A STUDY OF ADULT MOSQUITO CONTROL WITH AEROSOLS AT FORT LAUDERDALE, FLORIDA

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Since 1946 there has been an increase in the use of thermal aerosols carrying primary toxicants for the supplemental control of mosquitoes and other insects. Aerosols are clouds of droplets, mostly below 50 microns diameter, of petroleum oils in which are dissolved DDT, BHC, lindane, and other toxicants. The aerosol oils employed range from kerosene and fuel oil to Sovacide F. The latter material is specifically manufactured for thermal aerosol generation and has a greater solubility power for chlorinated toxicants than kerosene or fuel oil. S/V Sovacide F is in itself toxic to insects.

The use of fogs for the control of adult mosquitoes is primarily a supplementary operation designed to give immediate relief from invasions of these insects. Under conditions of heavy breeding, as found in marshes and swamps, the aerosol fog method of adult control does not replace the recognized and basic practices of drainage and larviciding.

In 1950 and 1951 Fort Lauderdale embarked upon a program of adult mosquito control in residential areas supplementary to the excellent work of the Broward County Anti-Mosquito District. The municipal program, which was carefully coordinated with the County program, included basic larviciding procedures as well as weekly street-by-street fogging with lindane, BHC, or DDT in S/V Sovacide F or No. 2 fuel oil. Three or four TIFA units were employed for the fogging treatments. One of these units was mounted on a motor-propelled catamaran which permitted fogging of both banks of the 290 miles of canals found within the city limits of Fort Lauderdale.

The city used approximately 13,000 gallons of S/V Sovacide F and 36,000 gallons of No. 2 fuel oil for fog or larvicide in 1950, and 24,000 gallons of S/V Sovacide F in 1951. In 1951 fuel oil was limited to the larvicide phase of the work. These petroleum carriers were used to disperse approximately 10,500 lbs. of DDT and 600 to 2,400 lbs. of lindane or BHC. Early in the season it became apparent to the Director of Insect Control that fog produced by S/V Sovacide F covered at least twice as much area as the fog from an equivalent volume of No. 2 fuel oil. Initial "knockdown" of mosquitoes was better and, in addition, the high solubility of S/V Sovacide F for the chlorinated toxicants reduced formulation time to a fraction of that required when fuel oil was employed.

The initial success of the aerosol adulticide phase of the Fort Lauderdale program was amply confirmed by the reports of residents. The immediate relief from insect attack experienced after fogging in areas heavily infested by mosquitoes was common knowledge. These reports were empirical, however, and gave no information on duration of relief. In view of this, it was desirable that factual data be obtained on the following points: Do aerosols effectively kill adult mosquitoes? How long are aerosols effective? What procedures in aerosol application should be followed to insure maximum effectiveness?

Experimental Studies. During the period covered by the brief field tests, *Aedes taeniorhynchus* predominated. An initial survey within the corporate limits of Fort Lauderdale indicated that the primary emergence areas were the salt marshes and mangrove swamps east of the city. Smaller secondary breeding areas were observed on undeveloped or partially developed

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"islands" within some residential districts.

In order to obtain estimates of the density of mosquito populations prior to and after fogging, the numbers of mosquitoes landing on the legs and arms of observers were determined during test periods of one minute at 10 stations in several areas. At these stations simultaneous counts were taken by three observers, one hour before the area was to be fogged, and at intervals of 2, 12, 24 and 48 hours after fogging. The data, in the form of the average number of landings per minute for all three observers before and after fogging, are given in Table 1.

plan. During the period of the tests the fog material consisted of 0.5% lindane dissolved in S/V Sovacide F. DDT is also employed by the city at the rate of 7.5% in S/V Sovacide F but, due to an increasing resistance of some species of mosquitoes, lindane has proved to be more effective. S/V Sovacide F with lindane was fogged at a rate of 10 gals. per hour from TIFA units mounted on trucks or jeeps traveling at a rate of 4 mi./hr. Fogging operations were conducted from 4 p.m. to 10 p.m. and from 4 a.m. to 8 a.m. During the spring and summer months, east or southeast winds of 2 to 4 miles per hour prevail, so most fog operations took place from the east side of

