# INSECTICIDE SUSCEPTIBILITY OF *AEDES AEGYPTI* FROM SANTO DOMINGO, DOMINICAN REPUBLIC[1]

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ABSTRACT. The insecticide susceptibility of *Aedes aegypti* adults and larvae from Santo Domingo, Dominican Republic, was investigated using World Health Organization standard procedures. A field strain was more resistant to insecticides than a colony strain that originated from the same place. Larvae produced from ovitrap-collected eggs were resistant to temephos (78.2% mortality on exposure to 0.025 mg/liter). Mortality rates after exposure of adults to discriminating concentrations showed that wild populations were resistant to DDT, malathion, propoxur, permethrin and deltamethrin. The problem of resistance was considered serious enough to warrant consideration of control measures other than the use of chemicals.

## INTRODUCTION

*Aedes aegypti* (Linn.) is an important vector of dengue and urban yellow fever. Although source reduction through proper environmental sanitation and effective exclusion of the mosquito from water stored for domestic use can keep Asian and American populations of *Ae. aegypti* in check, the use of insecticides is often necessary in control operations (World Health Organization 1984). A major problem is that *Ae. aegypti* is one of the few species of mosquitoes that has developed resistance to a variety of organochlorine, organophosphorous, carbamate and pyrethroid insecticides in subtropical and tropical regions of the world (World Health Organization 1986). In the western hemisphere, a regional program aimed at eradicating the mosquito in the 1950s was hampered by the appearance of DDT resistance (World Health Organization 1986). Although the species is resistant to a number of insecticides in some Caribbean countries, the susceptibility status of populations in the Dominican Republic was unknown.

The goal of this study was to understand the insecticide susceptibility pattern of *Ae. aegypti* from Santo Domingo, Dominican Republic. Such knowledge is essential in defining future control strategies of this medically important mosquito.

## MATERIALS AND METHODS

A description of the study area in Santo Domingo, Dominican Republic, was given by Tidwell et al. (1990). The specimens used in the tests were hatched from field-collected eggs (wild) or were obtained from an insectary colony established in 1987 using ovitrap samples from the same area. Additional ovitrap samples were added to the colony periodically ever since its establishment. A susceptible insectary strain of *Ae. aegypti* maintained at the International Center for Public Health Research, better known as The Wedge, was tested simultaneously with mosquitoes from Santo Domingo to establish the potency of test materials used.

Kits and procedures produced by the World Health Organization (1981a, 1981b) were used for testing the susceptibility of larval and adult mosquitoes. In addition, insecticide impregnated papers from the U.S. Army Environmental Hygiene Agency (USAEHA) were used for adult tests. All test papers and solutions were used before expiration dates.

Third and early fourth instar larvae were exposed to several concentrations of the insecticidal test solutions, but the results reported here include only those that contribute to an understanding of their susceptibility status. If 2 or more concentrations gave 100% mortality, only results of the lowest dosage are reported. The insecticides used and the *Ae. aegypti* larval discriminating dosages were malathion (1.0 mg/liter), fenthion (0.05 mg/liter) and temephos (0.02 mg/liter). Plastic drinking cups (296 ml) were used for exposing larvae.

Tests on adults were performed using malathion (5%) and propoxur (0.1%) impregnated papers from the World Health Organization (WHO) and the USAEHA as well as DDT (4%) and permethrin (0.25%) papers from WHO, and resmethrin (2.13%) papers from the USAEHA. Blood-fed, partially gravid and sugar-fed females were exposed for 1 h and then held for 24 h in an ice chest with a wet towel lining the bottom. Mortality was scored at the end of a 24-h holding period. Relative humidity and ambient temperature were measured at the time of ex-

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posure. The minimum and maximum temperatures within the ice chest, during the holding period, and of the water during the 24-h larval exposure period were also measured. All the insecticide concentrations, except that of resmethrin, were discriminating concentrations established by WHO to separate susceptible from resistant individuals.

## RESULTS

The water temperature during the 24-h exposure period of larval tests was between 20 and 28°C. The exposure temperature and RH ranges were 23–27°C and 58–86%, respectively, whereas the holding temperature range was 23–29°C in tests using adult mosquitoes.

