Journal of the American Mosquito Control Association, 10(3):403–406, 1994

EMERGENCY CONTROL OF *AEDES AEGYPTI* IN THE DOMINICAN REPUBLIC USING THE SCORPION™ 20 ULV FORCED-AIR GENERATOR

M. A. TIDWELL,[1] D. C. WILLIAMS,[1] T. A. GWINN,[1] C. J. PEÑA,[2]
S. H. TEDDERS,[1] G. E. GONZALVEZ[2] AND Y. MEKURIA[1]

ABSTRACT. In an effort to develop a more effective measure for use in emergency control of the dengue vector *Aedes aegypti*, applications of a combination of a larvicide (*Bacillus thuringiensis israelensis* [*B.t.i.*]) and an adulticide (permethrin) were made using a truck-mounted forced-air generator (Scorpion™ 20) and evaluated in the Dominican Republic. This method has the potential to simultaneously control adults and larvae. In bioassay cages placed in household water containers at the time of application, larval mortalities were 95.1 and 100% for 2 application rates of permethrin mixed with *B.t.i.* Adult mortalities were not as impressive, probably because of resistance to permethrin. Higher adult mortality in caged specimens (78.5%) and a substantial reduction in the natural population (68.4%) of *Ae. aegypti* were obtained following a 2.1-g AI/ha application of deltamethrin alone.

INTRODUCTION

The increasing threat of dengue (DEN) and dengue hemorrhagic fever (DHF) in the Americas has prompted renewed interest in the development of better vector control strategies. Because no cure or vaccine for dengue exists and because the high cost of treatment and hospitalization is a severe economic burden to affected countries, vector control must be relied upon to prevent or reduce transmission.

As a result of limited economic resources, especially in developing countries, reliance on repeated insecticide applications for the continued suppression of *Aedes aegypti* (Linn.) populations has diminished. There is, however, a renewed interest in community participation and source reduction *via* the removal of cans, jars, and other water-holding containers, and the prevention of mosquito access to larval habitats. Mosquito production is frequently enhanced by the lack or deterioration of municipal water supplies in tropical, developing countries. This lack of a dependable water supply has encouraged the use of an array of makeshift household water storage containers commonly including 55-gallon drums, as well as tanks, cisterns, large cans, jars, buckets, and other containers (Tidwell et al. 1990). Although these provide more or less continuous access to water for residents, they also increase substantially the number of mosquito-producing habitats with corresponding increase in mosquito-borne disease (Gratz 1973). The increase of the DEN and DHF threat in both the Americas and Asia is a good example.

In the event of an epidemic of DEN and DHF and the inescapable reliance on mosquito control for its containment, it is important to have an effective emergency vector control method. Ideally, this system should provide rapid and effective control of both adult and larval vector mosquito populations. Generally, the reductions of *Ae. aegypti* populations as a result of community participation programs directed at the larvae are slow in coming, and such programs are not practical for use in emergency control situations (Gratz 1991), because they do not target adult mosquitoes that may already be infected with dengue virus. Short-term vector control can be achieved more rapidly and effectively through insecticide application. In the past, larval and adult control activities were conducted separately and with sufficient resources large areas could be treated. However, in view of the current shortage of resources and the expanding threat of DEN/DHF, more efficient and effective control methods are being sought.

Both favorable and unfavorable results from using ultra-low volume (ULV) and thermal fog insecticide applications to control *Ae. aegypti* have been reported (Gratz 1991). Disparity in the results obtained has been due primarily to the insecticide application rate and the degree of insecticide penetration of dwellings. As might be expected, applications at higher rates together with good penetration of dwellings have provided the best control of adult vector populations (Gratz 1991).

The objective of this study was to address these factors and to evaluate a new forced-air system under field conditions. This system combines the ULV application of larvicide and adulticide for use in emergency vector control.

[1] University of South Carolina, International Center for Public Health Research, P. O. Box 699, McClellanville, SC 29458.

[2] Servicio Nacionál de Erradicación de la Malaria, Av. Duarte 269, Santo Domingo, República Dominicana.

Fig. 1. Use of the truck-mounted, Scorpion™ model 20, ULV forced-air generator in Santo Domingo.

MATERIALS AND METHODS

The urban residential area of Ensanche Espaillat, Santo Domingo, Dominican Republic, was selected as the study site because numerous *Ae. aegypti* studies had been conducted there and baseline data are available (Tidwell et al. 1990). In addition, the trained personnel of Servicio Nacional de Erradicacion de la Malaria (SNEM) had an active vector biology and control program under way that could facilitate a study of this type.

Houses in the study area were typically one story, stucco or cement block dwellings, with 2 or 3 bedrooms, a living room, and a kitchen. A more detailed description of the houses and area was given by Tidwell et al. (1990). Most houses had at least one and as many as 4 55-gallon drums or other containers for water storage. These containers were located both inside and outside of the dwellings.

