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OPERATIONAL NOTE

EFFICACY OF AN AEROSOL SURFACE SPRAY AGAINST CONTAINER-BREEDING *AEDES*

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ABSTRACT. The effectiveness of a residual insect surface spray against container-breeding mosquitoes was tested in Cairns, Australia. A formulation containing imiprothrin and cypermethrin (Mortein® Plus Cockroach Lure 'n' Kill High Performance Surface Spray) was selected based on the label claim to "kill continuously for up to 6 months." A 1-sec spray was applied to the water and interior surface of partially flooded tires and terra-cotta pots. Treatments were paired with a control and replicated at 2 sites within 3 residential properties for a total of 6 replicates. All mosquito larvae were removed and counted weekly, and a representative sample was identified in the laboratory. Complete control of *Aedes* species was achieved for 4 and 5 months in all tires and pots, respectively.

KEY WORDS Dengue, pyrethrin, *Aedes aegypti,* Australia, mosquito control

North Queensland, Australia, has had a series of dengue outbreaks in the past 10 years, including major epidemics in Townsville and Cairns (Hanna et al. 1998, Hanna et al. 2001). The vector, *Aedes aegypti* (L.) is common in urban areas of coastal Queensland north of Gladstone and westward toward the Northern Territory (Sinclair 1992). A prolonged epidemic in Cairns (November 1997–March 1999) was the catalyst for the inception of the Dengue Action Response Team (DART) in December 1998 by Queensland Health (Hanna et al. 2001).

DART members are licensed pest control operators that aid local governments to control dengue. Vector control is a combination of applying residual pyrethroid insecticides to kill adult *Ae. aegypti* inside houses and source reduction or larviciding with *S*-methoprene (formulated as Altosid Pellets®) to provide residual larval control. *S*-methoprene pellets are effective but have several operational disadvantages. First, they do not kill pupae or resting adults that are frequently found in breeding sites. Second, pellets can inadvertently be tipped or washed out by homeowners or heavy rain. Finally, *S*-methoprene pellets are not readily available to the public in Australia.

The DART has begun using aerosol pyrethroid sprays to kill larvae, pupae, and adult mosquitoes in containers. Aerosol cans have been tested for dengue control in southern Vietnam (Osaka et al. 1999) but were employed as an adulticide. Pyrethrins such as cypermethrin offered residual control of *Ae. aegypti* adults and larvae in laboratory testing of lethal ovitraps (Zeichner and Perich 1999) and should provide sustained control of larvae in the field. We measured the efficacy of a commercially available interior surface spray formulation against container-breeding *Aedes* under field conditions.

The experimental design was similar to Nasci et al. (1994). The surface spray Mortein® Plus Cockroach Lure 'n' Kill High Performance Surface Spray (active ingrediants [AI] 0.7 g/kg imiprothrin, 2.0 g/kg cypermethrin) is registered for indoor use to control crawling insects and spiders and was selected because the label claimed the product would "kill continuously for up to 6 months." Imiprothrin provides rapid knockdown (B. Peters, personal communication), whereas the cypermethrin is a residual insecticide (Zeichner and Perich 1999). Pot plant bases and discarded tires are common breeding sites for *Ae. aegypti* in north Queensland (Barker-Hudson et al. 1988, Hanna et al. 1998). Discarded small aircraft tires (50 cm diam) and new terra-cotta pots (14 cm diam) provided test containers that were easy to manipulate and remain flooded for at least 1 wk. Each tire was placed in an upright position in a shaded area; a 95-mm drainage hole was drilled to facilitate emptying of water. Tires and pots were flooded with tap water (ca. 3.5 liters and 1 liter, respectively), creating a surface area of 0.108 m^2 and 0.033 m^2, respectively. A 0.5-g alfalfa pellet was placed in each tire and pot to produce an infusion to enhance oviposition (Chadee et al. 1993). Tires and pots were treated by spraying the interior surface, including water surface, with surface spray for 1 sec (mean $\pm$ SD application of 3.03 $\pm$ 0.28 g and 3.26 $\pm$ 0.25 g for tires and pots, respectively [$n = 5$]). Two pairs of treated and untreated (control) pots and tires were placed in the front- and backyards of a well-shaded yard. Three houses were selected from different suburbs for a total sample of 6 replicate pairs per container.

