INSECTICIDE SUSCEPTIBILITY STUDIES IN INDIAN STRAINS OF *AEDES AEGYPTI* L.

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Until recently, the yellow fever mosquito, *Aedes aegypti* was not considered of much public health importance in India. However, in view of the outbreak of haemorrhagic fever in various parts of India (Fig. 1) in 1963 and again in 1964 (Rao, 1964; Myers, *et al.*, 1965; Krishnamurthy *et al.*, 1965), and the demonstration that *A. aegypti* was the chief vector of this disease (Singh and Sarkar, 1965), the study of this species in India is now considered of considerable importance. The epidemic potential of the disease is very high due to the prevalence of this mosquito in many parts of the country (Barraud, 1934). Information on insecticide susceptibility of Indian strains of *A. aegypti* is scanty. Such information is basic in the planning and execution of control programmes against this mosquito. The object of this study is to present this basic information for five recently collected strains of *A. aegypti*.

MATERIAL AND METHODS. The following strains of *A. aegypti* were used in the present investigation:

1. *Delhi:* A strain originated from the larvae collected in Delhi in September 1967.
2. *Varanasi:* A field-collected strain from Varanasi city in February 1967.
3. *Rajahmundry:* Developed from larvae collected at Rajahmundry in October 1967.
4. *Bangalore:* A strain raised from the eggs collected from Bangalore city area in September 1967.
5. *Mettupalayam:* A strain derived from field-collected larvae at Mettupalayam in July 1967.

The locations of the areas of origin of the various strains are given in Fig. 1.

The mosquito colonies were maintained in the laboratory at 80° F. and 80±5 percent R.H. The larvae were fed daily on a mixture of brewer's yeast and blood albumin (5:1). The larvae of the F_2 generations of Delhi and Rajahmundry, and F_4 generations of Varanasi, Bangalore and Mettupalayam were used for the insecticide tests. All susceptibility tests were performed on the late 3rd or early 4th instar larvae using the WHO standard method for mosquito larvae (World Health Organization, 1963). The insecticides employed in the present study were DDT, dieldrin, diemethrin, malathion, diazinon, sumithion (Bayer 41831), fenthion, abate, dursban, carbaryl, Bayer 39007 (Baygon) and Bayer 37344. The synergistic potency of Warf antiresistant and piperonyl butoxide to DDT were determined using the mixture of DDT and synergist in 1:1 ratio. Ethanolic solutions of technical or purified insecticides were used in all tests. Four replicates of 25 larvae were employed for each dosage level. Percentage mortalities were plotted on logarithmic probability paper and the LC_{50} and LC_{90} values were obtained from the regression lines fitted by eye.

RESULTS AND DISCUSSION. Data on larval resistance, for 12 insecticides and DDT with synergists Warf antiresistant and piperonyl butoxide, are given in Table 1. Chemical names for 5 of the materials that are newer, or may be less familiar are Abate®: *o,o*-dimethyl phosphorothioate; Dursban®: *o,o*-diethyl *o*-3,5,6-trichloro-2-pyridyl phosphorothioate; Bay 39007 (Baygon): *o*-isopropoxyphenyl methylcarbamate; Bay 37344: 4-(methylthio)-3,5-xylyl methylcarbamate; Warf antiresistant: *N,N*-dibutyl-*p*-chlorobenzenesulfonamide.

The LC_{50} levels for DDT show that all the strains tested were tolerant to DDT; Delhi and Mettupalayam were outstanding in this respect. Warf antiresistant was not very synergistic with DDT against

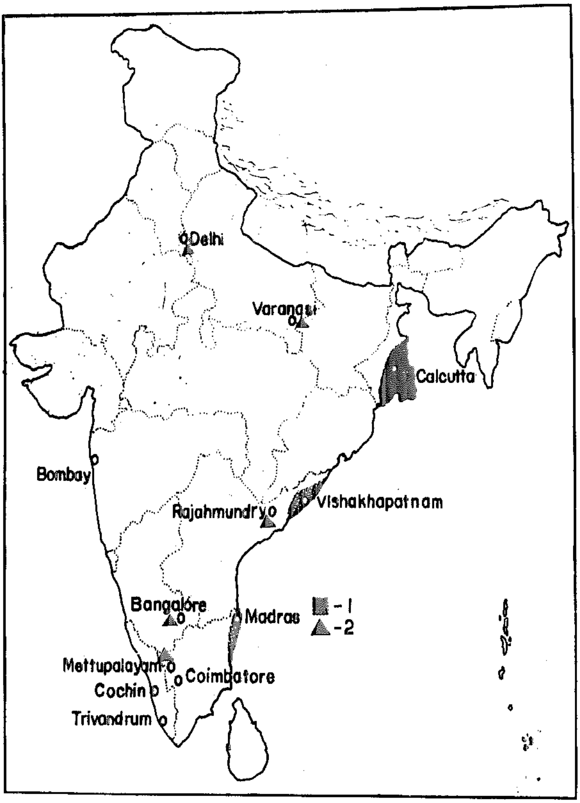

FIG. 1.—India: 1.—Areas where haemorrhagic fever has been reported. 2.—Areas where *A. aegypti* eggs and/or larvae have been collected.