Three spray tests were conducted using a *Bacillus thuringiensis israelensis* (*B.t.i.*) 1,200-ITU/mg formulation (Bmp 144™ [2×], Becker Microbial Products Inc., Plantation, FL 33322) as the larvicide component combined with a permethrin formulation (Permanone™ 10% EC, Roussel UCLAF Corporation, Montvale, NJ 07654) as the adulticide, and one application was made with only a 10-g AI/liter deltamethrin formulation (K-Othrin™, Roussel UCLAF Corporation). The *B.t.i.* was mixed with permethrin and applied based on a 91.4-m (300-ft.) swath width at 3 different rates: 788, 1,577, and 2,586 ml/ha in 3 separate tests. The rates for the permethrin in these tests were 2.74, 5.58, and 15.48 g AI/ha, respectively. The deltamethrin was applied at a rate of 2.10 g AI/ha.

The insecticides were applied using a truck-mounted forced-air generator (Scorpion™ model 20, Berry Corporation, Lexington, KY 40510). This unit produces an air blast of 336 kph (210 mph) and provides a sustained airflow for a distance of over 46 m (150 ft.). Truck speed was 8 kph (5 mph) in test 1 and 4 kph (2.5 mph) in test 2 and 3. The nozzle was directed toward the front of the houses, which were approximately 10 m from the point of discharge (Fig. 1). The truck circled the block once during each application.

Evaluation of the effectiveness of the spray applications was made in 10 test houses selected at random within each of the 3 test block areas. Sampling of natural adult *Ae. aegypti* populations in these houses was conducted before and 24 h after spray application to determine the

Table 1. Results of truck-mounted ULV applications of insecticides against *Aedes aegypti* adults and larvae in Santo Domingo, Dominican Republic (April 1993).

Insecticide	Rate	Number mosquitoes tested		Corrected percent mortalities[3]		% population reduction[4]
		Adults[1]	Larvae[2]	Adults	Larvae	
Permethrin and *B.t.i.*	2.74 g AI/ha 788 ml/ha	297	281	9.9	100	24.0
Permethrin and *B.t.i.*	5.58 g AI/ha 1,577 ml/ha	310	289	16.6	95.1	5.6
Permethrin and *B.t.i.*	15.48 g AI/ha 2,586 ml/ha	287	311	28.2	100	27.0
Deltamethrin	2.10 g AI/ha	281	299	78.5	15.1	68.4

[1] Adults were reared from eggs collected in Santo Domingo, D.R.

[2] Larvae were reared from eggs originating from the Wedge colony.

[3] Percent mortalities were corrected using Abbott's formula. Holding temperatures were 21–26°C for adults and 25–29°C for larvae for the 24-h periods.

[4] Percent population reductions were calculated by: [(prespray sweep net collection − postspray sweep net collection) ÷ prespray sweep net collection] × 100.

impact of the application on the natural population using the procedures described by Tidwell et al. (1990). Sampling was begun 3 days before the first spray application to determine prespray adult population levels.

The impact of the treatments on adult mosquitoes was also assessed by scoring mortality in bioassay cages. The bioassay cages cut from polyvinyl chloride pipe were 10 cm in diameter and 3.81 cm deep and both sides were covered with a nylon tulle. Thirty minutes prior to a spray application, a bioassay cage with 25 laboratory-reared female *Ae. aegypti* (the colony originated from eggs collected in Santo Domingo) was placed under a bed, in a closet, or in some other "protected" site within each of the 10 selected houses and 5 cages were placed in a control area. The cages were removed approximately 30 min post-application, placed in an insulated chest lined with damp toweling and returned to the laboratory. The specimens were transferred within 1 h to clean 473-ml paper cartons and polyester balls soaked in a 10% sugar solution were provided to them. The mortality was recorded after 24 h and percent mortalities were corrected using Abbott's formula (Abbott 1925).

One floating bioassay cage with 25 late 3rd- to early 4th-instar *Ae. aegypti* larvae (this colony originated from the insecticide-susceptible colony maintained by the International Center for Public Health Research, The Wedge) was placed in a drum at each of the 10 houses prior to the spray application. The floating cages were similar to those described by Sandoski et al. (1986). These cages were made from 1.9-liter, round, plastic food containers with 3 evenly spaced side windows each 9.5 × 7 cm. A single circular window 9.5 cm in diameter was cut in the bottom. Three ping-pong balls, used as floats, were hot-glued into circular sockets cut in the areas between the side windows and at a height that would permit the screened side windows to remain under the surface of the water. The windows were covered with a 52 mesh nylon screen attached with hot glue. After approximately 30 min, the larvae and 1 liter of the container water were transferred to the laboratory and held for 24-h mortality observations. Observations on the density of larvae in the drums were made before and after insecticide application to assess the impact of the spray on the natural larval population.