Larvae were sampled at 1- or 2-wk intervals by

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Table 1. Prevalence of mosquito species in positive control and treated tires (n = 106) and terracotta pots (n = 79) at 3 sites in Cairns in 1999.

Species	Prevalence (%)
Aedes aegypti	47.6
Ae. notoscriptus	24.8
Ae. palmarum	13.9
Culex quinquefasciatus	7.8
Toxorhynchites speciosus	5.4
Tripteroides sp.	0.3

emptying water into dedicated control or treatment trays to prevent contamination of untreated replicates. All larvae and pupae were counted, a representative sample was collected for identification, and the rest were discarded. The water was returned, and the tire or pot was topped off with tap water if necessary. Any tire or pot that had dried out, been tipped over, or solely contained predatory mosquito species was excluded from analysis. The mean proportion of tires and pots positive for *Aedes* larvae was compared by a t-test using SYSTAT (SYSTAT for Windows: Statistics, Version 5, SYSTAT, Inc., Evanston, IL).

Control tires and pots were colonized by *Aedes* species within 2 and 6 wk, respectively. *Aedes aegypti* was the most prevalent mosquito species in tires and pots (Table 1), followed by *Ae. notoscriptus* (Skuse), *Ae. palmarum* Edwards, *Culex quinquefasciatus* Say, and *Toxorhynchites speciosus* (Skuse). There was a significant difference between the mean proportion of treatment and control tires and pots positive for *Aedes* larvae, respectively (t = 11.013 [tires], t = 10.011 [pots], df 18, P < 0.001). Mortein Plus Cockroach Lure 'n' Kill High Performance Surface Spray provided 100% control of *Aedes* species in tires for 16 wk (Fig. 1) and 100% control in pots for at least 20 wk (Fig. 2). There was also a significant difference between the effectiveness of treatment between tires and pots (t = 2.436, df 17, P = 0.026). The differences in residual activity between tires and pots may be directly due to differences in application area. The treated surface area of tires was 3.27 times greater than that for the pots; therefore, the estimated dose was 3.52 times greater in pots than tires. Outdoor use of the product to control mosquito larvae could contribute to less than 6 months control (for cockroaches) claimed on the product label due to exposure to rainfall and sun.

One advantage of surface spray is that it provides sustained control of *Aedes* for several months. Additionally, it rapidly kills adult mosquitoes and cannot be dislodged from a treatment site. The aerosol cans are portable and can treat difficult-to-reach sites such as sump pits and gully traps. However, Altosid Pellets are still preferred to treat roof gutters. Aerosol surface sprays are also readily available to the public and may be an acceptable alternative treatment to householders who decline interior adulticiding during dengue epidemics. Surface spray in tires is also cost effective, with an average application cost of 7.62 versus 7.67 cents Australian for Altosid Pellets.

Several mechanisms may account for the surface spray's sustained control in containers. Cypermethrin can act as a larvicide (Zeichner and Perich 1999) and could potentially kill eggs. However, *Ae.*