*Larvae:* The effectiveness of larval test solutions was shown by the response of larvae from the Wedge colony of *Ae. aegypti*. A mortality of 100% was obtained in these larvae after exposure to malathion (0.125, 0.312 and 0.625 mg/liter), temephos (0.025 and 0.038 mg/liter) and fenthion (0.013 mg/liter). Data on larvae of *Ae. aegypti* from Santo Domingo (Table 1) indicate that both wild and colony populations were susceptible to malathion. The 78.2% mortality on exposure to 0.025 mg/liter dose of temephos, however, is a clear indication that the wild population had considerable resistance to this insecticide, because the discriminating dosage is 0.02 mg/liter (World Health Organization 1981a). The 19.0% mortality of field samples after exposure to 0.025 mg/liter fenthion, which had previously resulted in 99.3% mortality of colony specimens, indicates a need for further testing of the wild population using the discriminating dosage.

*Adults:* Discriminating concentrations of malathion, propoxur and permethrin gave 99–100% kill of Wedge adult *Ae. aegypti* whereas such a dosage of DDT gave 97% kill. The mortality after exposure of this lab strain to 2.13% resmethrin was 100%. *Aedes aegypti* from Santo Domingo had variable but measurable levels of resistance to 5 of the insecticides used in the tests (Table 2). The wild population was almost completely resistant to DDT. The 62.9, 78.0, 41.5 and 67.7% mortalities that resulted from exposure to discriminating dosages of malathion, propoxur, permethrin and deltamethrin, respectively, denote the existence of relatively high levels of resistance to these insecticides. Mortality from exposure to propoxur may have been even lower if wild mosquitoes were used. With respect to wild mosquitoes, tests using the same insecticide resulted in lower mortalities in successive years. The reduction in mortality was marked in exposures to malathion and permethrin. All the mosquitoes exposed to resmethrin were killed; however, the validity of using such a high concentration of resmethrin is discussed below.

## DISCUSSION

The *Ae. aegypti* population from Santo Domingo had variable levels of resistance. Although *Ae. aegypti* resistance to DDT, some organophosphates and pyrethroids has been reported from the Caribbean (Brown 1986), this may be the first finding of carbamate (propoxur) resistance in the species from the area. The resistance to temephos in Santo Domingo *Ae. aegypti* larvae is of concern because this has been the insecticide of choice for use in domestic and peridomestic breeding habitats (World Health Organization 1984). The mortality observed on exposure to temephos may be an underestimation because the insecticide is known to adhere to the surface of plastic containers (Rathburn and Boike 1969). Although no larval tests were done using the discriminating dose of fenthion, the low mortality obtained after exposure of wild Santo Domingo larvae to half that dose suggests the need for further tests to clarify their suscep-

Table 1. Susceptibility to insecticides of *Aedes aegypti* larvae from Santo Domingo, Dominican Republic.

| Test date | Insecticide | Concentration (mg/liter) | Test specimens | | Mortality (%) | SE (%) |
|---|---|---|---|---|---|---|
| | | | Source | Number[1] | | |
| 1987 | Malathion | 0.6245 | Colony | 150 (6) | 100.0 | 0.0 |
| | Control[2] | | Colony | 225 (9) | 2.2 | 1.0 |
| 1988 | Malathion | 0.6250 | Wild | 100 (4) | 100.0 | 0.0 |
| | Control | | Wild | 99 (4) | 0.0 | 0.0 |
| 1987 | Temephos | 0.0375 | Colony | 100 (4) | 100.0 | 0.0 |
| 1988 | Temephos | 0.0250 | Wild | 101 (4) | 78.2 | 4.1 |
| | Control | | Wild | 102 (4) | 0.0 | 0.0 |
| 1987 | Fenthion | 0.0250 | Colony | 150 (6) | 99.3 | 0.7 |
| 1989 | Fenthion | 0.0250 | Wild | 100 (4) | 19.0 | 3.9 |
| | Control | | Wild | 100 (4) | 0.0 | 0.0 |

[1] Numbers in parentheses represent the number of replicates of a test.
[2] This control served for all 3 insecticides which were tested simultaneously in 1987.

