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SUSCEPTIBILITY OF SEVENTEEN STRAINS OF *AEDES AEGYPTI* (L.) FROM PUERTO RICO AND THE VIRGIN ISLANDS TO DDT, DIELDRIN, AND MALATHION

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INTRODUCTION. In 1963, the Communicable Disease Center established a program for the eradication of *Aedes aegypti* (L.) from the continental United States, Puerto Rico, and the Virgin Islands. The development of operational procedures for this program requires consideration of baseline data on insecticide susceptibility in the numerous areas of infestation. In both Puerto Rico and Florida resistance to DDT, dieldrin, and other chlorinated hydrocarbons by this species has been reported (Evans *et al.*, 1960; Fox *et al.*, 1960; Fox, 1961; Porter *et al.*, 1961). The following report describes the results of susceptibility tests with DDT, dieldrin, and malathion against larvae and adults of 13 strains of *A. aegypti* from Puerto Rico and 4 strains from the Virgin Islands.

METHODS. Temporary colonies for rearing and collection of F_1 eggs were established in San Juan from larvae collected during the period of May 28 to June 7, 1963, by personnel from the Public Health Service Quarantine Stations at San Juan and Miami. The eggs were shipped to Savannah, Georgia to provide larvae and adults of each of the 17 strains of *A. aegypti*. Test specimens were F_1 generation except for the St. John strain which was F_2. The standard procedures established by the World Health Organization were used to measure susceptibility to DDT, dieldrin, and malathion (Anon., 1960). Tests were replicated three or four times at each concentration of insecticide used.

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Twenty to 25 larvae or female adults were exposed in each replication. In the majority of the tests, specimens of a susceptible strain (CD) were included as a check. Untreated checks of the Puerto Rico and Virgin Islands strains likewise were employed.

The code designations for the areas from which the mosquitoes were obtained are:

Puerto Rico:

PR #1	Isla Verde, San Juan
PR #2	Hoare Section, Santurce
PR #3	Martin Peña Canal, Santurce
PR #4	Puerta Tierra, Old San Juan
PR #5	Cataño and Guaynabo (combined)
PR #6	Rio Piedras Section, San Juan
PR #7	Aguadilla
PR #8	Arecibo
PR #9	Humacao
PR #10	Fajardo
PR #11	Mayagüez
PR #12	Ponce
PR #13	Caguas

Virgin Islands:

St. Croix:

St. C #1	Christiansted
St. C #2	Frederiksted

St. Thomas:

St. T #1	Charlotte Amalie

St. John:

St. J #1	Cruz Bay

RESULTS. *DDT.* Against DDT (Table 1) the larvae of all strains had a lesser susceptibility than the susceptible CD strain. The PR-10 strain showed the highest level of susceptibility of the 17 strains tested. Resistance was greatest in Puerto Rico strains 2, 8, 11, 12, 13, and in the Virgin Islands strains. The greatest loss of susceptibility to DDT was exhibited by PR-12, St. C-1, and St. T-1.

In the adult tests against DDT (Table 1), a lowered susceptibility of similar magnitude was evidenced in all strains tested. However, as evident from the data, the mortalities obtained with the CD-susceptible strain were lower than anticipated and, except for the results at the 4 percent level, relatively little kill was apparent. With the exception of the PR-4 strain, significant differences in mortalities were obtained between the field strain and the CD strain at the 4 percent level. The susceptible strain was not utilized in all of the adult tests at 4 percent, but the fact that the strains not so tested also exhibited a definite loss of susceptibility in the larval tests supports the conclusion that resistance is present in all strains.

Dieldrin. Larval tests with dieldrin (Table 2) indicate that all strains had a high level of resistance to that toxicant but the level of resistance varied among the different strains as indicated by the response to the concentration of 2.5 parts per million. Maximum resistance to dieldrin was evident in the St. T-1 strain.

In the adult tests with dieldrin (Table 2), all strains showed marked resistance to dieldrin, poor kills being recorded even at the highest concentration of dieldrin (4 percent).

Malathion. With malathion (Table 3), there were differences between the field strains and the susceptible strain in the response of the larvae to concentrations of 0.1 ppm. However, the high kills obtained with malathion at 0.5 and 2.5 ppm indicated that the field strains are susceptible to that compound.

Similar results were apparent in the adult tests (Table 3) where essentially complete kills were evident at the 3.2 percent concentration with the susceptible CD strain or with the field strains.

DISCUSSION. In Puerto Rico, DDT had been used from 1945 to 1955 in *A. aegypti* control programs in the areas of PR-1, 2, 3, 4, 6, 8, and 12. Dieldrin was employed for control of *Culex* in the same areas from 1956 to 1958. Since 1960, malathion has been applied to indoor breeding sites at 6-week intervals in these areas.