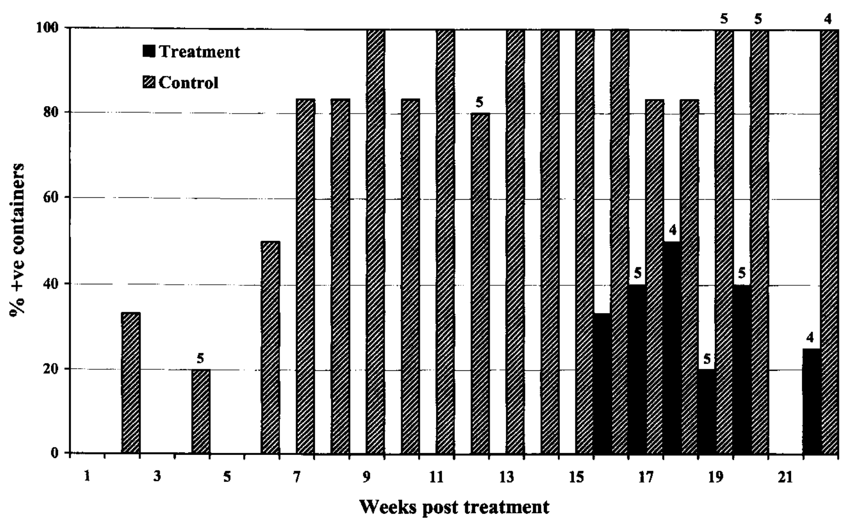

Fig. 1. Efficacy of Mortein® Plus Cockroach Lure 'n' Kill High Performance Surface Spray (AI imiprothrin and cypermethrin) on *Aedes* sp. in discarded airplane tires in Cairns, Australia. Values are the percentage of tires positive for *Aedes* larvae or pupae, excluding tires that had either dried out or in which only *Toxorhynchites speciosus* (predatory larvae) was present (n = 6 unless indicated above individual histogram bars). % + ve containers = percentage of total containers that contained *Aedes* larvae.

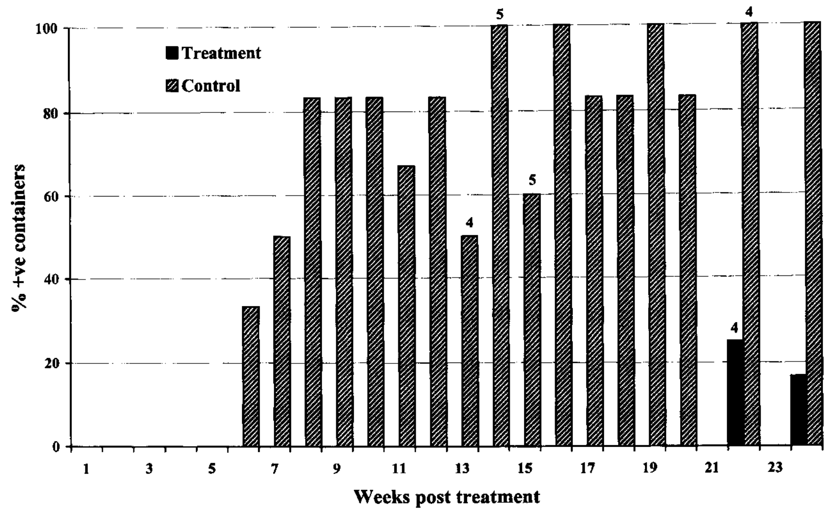

Fig. 2. Efficacy of Mortein® Plus Cockroach Lure 'n' Kill High Performance Surface Spray (AI imiprothrin and cypermethrin) on *Aedes* sp. in terra-cotta pots in Cairns, Australia. Values are the percentage of pots positive for *Aedes* larvae or pupae, excluding pots that had either dried out or in which only *Toxorhynchites speciosus* (predatory larvae) was present (n = 6 unless indicated above individual histogram bars). % + ve containers = the proportion of total containers that contained *Aedes* larvae.

aegypti eggs treated with 2% permethrin were not killed; rather, the larvae died during or soon after eclosion (S. Ritchie, unpublished data). Ovipositing mosquitoes may either be killed by the insecticide (Zeichner and Perich 1999) or repelled by this formulation. Synthetic pyrethrins have an "excito-repellent" effect on mosquitoes (Arredondo-Jimenez et al. 1997), and the propellent hydrocarbons in the aerosol can create an oil slick that may also prevent oviposition. At week 12 and 14 posttreatment, respectively, early instars (1st–2nd stage larvae) *Cx. quinquefasciatus* and *Tx. speciosus* were observed in a treated tire, although all larvae subsequently died. This suggests that oviposition had only begun recently. Detailed studies quantifying oviposition and larval control should be conducted to determine the mode of action of surface sprays through time. Additionally, comparative studies of different residual pyrethrins on different surfaces under varying environmental conditions should be conducted.

The use of an interior insect surface spray in water-holding containers provides a novel strategy for dengue mosquito control. The sustained control minimizes the need to retreat mosquito breeding sites. Care must be taken to avoid treating potable water and fish-rearing equipment. The potential for the development of pyrethroid resistance will be reduced by recommending public use of insect surface spray only during a dengue outbreak.

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