Table 2. Susceptibility to insecticides of *Aedes aegypti* adult females from Santo Domingo, Dominican Republic.

| Test date | Insecticide and concentration[1] | Test specimens | | Mortality (%)[3] | SE (%) |
|---|---|---|---|---|---|
| | | Source | Number[2] | | |
| 1987 | DDT 4%/W | Colony | 139 (6) | 21.1 | 3.5 |
| | Control | | 143 (6) | 16.1 | 3.1 |
| 1988 | DDT 4%/W | Wild | 88 (4) | 5.7 | 2.5 |
| | Control | | 93 (4) | 2.2 | 1.5 |
| 1990 | DDT 4%/W | Wild | 98 (4) | 1.0 | 1.0 |
| | Control | | 96 (4) | 1.0 | 1.0 |
| 1987 | Malathion 5%/A | Colony | 109 (5) | 100.0 | 0.0 |
| | Control | | 109 (5) | 1.8 | 1.3 |
| 1989 | Malathion 5%/W | Wild | 83 (4) | 98.7 | 1.2 |
| | Control | | 57 (4) | 5.3 | 3.0 |
| 1990 | Malathion 5%/W | Wild | 97 (4) | 62.9 | 4.9 |
| | Control | | 100 (4) | 0.0 | 0.0 |
| 1987 | Resmethrin 2.13%/A | Colony | 118 (5) | 100.0 | 0.0 |
| | Control | | 109 (5) | 3.7 | 1.8 |
| 1987 | Propoxur 0.1%/A | Colony | 109 (5) | 78.0 | 4.0 |
| 1989 | Permethrin 0.25%/W | Wild | 85 (4) | 90.1 | 3.2 |
| | Control | | 76 (3) | 5.3 | 2.6 |
| 1990 | Permethrin 0.25%/W | Wild | 170 (8) | 41.5 | 3.8 |
| | Control | | 137 (6) | 9.5 | 2.5 |
| 1990 | Deltamethrin 0.025%/W | Wild | 99 (4) | 67.7 | 4.7 |
| | Control | | 89 (4) | 12.4 | 3.5 |

[1] /A indicates that test papers are from the U.S. Army Environmental Hygiene Agency and /W indicates that they are from World Health Organization. The control for the 1987 resmethrin test served for the propoxur test also.

[2] Numbers in parentheses indicate the number of replicates of a test.

[3] Exposure mortalities were corrected using Abbott's formula (Busvine 1971) when control mortalities were between 5 and 20%.

tibility status. There are previous records of *Ae. aegypti* resistance to this insecticide in the Caribbean (Brown 1986).

Adult tests showed that the Santo Domingo strain of *Ae. aegypti* had some level of resistance to one or more members of all 4 insecticide groups tested. The high level of DDT resistance observed may be due to past intensive selection that left behind a highly resistant population or to ongoing selection or both (Abedi and Brown 1960). Cross-resistance resulting from selection by DDT may have contributed to the pyrethroid (permethrin and deltamethrin) resistance observed (Brattsten et al. 1986). For each insecticide tested in more than one year, the decreasing mortalities observed in successive years may have been due to continued selection pressure from household use of pesticides as well as applications by the National Malaria Eradication Service (SNEM). According to unpublished SNEM records, various amounts of DDT, temephos and malathion were used in 1987 and 1988 for vector control purposes. In addition, during the same period and 1989, the U.S. Agency for International Development Vector Control Project has made 55 ULV and thermal fog applications of malathion in the <1 $km^2$ study area at the rate of 146.5–586.0 ml/ha for experimental purposes. The Project also made 4, 3 and 1 applications of <73.3 ml/ha of resmethrin, dibrom and deltamethrin, respectively. Temephos was applied experimentally to essential water storage containers. However, as the treated area was so small it is unlikely that these insecticide applications contributed significantly to the selection pressure for resistance.

The concentration of resmethrin on the test papers was probably too high. Permethrin is 1.5 times as toxic as resmethrin to *Anopheles stephensi* Liston (Zerba 1988). Consequently, the diagnostic dose of resmethrin that is comparable to the diagnostic dose of permethrin (0.25%) should probably be on the order of 0.38% and not 2.13%.

The appearance of resistance to temephos diagnosed in the *Ae. aegypti* larvae from Santo Domingo and to various organochlorine, organophosphorus, carbamate and pyrethroid insecticides in adults from the same area is of grave concern. Tests conducted from 1987 to 1990 have shown that the resistance level increased from year to year. If there is continued insecticidal selection pressure, the resistance situation may get worse. Considering that the potential for a dengue hemorrhagic fever outbreak is high (Tidwell et al. 1990) and that widespread resist-

ance will limit the choice of insecticides to be used, serious consideration should be given to enforcing environmental sanitation and testing biological control measures. Further, the insecticide susceptibility status of *Ae. aegypti* populations in all urban centers should be monitored closely regardless of whether or not organized control operations are conducted.

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