TABLE 1.—Per cent reduction in mosquito populations following application of S/V Sovacide F fogs plus 0.5% lindane

	Percent Control Based on Landing Counts Before Fogging			
	2 Hours After	12 Hours After	24 Hours After	48 Hours After
Type of Area	%	%	%	%
Residential; No Emergence, 0.5–1 Mile	89	88	77	2
Residential; Emergence within 0.25 Mile	47	63	85	30
Dense Salt Marsh; Heavy Emergence	55	3	0	0
Ditched Salt Marsh; Moderate Emergence	76	50	65	0

The 10 stations were selected to typify four known conditions of infestation: (a) residential area, no known emergence within 0.5 to 1.0 miles; (b) residential area, moderate emergence within 0.25 miles; (c) dense salt marsh or mangrove swamp, heavy emergence; (d) open or ditched salt marsh, moderate to heavy emergence.

The tests were not isolated experiments but were coordinated with the standard procedure of fog application followed by the Director of Insect Control during the early summer of 1951. This consisted of an approximately weekly fogging of all areas of the city, according to an orderly

residential blocks. Under good conditions the fog was sufficiently dense to drift down wind through the entire block—a distance of 300 ft. or more. During one test under the above conditions, approximately 385 acres were fogged by one TIFA unit in 4½ hours, or 45 gallons of insecticidal solution were applied over the area. This was equivalent to an approximate output of 0.12 gal. of solution per acre. At this rate, the output of lindane from an 0.5% solution was approximately 0.005 lb./acre, and in those applications where DDT was employed, the output of DDT from a 7.5% solution was 0.07 lb./acre.

Table 1 summarizes the mosquito landing counts made during the tests, in terms of percent reduction of mosquitoes based on landing counts immediately preceding fog application. Of primary interest are the data for residential areas at some distances from emergence sources. Under these conditions where annoying invasions were intermittent, an average of 89% reduction in population was obtained within 2 hours after fogging with 0.5% lindane in S/V Sovacide F. Effective relief from annoyance continued for at least 24 hours. Tests conducted in residential areas close to secondary emergence places do not show as great an initial reduction (47%—2 hrs.; 63%—12 hrs.) as observed in more distant residential districts, but relief from annoyance was noticeable.

Table 1 also shows that although a significant reduction of adult mosquitoes followed fog application in ditched mangrove swamps, the effect disappeared rapidly after 24 hours. In dense swamp, there was no significant reduction in population after two hours. The greater effectiveness of fogs in the ditched mangrove swamps possibly resulted from the dense aerosol clouds which were able to move down the main ditches and into the feeder or lateral ditches. This may have provided deeper penetration into the dense masses of vegetation.

The data discussed above re-emphasize the supplemental and temporary nature of thermal aerosol fogs in adult mosquito control. Where employed with a full understanding of these limitations, aerosol fogs appear to offer quick and even spectacular relief from local mosquito invasion.

Variability of Mosquito Landings on Individuals. In the study reported, three observers made simultaneous landing counts for one-minute periods at 10 stations at various intervals with relation to the time of fog application. A consistent variation in the rate of mosquito landings (*Aedes taeniorhynchus*) was noted by each of the three observers. Obviously, if a consistent difference exists in the degree of repellency or attraction shown toward mosquitos by individuals, fallacies may be introduced with attempts to sample populations by the landing count method.

To establish the significance of individual response, a statistical analysis was made of the landing counts for the entire study. This analysis is summarized in Table 2. The data in Table 2 indicate that the lower rate of mosquito landings reported by Observer #1, in comparison with counts reported by Observers #2 and #3, is highly significant. In each case, the differences in counts between Observers #2 and #3 and Observer #1 exceed the least significant difference (5.25) required at the 1% level. Simply stated, this means that the odds are 99:1 against the probability that the observed difference occurred by chance alone. It is also evident that a significant difference exists between Observer #2 and Observer #3, although significance is of a lower order (odds of 19:1 against chance occurrence).

