

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 LD₅₀ 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 LD₅₀ 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.

Literature Cited

GJULLIN, C. M. and R. F. PETERS. 1952. Recent studies of mosquito resistance to insecticides in California. *Mosquito News* 12:1-7.

LUDVIK, G. F. 1953. Topical application of insecticide solutions to *Anopheles quadrimaculatus*. *Jour. Econ. Ent.* 46:364-365.

RESISTANCE OF *ANOPHELES SUNDAICUS* TO DDT¹ A PRELIMINARY REPORT

HERBERT A. CRANDELL

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

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

holding period. These "mosquitoes" proved to be *Anopheles sundaicus*. A later but even more convincing indication that *A. sundaicus* may have developed resistance to DDT was the failure of the DDT residual spray program in the Djakarta coastal area to effect control of, or even to reduce appreciably the incidence of malaria. This is evidenced by the following parasite indices for infants under 1 year of age for five kampungs (villages) in that area:

Infant Blood Smears

Year	Number examined	Number positive	Percent positive
1952 (Before spraying)	350	66	18.8
1953 (After first spraying)	350	61	17.4
1954 (After second spraying)	285	47	16.5

Numerous tests for the presence of resistance to DDT have been made in the past several months in various parts of the islands of Java and Madura. Essentially the tests consist of confining wild-caught anopheline mosquitoes on previously-sprayed plywood panels for 30-minute exposure periods. Exposed mosquitoes are then transferred to holding-cages and mortality counts made at the end of 24 hours. Unsprayed panels serve as checks.

The results of tests made thus far indicate that—

- (1) *Anopheles sundaicus* in the Djakarta coastal area and in the city of Tjirebon are resistant to DDT even at dosages of as high as 4 grams per sq. meter;
- (2) limited data indicate *sundaicus* in the Djakarta coastal area to be approximately 23 times, and in Tjirebon 27 times as resistant to DDT as *sundaicus* from unsprayed areas;

- (3) this resistance is apparently an "acquired" or "developed" resistance in contrast to a "natural" resistance;
- (4) females are approximately 1.7 times more resistant to DDT than males from the same area;
- (5) there is no evidence of resistance to DDT in other areas of Java or on Madura;
- (6) as yet no other anopheline species have shown any indication of resistance to DDT, even when from the same areas where *sundaicus* has developed resistance.

Dieldrin at a dosage rate of one-fourth (0.25) gram per sq. meter was found in panel-tests to be effective against the DDT-resistant strain of *sundaicus*—one hundred per cent mortalities being consistently obtained in tests made in conjunction with the DDT-resistance investigation. On the basis of these results Dieldrin was recommended for use in the areas where *sundaicus* has shown resistance to DDT. In view of the already-established resistance of *sundaicus* to DDT, however, it was believed advisable to use a dosage rate of 0.5 grams of Dieldrin per sq. meter (1.25% suspension). Residual spraying operations were begun with Dieldrin in the Djakarta coastal area in March of this year (1954). Results thus far indicate that Dieldrin is proving effective in controlling malaria in the Djakarta coastal area, where DDT failed to provide control.

As stated earlier, the resistance studies are still in progress. There remain many areas to be visited and other vector species to be tested. Upon completion of these investigations a final report will be submitted which will include specific data on results obtained and a detailed description of equipment and procedures used.