p.p.b. of Baytex in the lakes since they have an average depth of about 20 feet.

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AN ANALYSIS OF AIRCRAFT APPLICATIONS OF MEDITERRANEAN FRUIT FLY SPRAY ON INDICES OF *AEDES AEGYPTI* (L.)

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There has been considerable interest expressed and questions have been raised about the possible beneficial effects on domestic mosquito control of insecticides dispensed from spray booms on aircraft. Stutz (1945) made some of the first general observations regarding the effectiveness of this method for controlling *Culex* spp. and *Aedes aegypti* breeding in artificial receptacles. They were not altogether encouraging.

Since 1956, widespread aircraft applications of insecticide baits for the control of the Mediterranean fruit fly, *Ceratitis capitata* Wiedemann have been made in south Florida. The 1956, 1958 and 1962 control campaigns were the most extensive and extended into several counties. No observations were made in these years with respect to the effects of these insecticidal treatments on mosquitoes.

The most recent occurrence of the Mediterranean fruit fly was in the Greater Miami, Florida area in 1963. It was most opportune then that sprays were applied, in part, to areas which had been routinely inspected for several years by personnel from the Dade County Mosquito Control Division and the Public Health Service, Division of Foreign Quarantine *Aedes aegypti* Detection and Control Program. Inspections made in August, 1963, first indicated an apparent correlation between the use of the Mediterranean fruit fly sprays and mosquito reduction. At this time a heavily and regularly infested area, which had been sprayed from the air, was found negative to *A. aegypti* while in adjoining unsprayed blocks *A. aegypti* breeding was still somewhat as in previous inspections. It was then that one of the inspectors observed particles of insecticidal bait drifting into a receptacle filled with water containing *A. aegypti* larvae. Samples were taken from this container but the larvae appeared agitated and soon died. This sudden drop in the *A. aegypti* index in association with the aerial spray program in progress at the time intrigued

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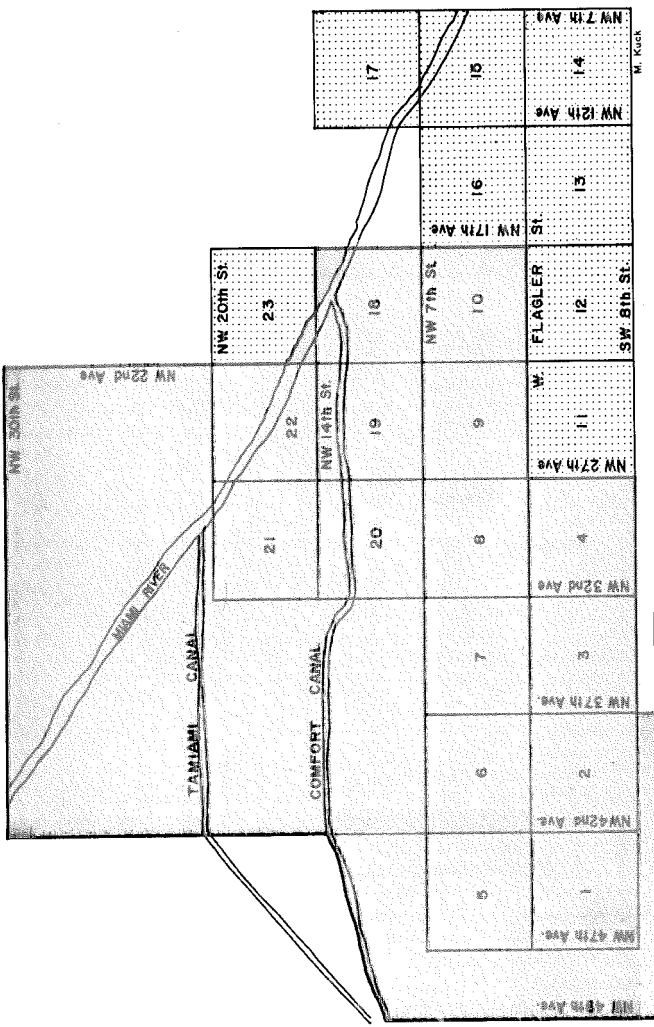

FIG. 1.—*Aedes aegypti* populations study area, Miami, Florida, showing the zones sprayed for Mediterranean fruit-fly control and those zones inspected outside of the treated area.

the authors, who then decided to study the effectiveness of this spray for *A. aegypti* control.

During the 1963 fruit fly control program in Miami, Florida, 39 separate applications of fruit fly spray were made and approximately 40,410 gallons of the insecticidal sauce mixture used. The spray formula consisted of the following ingredients:

1.2 pounds of 25% wettable malathion
1 pint of "protein insecticide bait No. 7"[3]
Sufficient water to make one gallon of spray

The number of applications of spray varied with the area concerned; some locations received more treatments than others. The spray was dispensed at the rate of 1 gallon per acre over a total of 5,125 acres which were mostly urban. The treatments were made from June 24, 1963 through October 21, 1963. The areas covered by these treatments and those which have also been carefully inspected to determine the incidence of *A. aegypti* relative to this study are indicated in Figure 1.

