

## INVESTIGATION OF SUSPECTED RESISTANCE OF MOSQUITOES TO DDT IN SOUTHERN ONTARIO<sup>1</sup>

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The insecticide DDT, particularly in the form of aerial sprays, has been applied for mosquito control in southern Ontario since 1945. Poor control was reported in certain areas in 1951, resulting in the partial substitution of dieldrin in 1952 and lindane in 1953. Since the aerial operators concerned felt that they were combating a case of resistance to DDT, an investigation was carried out on this point.

In May and August, 1953, a total of 33 collections of larvae were taken in selected localities, particularly Hamilton (treated for 8 years), Toronto, Rondeau Park, and Port Franks (treated for 5 years), and Orillia, Harrow, and Camp Borden (treated for 2 years). Untreated localities selected as controls included Guelph, Hespeler, Ayr, Breslau, and New Hamburg, all in the central agricultural region of southern Ontario, and St. Catharines and Point Pelee. Collections were also made at London and Ipperwash, where only adulticide aerosols had been applied; these areas were classed with the untreated areas.

During May the principal species collected were *Aedes fitchii* (F. & Y.), *A. stimulans* (Wlk.), and *A. excrucians* (Wlk.); several collections contained *A. canadensis* (Theo.), *A. implicatus* Vock.

(= *A. impiger* of American authors), *A. cinereus* Mg., and a few specimens of *Culiseta inornata* (Will.) and *C. morsitans* (Theo.). During August the principal species were *Culex pipiens* L., *C. restuans* Theo., and *C. apicalis* Adams, with a single large collection of *Aedes vexans* (Mg.). The species of *Culex* characteristically occurred in the cities of Toronto and Hamilton, whereas the species of *Aedes* were characteristic of the partially wooded, central agricultural regions.

Larvae were transported to the laboratory in 1-gal. square-sided glass jars, and transferred to 10- by 15-in. enamel pan and fed on powdered fox-chow and yeast. Tests were performed on groups of 20 to 50 larvae in the third and fourth instars to 1 litre of water in a 7- by 11-in. enamel pan, 0.01 to 0.1 part per million of DDT were added in a small amount of ethanol. Those larvae that still could move or had pupated after 24 hr. at 23° C. were counted as survivors. The larvae that were not tested were reared to the adult stage by the method of Ludvik (1953) in screened quart Sealright containers. The adults, divided according to sex, were tested 3 to 5 days after emergence; 0.05 to 1.0 microgram of DDT were typically applied in 0.25 ml. of methanol by the method of Ludvik (1953), with a tuberculin syringe and a 26-gauge hypodermic needle. The mosquitoes that could fly after 24 hr. at 23° C. and 70-95 per cent R.H. were counted as survivors. Control mortalities of adults of *C. pipiens* treated with the solvent alone were 14 per cent for males and 3 per cent for females.

The results are shown in Tables 1 and 2. The collections each represented one of the four following groups: (a) *Culex* spp., (b) *Aedes vexans*, (c) *A. canadensis*, mainly, (d) *A. fitchii*, *A. stimulans*, or *A. excrucians*, or combinations of these

<sup>1</sup> Contribution No. 3232, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada. The results herein reported were obtained by the Entomology Division in a program of studies on the biology and control of biting flies being carried out on behalf of the Defence Research Board, Canada Department of National Defence, and with the co-operation of that organization and other agencies.

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banded-legged species. The results for each group, which involved up to 7 tests, were combined for treated and for untreated areas.

The figures show that the higher mortalities were obtained with larvae from treated areas as often as with larvae from

untreated areas. In the 5 instances where paired assessments were made with larvae from treated and untreated areas, Student's *t* test yielded a *p* value of 0.12. In the 9 cases where the assessments on adults were similarly paired, the *p* value was 0.29. These results are far from showing

TABLE 1.—Toxicity of DDT to mosquito larvae collected from treated and untreated areas

Species	Area	Percentage mortality at concentration * of				
		0.1	0.05	0.025	0.02	0.01
<i>Aedes fitchii</i> ,	Treated	90(30)**	93(30)	..	..	..
<i>A. stimulans</i> , or						
<i>A. excrucians</i>	Untreated	86(28)	94(30)	84(25)	..	..
<i>Aedes</i>	Treated	..	71(21)	..	..	..
<i>canadensis</i> mainly	Untreated	93(31)	91(66)	..	..	..
<i>Aedes vexans</i>	Untreated	100(147)	99(148)	96(163)	..	..
<i>Culex pipiens</i> ,	Treated	99(280)	94(323)	96(181)	46(67)	34(65)
<i>C. restuans</i> , or						
<i>C. apicalis</i>	Untreated	97(34)	..	69(88)	..	..

