours total, were spent fogging during favorable weather. Thus, the actual time during

TABLE 1.—Hours fogged vs. hours of acceptable fogging weather.[1]

Month	Hours of acceptable fogging weather	Hours fogged	Hours fogged during acceptable weather	Hours fogged during unacceptable weather
		1967		
April	9	0	0	0
May	48	4	0	4
June	99	78.5	44.5	34
July	150	71	57	14
August	150	85.5	65	20.5
September	96	5.5	1.5	4
Total	552	244.5	168	76.5
		1968		
April	57	0	0	0
May	75	0	0	0
June	48	115	21	94
July	108	180	86.5	93.5
August	87	196	70	126
September	87	137.5	66	71.5
October	66	58	26.5	31.5
Total	528	686.5	270	416.5

[1] Acceptable weather for fogging was defined as wind velocity of less than 5 miles per hour with no precipitation between 6:00 p.m. and 6:00 a.m.

which foggers would have been effective in this period was quite limited (20.5 percent of the time from April 1 to October 1).

Mortality of caged mosquitoes exposed to the fog is shown in Tables 2 and 3. Mortality of mosquitoes exposed to fog from the TIFA fogger at 25 feet from the roadside ranged between 0 percent and 80 percent, the mean being 33 percent (Table 2). Furthermore, data show that the mean mortality decreased as distance from the fog generator increased (Table 2). The mortality of caged mosquitoes exposed to the Dyna-Fog machine was very similar to that obtained from the TIFA test (Table 3). Using the "t" test, there was no statistical significance between the mean mortality of mosquitoes exposed to the TIFA and the Dyna-Fog machines.

Observations of both foggers in operation showed that the fog usually rose immediately after it left the nozzle, presumably due to convection currents. The fog seldom blanketed the ground for more than 75 feet from the point of release before it rose. The average lot depth in the test city was 150 feet, without alleys separating the properties. Since only one side of the street was fogged, only one-quarter of the property that was intended to be fogged during each night was actually covered.

Less than 50 percent of the test mosquitoes exposed in the treated area were killed by the fog. No reduction in the mosquito populations was recorded by bite counts after an area had been fogged.

CONCLUSIONS. Money spent on the adult surveillance program was generally wasted since the data from the light traps were not used to correlate fogging operations or establish population trends. Of species collected from light traps, *Aedes vexans* and *Culex pipiens* complex were predominant. Since the *C. pipiens* complex are known to breed in some oxidation lagoons and many kinds of artificial containers, an educational program could have alerted the public to these local breeding areas, and used to solicit help in eliminating these sites.

The larviciding program was based on an outdated survey and the fixed idea that all oxidation lagoons were mosquito breeding sites. Cost of operation in this area of mosquito control could have been more

TABLE 2.—Mortality * of caged mosquitoes exposed to fenthion aerosol fog applied during routine mosquito control program.

TIFA Model 40F

Wind direction and velocity	Direction of cages from fogger	Distance of cages from fogged route				
		25′	50′	75′	100′	125′
North 4 m.p.h.	North	50%	63%	25%	0%	0%
North 4 m.p.h.	South	71%	71%	29%	0%	0%
North calm	Northeast	40%	10%	20%	10%	20%
North calm	Southwest	80%	80%	70%	20%	0%
East 5 m.p.h.	East	0%	0%	0%	0%	0%
East 5 m.p.h.	West	0%	10%	0%	20%	0%
Southwest 5 m.p.h	East	50%	60%	30%	0%	0%
Southwest 5 m.p.h	West	10%	0%	0%	0%	0%
Southwest 7 m.p.h.	North	20%	10%	20%	10%	10%
Southwest 7 m.p.h.	South	11%	11%	0%	0%	0%
Southeast 5 m.p.h.	North	0%	0%	10%	0%	0%
Southeast 5 m.p.h.	South	0%	11%	11%	0%	0%
Northeast 6 m.p.h.	North	10%	20%	30%	10%	10%
Northeast 6 m.p.h.	South	78%	78%	22%	11%	11%
South 8 m.p.h.	North	60%	20%	10%	0%	10%
South 8 m.p.h.	South	11%	11%	0%	0%	0%
Southeast 5 m.p.h.	East	60%	60%	70%	30%	20%
Southeast 5 m.p.h.	West	67%	22%	11%	0%	0%
East 6 m.p.h.	North	30%	30%	20%	10%	0%
East 6 m.p.h.	South	11%	0%	0%	0%	0%
Mean		33%	28.4%	18.9%	6.1%	6.1%