Records of routine inspections carried out by the Dade County Mosquito Control Commission and the Public Health Service *Aedes aegypti* Detection and Control Program staff were examined and comparisons made of inspection records within and adjacent to areas subjected to the Mediterranean fruit fly spray. Results of these observations are contained in Tables 1–4.

Examination and comparison of these data would indicate that apparently the *A. aegypti* indices declined significantly in the zones receiving aerial sprays. This is particularly marked when comparing these zones with the overall general[4] and *A. aegypti* indices for the county at large as given in Table 6. A fair evaluation of these results, cannot, however be determined without considering the following related factors.

(1) *Precipitation* during the months when these studies were made was generally more conducive to mosquito breeding in 1962 than it was in 1963, yet the overall *A. aegypti* index for Dade County in 1962 was lower than in 1963. (Table 5).

It is conceivable that the rains of 1963 were sufficient to flush out the insecticidal materials to a certain extent.

(2) *Temperature* cannot be considered as a factor of significance in these studies as the degree variation was not more than 3.3° F. in 1962 and 2.6° F. in 1963.

(3) *Areas inspected* are an important factor. Any comparison between the 1962 and 1963 *A. aegypti* indices must consider that different areas of the county were inspected. In addition, as Tables 1, 3 and 4 indicate, certain zones received more spray treatments than others.

(4) *Socio-economic changes* are markedly evident in certain zones under study. These have been changes due primarily to the influx of refugees with the subsequent absorption of their culture and health standards.

(5) *Time of inspections* undoubtedly is of some importance since the inspections were made at varying intervals before or after the application of the aerial spray.

Because of the number and nature of these variables and because these observations were made without an opportunity to arrange for test plot organization, it cannot be stated conclusively that the aerial treatments alone were responsible for the reductions noted in Tables 1–4. The results of these studies do lead the authors to conclude, however, that aerial applications of insecticides appear beneficial and should be considered as a possibility for the control of domestic mosquitoes under certain conditions, i.e., where there is an urgent need to rapidly reduce mosquito populations during mos-

[3] A proprietary item manufactured by A. E. Staley Co., Decatur, Ill. containing amino acids and amino acid salts, sodium chloride, ammonium chloride, miscellaneous cellulosic, carbohydrates and water.

[4] In the text and tables the term *general* refers to all species of mosquitoes found breeding in domestic situations including *A. aegypti*.

TABLE 1.—Summary of zones inspected within the boundaries of aircraft application.

Zone	Dates sprayed	Dates inspected	No. premises inspected	No. premises breeding		Breeding index		Previous breeding index		
				All species	*Aedes aegypti*	General	*Aedes aegypti*	Dates inspected	General	*Aedes aegypti*
1	July 16 (spot), 22, 30 Aug. 7, 13, 21, 27 Sept. 6, 11	7/29–8/6/63	640	9	9	1.4	1.4	11/1/62–1/3/63	1.4	1.4
2	"	7/19–26/63	627	27	10	4.3	1.6	10/24–31/62	6.8	4.8
3	"	7/8–24/63	826	16	16	1.9	1.9	11/27–12/5/62	5.64	4.2
4	"	8/2–13/63	852	26	26	3.1	3.1	12/11–19/62	3.22	2.48
5	"	8/6–14/63	662	3	0	0.5	0.0	1/11–22/63	2.0	0.8
6	"	7/12–19/63	607	5	2	0.8	0.3	1/4–10/63	1.3	0.65
7	"	8/2–13/63	951	4	2	0.4	0.2	11/2–26/62	4.62	3.67
9	July 24 (spot), 29 Aug. 5, 13, 22, 27 Sept. 5, 11, 17	8/5–21/63	923	16	11	1.7	1.2	11/20–30/62	4.0	2.75
18	"	9/4–10/63	501	7	4	1.4	0.8	1/15–21/63	3.7	2.5
19	"	9/12–23/63	535	12	9	2.2	1.7	1/21–29/63	3.5	0.35
20	June 24, 28 (spot) July 1, 8, 15, 22, 29 Aug. 6, 12, 19, 26 Sept. 4, 10	8/5–10/63	605	3	2	0.5	0.3	2/8–20/63	3.9	1.7
	Totals and averages		7729	123	91	1.7	1.2		3.64	2.3

TABLE 2.—Summary of zones inspected outside the boundaries of aircraft application.