No attempt was made to determine the cause of individual difference in repellency or attraction for mosquitoes. This was a basic problem beyond the scope of the study. The existence of such variation appears to emphasize the desirability of employing two or more observers simultaneously when landing counts are

TABLE 2. Analysis of mosquito landings per minute (*Aedes taeniorhynchus*).

	Observer #1	Observer #2	Observer #3
Mean	10.4	16.1	19.7
Difference	—	+5.7	+9.3

Difference for significance @ 1% (99:1) — 5.25
Difference for significance @ 5% (19:1) — 3.26

used as indices of the density of mosquito population.

CONCLUSIONS AND RECOMMENDATIONS:

1. During the 1951 routine fogging at Fort Lauderdale, Fla., operations were conducted between 4 and 10 p.m., and between 4 and 8 a.m. The periods between 4 and 8 p.m. and 6 and 8 a.m. are daylight periods when, under south Florida conditions, undesirable inversion currents and wind changes often prevent the uniform distribution of aerosol fogs at ground level. Under these circumstances, a large proportion of the aerosol may quickly dissipate and thus become ineffective. In order to conserve insecticide and to obtain maximum control of mosquitoes, it was suggested that all fog operations be carried on during the night between 9 p.m. and 6 a.m.
2. The 7.5% DDT formulation, together with the existing rate of application at Fort Lauderdale resulted in the distribution of 0.07 lb. of DDT per acre fogged. Previous investigations, as reported by the Des Plaines Valley, Illinois, Mosquito Abatement District indicate that effective adult control is obtained where 0.1 to 0.3 lb. of DDT are distributed per acre. These dosages are substantially lower than the 2 lbs. per acre adopted as the proper limit for safety of birds by the U. S. Fish and Wildlife Service.
   Taking all things into consideration, it was suggested that from 10% to 15% Technical DDT be employed in future fog operations at Fort Lauderdale when DDT is the prescribed toxicant. This concentration assumes TIFA output rates of from 10 to 20 gals./hr. and a vehicle speed of 4 to 5 miles/hr. Under these conditions approximately 0.1 to 0.3 lb. of DDT will be distributed per acre.
3. The lindane formulation (0.5%) used for fogging at Fort Lauderdale resulted in the distribution of approximately 0.005 lb. of lindane per acre. There is little information concerning minimum effective amounts of lindane when applied as a thermal aerosol for adult mosquito control. However, lindane is considered to be approximately 10 times more effective than DDT; thus, on an acre basis 0.01 lb. of lindane should be distributed to be equivalent to 0.1 lb. of DDT. At the rate of fog application in this study, a 1% solution of lindane was suggested in place of the present 0.5% formulation.
4. The rate of fogging at Fort Lauderdale (10 gals./hr.) produced a very dry fog and resulted in no visible oil deposition on foliage close to the generator. This type of fog is effective in killing mosquitoes in residential areas. However, where slight deposit of oil on foliage may be unimportant, it was suggested that the generator output be increased to 15 or 20 gals./hr. This rate of application will improve initial kill of adult mosquitoes and the duration of control in marshes and in areas adjacent to them.
5. When data on mosquito populations are obtained by the landing count method, variations in the degree of repellency or attraction for the insects by individual observers should be taken into consideration. It is recommended that two or more observers be employed when landing counts are taken.

If you have not already purchased a copy of AMCA Bulletin #2, "Ground Equipment and Insecticides for Mosquito Control," place your order soon. The information it contains is indispensable to mosquito control workers. Copies of the Bulletin are still available at $2.00 each. Orders should be sent to Mr. C. T. Williamson, Suffolk Co. Mosquito Control Commission, Yaphank, N. Y.