* Corrected for natural mortality by Abbott's formula.

TABLE 3.—Mortality * of caged mosquitoes exposed to fenthion aerosol fog applied during routine mosquito control program.

Dyna-Fog Model 1200

Wind direction and velocity	Direction of cages from fogger	Distance of cages from fogged route				
		25′	50′	75′	100′	125′
South 6 m.p.h.	North	0%	10%	0%	0%	10%
South 6 m.p.h.	South	0%	10%	0%	10%	10%
Northwest 4 m.p.h.	Northeast	56%	0%	0%	11%	0%
Northwest 4 m.p.h.	Southeast	50%	25%	25%	0%	0%
East 7 m.p.h.	North	56%	11%	0%	11%	0%
East 7 m.p.h.	South	44%	33%	11%	11%	11%
South 6 m.p.h.	Northeast	56%	78%	56%	44%	0%
South 6 m.p.h.	Southwest	56%	56%	0%	0%	0%
Southeast 7 m.p.h.	North	60%	40%	60%	0%	10%
Southeast 7 m.p.h.	South	33%	0%	11%	33%	11%
East 9 m.p.h.	North	11%	0%	11%	0%	0%
East 9 m.p.h.	South	0%	11%	0%	0%	0%
South 6 m.p.h.	North	22%	11%	22%	0%	0%
South 6 m.p.h.	South	33%	22%	22%	0%	0%
Southeast 6 m.p.h.	Southwest	63%	13%	37%	13%	0%
Southeast 6 m.p.h.	Northeast	37%	0%	25%	25%	0%
Southeast 7 m.p.h.	Southwest	70%	60%	50%	20%	10%
Southeast 7 m.p.h.	Northeast	56%	22%	22%	11%	0%
North 8 m.p.h.	East	10%	10%	0%	0%	0%
North 8 m.p.h.	West	0%	10%	10%	10%	0%
Mean		35.7%	21.1%	18.1%	9.9%	3.1%

* Corrected for natural mortality by Abbott's formula.

effectively applied to updating the larval survey and then to treating breeding sites.

Correlation of operation records and climatological data showed that less than 50 percent of the time spent in fog application was suitable for fogging. Cage tests showed that the fogging operation was not effective in killing test mosquitoes.

The results of this study of a small urban mosquito control program in action suggests that entomologists who advise local health officials should emphasize the importance of establishing priorities in organizing and financing control programs. These priorities should reflect not only the magnitude and importance of the mosquito problem in the area but also the ability and willingness of the city officials and community to finance and provide qualified personnel for the program.

Our experiences lead us to believe the following priorities are generally desirable in our area of the Midwest: (1) a comprehensive and continuing survey of the community to locate larval habitats and the effective treatment of these sites; (2) a periodic quantitative assessment of the efficacy of the larviciding program by adult landing counts; (3) the use of mist-spray or thermal aerosol fogging equipment in and around public assembly areas where mosquito populations have been found at nuisance level; (4) the general use (only during favorable weather conditions) of such equipment to reduce adult mosquito populations; (5) the lowest priority should be given to the operation of light traps for continuous adult survey since small communities usually cannot afford or obtain trained personnel required for the adult survey and can make limited use of the data accumulated.

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