In the Virgin Islands DDT has been, and still is, used for domestic mosquito larviciding. Dieldrin was applied as a house spray in St. Thomas in 1960, and chlordane is currently in use as an adulticide (fog).

With the Puerto Rico strains (PR-1 to 10, 13), DDT gave high kills of *A. aegypti* larvae at 2.5 ppm; therefore, it could be of control value as a larvicide if employed

TABLE 1.—Comparative susceptibility to DDT of 17 strains of *Aedes aegypti* (L.) from Puerto Rico and Virgin Islands.

Strain	Percent Mortality of Larvae at Concentration (p.p.m.) Shown					Percent Mortality of Adults at Concentration (%) Shown				
	0.004	0.02	0.1	0.5	2.5	0.25	0.5	1.0	2.0	4.0
PR–1	0(0)	0(64)	2(92)	77(100)	100	..	0(0)	1(0)	1(13)	11(91)
–2	0(0)	1(40)	3(80)	42(100)	98	..	..	0(4)	0(8)	0(80)
–3	0(4)	0(64)	16(92)	81(100)	100	1(0)	1(4)	0(0)	3(4)	1
–4	0(0)	0(36)	4(84)	72(100)	100	..	0(0)	0(0)	1(16)	1(20)
–5	0	0	2	81	98	..	0(0)	0(4)	1(0)	1(67)
–6	0(0)	0(32)	18(84)	78(100)	100	..	0(0)	0(4)	0(4)	6(61)
–7	0(8)	0(28)	8(100)	87(100)	100	0	0(0)	0(4)	0(0)	3(88)
–8	1(0)	1(24)	6(84)	47(100)	94	0(0)	0(0)	1(0)	0(0)	0
–9	..	0(36)	1(84)	68(100)	95	..	1(0)	0(0)	0(0)	7(83)
–10	0(8)	0(72)	31(74)	99(100)	100	0(0)	0(0)	0(0)	3(8)	17
–11	0(4)	0(56)	0(80)	20(100)	81	2	0(0)	1(0)	0(12)	1(72)
–12	0(0)	5(76)	0(100)	17(100)	77	0(0)	0(0)	0(0)	0(0)	1
–13	0(4)	0(28)	6(92)	32(100)	99	0(0)	2(0)	0(0)	0(8)	3
St. C–1	0(4)	0(24)	7(88)	41(100)	70	..	..	0(0)	1(20)	1(71)
–2	..	0(0)	3(96)	19(100)	52	..	0(0)	0(4)	1(12)	3(100)
St. T–1	0(0)	1(28)	0(88)	12(100)	22	0(0)	0(0)	0(0)	0(0)	1
St. J–1 *	0(8)	0(36)	5(92)	26(100)	87	..	0(0)	1(0)	1(0)	0(100)

Figures in parentheses indicate comparative percent mortality of a susceptible (CD) strain.
* F_2 generation.

TABLE 2.—Comparative susceptibility to dieldrin of 17 strains of *Aedes aegypti* (L.) from Puerto Rico and Virgin Islands.

Strain	Percent Mortality of Larvae at Concentration (p.p.m.) Shown						Percent Mortality of Adults at Concentration (%) Shown						
	0.0008	0.004	0.02	0.1	0.5	2.5	0.05	0.1	0.2	0.4	0.8	1.6	4.0
PR–1	0(0)	0(0)	0(48)	1(100)	24	61	0	0	1(0)	2(20)	2(100)	4(100)	2
–2	0(0)	0(0)	3(84)	2(100)	26	73	..	0	0(0)	2(35)	2(100)	9(100)	3
–3	0(0)	1(0)	12(72)	23(100)	84	96	0(0)	2(0)	1(0)	1(28)	10	16	10
–4	0(0)	0(4)	4(80)	9(100)	40	81	0	1	0(0)	0(12)	12(100)	6(100)	10
–5	1	0	1	4	34	64	0	1	1(0)	1(16)	6(100)	9(100)	15
–6	0(0)	0(0)	4(68)	5(100)	23	45	1	0	1(4)	0(21)	2(100)	2(100)	0
–7	0(0)	1(12)	5(56)	15(100)	42	90	1	0(4)	3(0)	0(20)	13(96)	7	8
–8	0(4)	0(0)	0(40)	1(100)	19	96	0(0)	0(4)	0(0)	0(8)	1	0	0
–9	..	0(0)	2(80)	7(100)	30	78	1	0	1(0)	0(4)	13(83)	14(100)	22
–10	0(8)	0(16)	0(56)	9(100)	51	67	0(0)	0(0)	0(0)	0(33)	6	8	4
–11	0(0)	0(0)	0(84)	2(100)	11	79	0	0(0)	0(4)	1(32)	0(100)	4	1
–12	0(8)	1(4)	0(100)	1(96)	14	73	0(0)	1(0)	0(0)	0(13)	2	1	0
–13	0(12)	1(40)	1(88)	1(100)	27	100	0(0)	1(0)	0(0)	5(4)	9	10	3
St. C–1	0(0)	0(0)	8(80)	14(100)	33	66	..	..	0(4)	1(16)	7(92)	16(100)	13
–2	..	..	2(92)	2(100)	23	50	..	..	0(0)	3(16)	4(80)	1(100)	3
St. T–1	0(0)	0(8)	0(88)	0(100)	0	12	0(0)	0(0)	1(0)	0(75)	0	1	2
St. J–1 *	1(0)	0(0)	15(80)	17(100)	58	79	0	0	0(8)	11(36)	23(100)	18(100)	14