Zone	Dates inspected	No. premises inspected	No. premises breeding		Breeding index		Previous breeding index		
			All species	*Aedes aegypti*	General	*Aedes aegypti*	Dates inspected	General	*Aedes aegypti*
11	7/6–8/2/63	700	14	14	2.0	2.0	10/31–11/20/62	2.07	1.75
12	7/8–25/63	1094	38	30	3.5	2.7	10/22–31/62	2.52	1.9
13	7/16–25/63	931	66	40	7.1	4.3	10/25–11/1/62	5.9	4.44
14	6/25–7/16/63	995	79	70	7.9	7.0	10/8–16/62	8.2	6.3
15	6/7–25/63	800	47	31	5.9	3.9	10/17–25/62	10.4	7.83
16	6/25–7/31/63	537	26	18	4.8	3.4	11/1–13/62	10.9	8.9
17	8/6–14/63	562	36	30	6.4	5.3	1/17–2/11/63	3.5	2.0
23	8/6–9/4/63	599	34	24	5.7	4.0	2/8–26/63	3.2	1.9
	Totals and averages	6218	340	257	5.5	4.1		5.83	4.4

TABLE 3.—Summary of zones inspected previous to aircraft applications but within spray boundaries.

Zone	Dates sprayed	Dates inspected	No. premises inspected	No. premises breeding		Breeding index		Previous breeding index		
				All species	*Aedes aegypti*	General	*Aedes aegypti*	Dates inspected	General	*Aedes aegypti*
8	July 16 (spot), 22, 30 Aug. 7, 13, 21, 27 Sept. 6, 11	6/27–7/3/63	652	20	17	3.1	2.6	10/22–11/1/62	2.04	1.15
10	July 24 (spot), 29 Aug. 7, 13, 22, 27 Sept. 5, 11, 17	6/21–7/8/63	993	66	58	6.6	5.8	11/30–12/12/62	1.22	0.85
		Totals and averages	1645	86	75	5.2	4.6		1.63	1.00

TABLE 4.—Summary of zones inspected within spray boundaries but after completion of spray program.

Zone	Dates sprayed	Dates inspected	No. premises inspected	No. premises breeding		Breeding index		Previous breeding index		
				All species	*Aedes aegypti*	General	*Aedes aegypti*	Dates inspected	General	*Aedes aegypti*
21	June 24, 28 (spot) July 1, 8, 15, 22, 29 Aug. 6, 12, 19, 26 Sept. 4, 10	10/14–11/7/63	606	11	5	1.8	0.8	2/20–3/4/63	3.1	1.1
22	July 24 (spot), 29 Aug. 7, 13, 22, 27 Sept. 5, 11, 17	9/23–27/63	322	10	8	3.1	2.5	1/29–2/8/63	1.7	1.5
		Totals and averages	928	21	13	2.3	1.4		2.4	1.3

TABLE 5.—Precipitation in inches as recorded at the Miami International Airport

Month	1962	1963
June	10.36	6.80
July	3.74	1.77
August	8.02	4.77
September	7.82	11.12

quito-borne disease epidemics or possibly when needed as a means of economy. The authors further urge that additional testing be done to determine the latitude and scope of aerial applications of insecticides for domestic mosquito control.

TABLE 6.—Overall general and *Aedes aegypti* breeding indices for Dade County, Florida.

	Aedes aegypti		General	
Month	1962	1963	1962	1963
June	3.8	3.0	5.9	4.7
July	1.2	3.2	1.8	4.2
August	1.3	3.0	2.0	3.6
September	2.25	5.5	3.6	6.1

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INSECTICIDE-RESISTANCE RESEARCH ON *A. AEGYPTI*

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In 1954, populations of *A. aegypti* in Trinidad were discovered to be DDT-resistant. These resistant larvae were found by Brown and Perry (1956) to detoxify DDT to DDE, but the detoxifying enzyme could not be demonstrated by Brown (1956) *in vitro*. The DDT-resistance character in the Trinidad strain was reported by Coker (1958) to be due to a single gene allele, and this was confirmed by Qutubuddin (1958). A DDT-tolerance developed in a Malayan strain was considered by Coker (1958) to be due to a different factor.

Ten years later, in 1964, DDT-resistant populations of *A. aegypti* are now known in many Caribbean islands, notably Jamaica and Hispaniola, and on the adjacent mainland of South America in northeastern Colombia, Venezuela and the Guianas. Moreover, dieldrin-resistance has been reported from Puerto Rico by Fox (1961), and subsequently discovered in Jamaica, the Virgin Islands, the Grenadines and Curaçao. Strong DDT-resistance has been developed by laboratory selection of DDT-tolerant strains from New Orleans and Key West, Florida (Abedi and Brown, 1961a). Increased DDT-tolerance has been reported in *A. aegypti* from Saigon, Vietnam, and strong DDT-resistance has been developed in the laboratory in a strain from Penang, Malaya (Abedi and Brown, 1960). Both DDT-resistance and dieldrin-resistance have been developed by laboratory selection of material from Karachi, Pakistan. It would appear that *A. aegypti* resembles *Culex fatigans* in being capable of both types of resistance to most of the chlorinated hydrocarbon insecticides in any part of its range.

The mechanism of DDT-resistance in this mosquito is revealing itself in studies in our laboratory to be very similar to that in the house fly, which Sternburg, Kearns and Moorefield (1954) had discovered to be mainly due to detoxication