The distribution and size of spray particles were monitored through the use of magnesium-coated and silicon-treated slides in battery-powered, spinning droplet collectors placed approximately 1 m from bioassay cages.

The effectiveness of individual spray applications was determined from the insecticide droplet dispersal patterns, bioassay mortalities, and natural population reduction data.

RESULTS AND DISCUSSION

A summary of the results is provided in Table 1. Good penetration was obtained using the Scorpion 20, ULV forced-air generator. The spray reached all water-holding drums and tanks, both inside and outside the houses, and larval mortalities ranged from 95.1 to 100% in the floating bioassay cages. Inspection of the treated drums on the next day revealed primarily late 4th-instar larvae and pupae. Adult mortalities with the *B.t.i.* + Permanone mixture were poor. Mekuria et al. (1991) demonstrated that *Ae. aegypti* populations from the Dominican Republic possess a high level of resistance to permethrin. Therefore, resistance could account for the poor reduction observed in these tests.

During previous ULV applications in this area, mortalities obtained from mosquitoes in cages in "protected" sites more accurately reflected the reduction observed in the natural populations than cages placed in unprotected areas. Susceptible specimens that were meant to be used in these cages were delayed in their development and were unavailable at the time of this study. Because penetration of the sprays was good, it can be anticipated that use of an adulticide to which there was no resistance would have achieved a high level of adult control.

Adult mortalities from deltamethrin were much higher; with only a single application the natural population reduction was 68.4%. This correlated well with the high mortality (78.5%) obtained from the bioassay cages, all of which had been placed in protected locations. Unfortunately, at the time of this application an EC formulation of deltamethrin that could be mixed with *B.t.i.* was not available for testing.

Droplet mass median diameters for tests 1–3 were 34.2, 22.0, and 42.8 μm, respectively, as determined by measurement of 200 droplets from magnesium-coated slides. Droplets from silicon-coated slides exposed during test 4 had a mass median diameter of 24.8 μm.

These tests demonstrated the excellent potential for the control of both adult and larval mosquitoes through a combined ULV adulticide and larvicide application. This ULV application of larvicide, blown into the houses and premises in conjunction with the adulticide, has an economic advantage in that the extensive manpower that traditionally would have been required to individually treat larval-producing habitats could be substantially reduced.

With judicious selection of insecticides, forced-air ULV application of larvicide/adulticide combinations has a good potential for use in emergency control of DEN/DHF. The simultaneous impact on adult and larval stages of the vector can significantly and rapidly reduce the population with consequent beneficial effects by limiting disease transmission.

ACKNOWLEDGMENTS

We thank the following companies for providing financial support and materials that made this project possible: Adapco, Incorporated (Sanford, FL); Berry Corporation; Lobel Chemical Corporation (New York, NY); Barsky Sales, Incorporated (Sandy Hook, CT); and Becker Microbial Products, Incorporated. We also thank the technical representatives from SNEM who assisted in the field work: Angel T. Solis, Gavino Guzman, Dorian A. Montero, Gilda J. Ventura, Juana De Los Santos, Gervacia Padilla, and Teofilo Santana. Finally, we thank Jeff Stivers and Thereza Carvalho-Tidwell for many helpful suggestions and manuscript review.

REFERENCES CITED

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18: 265–267.

Gratz, N. G. 1973. Mosquito-borne disease problems in the urbanization of tropical countries. CRC Crit. Rev. Environ. Control 3(4):455–495.

Gratz, N. G. 1991. Emergency control of *Aedes aegypti* as a disease vector in urban areas. J. Am. Mosq. Control Assoc. 7:353–365.

Mekuria, Y., T. A. Gwinn, D. C. Williams and M. A. Tidwell. 1991. Insecticide susceptibility of *Aedes aegypti* from Santo Domingo, Dominican Republic. J. Am. Mosq. Control Assoc. 7:69–72.

Sandoski, C. A., W. C. Yearian and M. V. Meisch. 1986. Swath width determination for Beecomist-applied *Bacillus thuringiensis* (H-14) against *Anopheles quadrimaculatus* larvae in rice fields. J. Am. Mosq. Control Assoc. 2:461–468.

Tidwell, M. A., D. C. Williams, T. C. Carvalho-Tidwell, C. J. Peña, T. A. Gwinn, D. A. Focks, A. Zaglul and M. Mercedes. 1990. Baseline data on *Aedes aegypti* populations in Santo Domingo, Dominican Republic. J. Am. Mosq. Control Assoc. 6:514–522.