these strains as it reduced the LC_{50} to DDT only 1 to 4 times. Piperonyl butoxide, on the contrary, was not synergistic against Rajahmundry and Varanasi, although it increased the potency of DDT 6 times against Mettupalayam strain. All the strains were found to be susceptible to dieldrin but not to dimethrin; the latter proved to be almost equitoxic with DDT. Malathion and diazinon were not effective against these larvae as all the strains were found to be highly tolerant to these insecticides. However, the strains were found to be highly susceptible to other OP-compounds tested. Dursban proved to be the most toxic among them, being 114 to 500 times as toxic as DDT, while abate was 85 to 117 times, fenthion 17 to 40 times and sumithion 5 to 50 times as toxic as DDT respectively. All the strains were found to be highly tolerant to carbaryl and Bayer 39007 and moderately tolerant to Bayer 37344.

The strains of *A. aegypti* employed in this study were found to be tolerant to DDT. Probably this tolerance of Indian strains may be a result of the mosquitoes being exposed to DDT during the recent antimalarial spraying in India. The synergistic effect of Warf antiresistant was only 1 to 4 times as is the case with susceptible strains of *A. aegypti* observed by

TABLE 1.—Larval susceptibility, in p.p.m., of five Indian strains of *A. aegypti.*

Insecticide	Delhi		Mettupalayam		Rajahmundry		Varanasi		Bangalore	
	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}	LC_{50}	LC_{90}
DDT	0.16	0.29	0.125	0.21	0.068	0.20	0.092	0.21	0.055	0.088
DDT+WARF (1:1)	0.09	0.18	0.060	0.135	0.074	0.17	0.064	0.12	0.074	0.130
DDT+PBO (1:1)	0.09	0.17	0.041	0.085	0.12	0.27	0.105	0.22	0.11	0.20
Dieldrin	0.0071	0.012	0.015	0.20	0.006	0.015	0.0048	0.0094	0.021	0.046
Dimethrin	0.092	0.18	0.094	0.145	0.082	0.14	0.10	0.18	0.13	0.28
Malathion	0.135	0.225	0.125	0.190	0.130	0.25	0.09	0.14	0.14	0.23
Diazinon	0.170	0.32	0.20	0.40	0.31	0.44	0.25	0.40	0.32	0.47
Fenthion	0.0039	0.006	0.0032	0.0043	0.0036	0.0049	0.0040	0.0064	0.0026	0.0037
Sumithion	0.0084	0.012	0.0073	0.0125	0.0074	0.012	0.0096	0.016	0.012	0.019
Abate	0.0015	0.0024	0.0012	0.0022	0.00082	0.0012	0.00078	0.0015	0.0012	0.0019
Dursban	0.00032	0.00045	0.00047	0.0007	0.00039	0.00062	0.00049	0.00068	0.00048	0.00064
Carbaryl	1.40	4.80	2.1	4.0	1.28	2.50	2.0	4.0	2.4	5.0
Bayer 39007	1.45	2.40	1.28	2.0	1.30	2.40	1.00	2.60	1.95	3.3
Bayer 37344	0.62	1.0	0.36	0.60	0.25	0.40	0.64	1.00	0.745	1.5

Pillai *et al.*, (1963). It is, however, of unusual interest to note the high tolerance of all the strains to malathion and diazinon, even though these insecticides up to the time of writing have never been used in India for mosquito control. The LC_{50} levels of Indian strains are higher than the LC_{50} values reported for the various strains in Bangkok by Lofgren *et al.* (1967). In all the strains the tolerance did not extend to fenthion, as it did in the case of populations of *A. nigromaculis* in California, in which there was a wide spectrum of OP-resistance extending to parathion, methyl parathion, malathion and fenthion (Brown *et al.*, 1963). Dursban, abate, and fenthion are found to be good larvicides against all the strains tested. Another interesting finding in the present study is the low susceptibility of these strains to all the carbamates tested. Brown and Abedi (1960) similarly recorded an LC_{50} of 1.93 ppm to carbaryl in a susceptible strain from Penang. The high tolerance of these strains to DDT, malathion, diazinon and the carbamates suggests the populations tested were genetically heterogenous.

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