Figures in parentheses indicate comparative percent mortality of a susceptible (CD) strain.
* F_2 generation.

TABLE 3.—Comparative susceptibility to malathion of 17 strains of *Aedes aegypti* (L.) from Puerto Rico and Virgin Islands.

	Percent Mortality of Larvae at Concentration (p.p.m.) Shown						Percent Mortality of Adults at Concentration (%) Shown					
Strain	0.0008	0.004	0.02	0.1	0.5	2.5	0.4	0.8	1.6	3.2	6.4	12.8
PR–1	0	0(0)	0(0)	2(28)	88(100)	100	1(0)	5(0)	68(56)	100(100)	100	100
–2	0	0(0)	0(0)	0(52)	92(100)	100	1(0)	3(4)	57(88)	99(100)	100	100
–3	0(0)	0(0)	0(0)	12(20)	99	100	0(0)	9(4)	76(76)	100(100)	100	100
–4	0	0(0)	0(0)	0(56)	88(100)	100	0(0)	2(0)	24(79)	92(100)	100	100
–5	0	0	0	0	95	100	0(0)	5(0)	64(80)	100(100)	100	100
–6	1	0(0)	0(0)	0(12)	97(100)	100	0(0)	5(13)	88(96)	99(100)	100	100
–7	0(0)	0(0)	1(0)	1(40)	92	100	1(0)	4(4)	50(76)	100(100)	100	100
–8	0(0)	0(0)	0(16)	4(44)	97	100	0(4)	7(0)	77(88)	100(100)	100	100
–9	..	..	0(0)	4(28)	98(100)	100	0(0)	6(0)	67(87)	100(88)	100	100
–10	0(0)	0(0)	0(0)	7(92)	98	100	1(0)	14(4)	68(77)	100(100)	97	100
–11	0(0)	0(0)	0(0)	8(80)	98	100	0(0)	8(24)	78(88)	100(100)	100	100
–12	0	0(0)	0(4)	0(40)	93(100)	100	0(0)	19(24)	98(90)	100(100)	100	100
–13	0(0)	0(0)	0(12)	12(84)	99	100	0(4)	0(20)	53(84)	97(100)	100	100
St. C–1	0	1(0)	1(0)	11(60)	99(100)	100	..	16(17)	28(92)	98(100)	100	100
–2	..	..	0(0)	0(32)	98(100)	100	..	1(0)	36(57)	97(96)	100	100
St. T–1	0	0(0)	0(4)	0(40)	96(100)	100	1(0)	4(71)	58(100)	100(100)	100	100
St. J–1*	0	0(0)	0(0)	1(20)	98(100)	100	2(0)	0(24)	69(96)	100(100)	100	100

Figures in parentheses indicate comparative percent mortality of a susceptible (CD) strain.
* F_2 generation.

at that strength. However, with the obvious potential for the development of DDT resistance to a magnitude shown by the St. Thomas strain, any persistent use of DDT in Puerto Rico could be expected to intensify the DDT resistance. Presumably, such treatment would be of short-term value and would require close evaluation on a field basis to determine its practical effectiveness. In the Virgin Islands the use of DDT appears unfeasible, particularly on St. Thomas.

The magnitude of dieldrin resistance indicates little promise for effective field treatment in Puerto Rico or the Virgin Islands.

Malathion gave highly effective kills of the larvae and adults of the 17 strains. Of the three toxicants it is the insecticide of choice regarding its lethal effect on the species. Whether malathion will persist sufficiently under outdoor conditions to give an extended period of effectiveness against larvae and adult *A. aegypti* can only be determined by field testing. As resistance to any chemical is associated with intensity and magnitude of its application, any extensive field treatments should include determination of the susceptibility of the *A. aegypti* population before and after treatment.

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