\* Parts per million.

\*\* Total number of mosquitoes in samples indicated by parentheses.

TABLE 2.—Toxicity of DDT to adult mosquitoes collected from treated and untreated areas

Species	Area	Percentage mortality * at dosage ** of				
		1.0	0.5	0.25	0.1	0.05
<i>Females</i>						
<i>Aedes fitchii</i> ,	Treated	83(30)***	100(25)	..	..	..
<i>A. stimulans</i> , and						
<i>A. excrucians</i>	Untreated	90(348)	94(216)	..	..	..
<i>Aedes canadensis</i>	Treated	100(11)	..	..	..	..
mainly	Untreated	96(78)	..	..	..	..
<i>Aedes vexans</i>	Untreated	..	..	100(12)	99(90)	95(60)
<i>Culex pipiens</i> ,	Treated	81(41)	86(44)	81(83)	80(98)	71(93)
<i>C. restuans</i> , and						
<i>C. apicalis</i>	Untreated	..	..	..	94(18)	75(20)
<i>Males</i>						
<i>Aedes fitchii</i> ,	Treated	..	88(8)	..	..	..
<i>A. stimulans</i> , and						
<i>A. excrucians</i>	Untreated	95(61)	98(65)	..	..	..
<i>Aedes canadensis</i>	Treated	100(11)	..	..	..	..
mainly	Untreated	97(18)	..	..	..	..
<i>Aedes vexans</i>	Untreated	..	..	100(25)	100(31)	..
<i>Culex pipiens</i> , and						
<i>Culex</i> spp.	Treated	81(27)	96(53)	92(85)	100(47)	98(44)

\* Control mortalities for solvent alone: females, 3 per cent; males, 14 per cent.

\*\* Micrograms per mosquito.

\*\*\* Total number of mosquitoes in samples indicated by parentheses.

any significant difference at the 5 per cent level, where  $p$  equals 0.05.

The larvae of all the species tested, whether from treated or untreated areas, were more susceptible than a strain of *Aedes aegypti* (L.), laboratory-reared in the absence of DDT, which showed only 68 per cent mortality in 0.1 p.p.m. of DDT. They are very much less resistant than the strains discovered by Gjullin and Peters (1952) in California, where the LD<sub>50</sub> figures were from 0.05 to 0.08 p.p.m. for *Culex quinquefasciatus* Say, 0.11 p.p.m. for *A. nigromaculis* (Ludl.), 0.15 p.p.m. for *C. tarsalis* Coq., and 0.33 p.p.m. for *A. dorsalis* (Mg.). The adult females of all the species tested in Ontario were more susceptible than females of the laboratory strain of *A. aegypti*, which showed only 74 per cent mortality at a dose of 1 microgram of DDT. They were also more susceptible than the females of *Anopheles quadrimaculatus* Say, studied by Ludvik (1953) in Alabama, for which the LD<sub>50</sub> was 0.07 micrograms.

Though fragmentary, the results of this investigation indicate that no significant

degree of resistance to DDT has yet been developed by *Aedes* and *Culex* mosquitoes in southern Ontario.

The authors gratefully acknowledge the assistance of Messrs. B. E. Lanning, Survey Assistant, and E. J. Duff, Assistant Technician, Veterinary and Medical Entomology Unit, Ottawa, and of F. Jursic and C. H. McDougall, Technicians, Department of Zoology, University of Western Ontario, London; and the supervision of Dr. C. R. Twinn, Head, Veterinary and Medical Entomology Unit, Ottawa, and the support of Mr. A. C. Jones, Defence Research Board of Canada, Ottawa. The authors are indebted to Dr. J. McLintock, Veterinary and Medical Entomology Unit, Ottawa, for confirming the identification of the species.

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## RESISTANCE OF *ANOPHELES SUNDAICUS* TO DDT<sup>1</sup> A PRELIMINARY REPORT

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*Anopheles sundaicus*, the principal malaria vector along the coastal areas of the island of Java, Indonesia, has been found in two localities to be resistant to DDT. These localities are the Djakarta coastal area (including the harbor area of Tandjung Priok) and the city of Tjirebon which is on the coast approximately 200 kilometers east of Djakarta. Further in-

vestigations are in progress to include other areas of Indonesia and other vector species.

The possibility that resistance to DDT may be developing in the Djakarta coastal area was first suspected when it was reported that "mosquitoes" in that area were not being killed by the DDT residual applied in malaria control spraying operations. This report was based on the observation that considerable numbers of "mosquitoes," collected from surfaces sprayed with DDT, survived the 48-hour

<sup>1</sup> These investigations are under the joint sponsorship of USOM in Indonesia and the Malaria Institute of the Ministry of Health, Djakarta, Indonesia.