Journal of the American Mosquito Control Association, 36(2):123–126, 2020

SCIENTIFIC NOTE

EFFICACY OF RESIDUAL PESTICIDE–TREATED PLANT SAUCERS AGAINST *AEDES ALBOPICTUS* LARVAE UNDER SEMI–FIELD AND FIELD CONDITIONS

YONGXING JIANG, CASON E. BARTZ AND JUSTIN K. BAKER

Gainesville Mosquito Control Services, Gainesville, FL 32609

ABSTRACT. Plant saucers are ubiquitous, outdoor water-holding receptacles and are one of the most productive domestic mosquito habitats in the urban environment. Two kinds of commonly used plant saucers, clay and plastic, were manually treated with 3 residual insecticides, bifenthrin (Talstar® Professional), lambda-cyhalothrin (Lambda 9.7 CS), and tau-fluvalinate (Mavrik® Perimeter), at their maximum rates to assess their residual efficacy against *Aedes albopictus* larvae under semi–field and field conditions. Both clay and plastic saucers treated with bifenthrin and lambda-cyhalothrin provided weeks of control of 3rd instars of *Ae. albopictus*, whereas tau-fluvalinate provided only 1 day of control. Results from this study show that bifenthrin and lambda-cyhalothrin can provide good control of *Ae. albopictus* larvae for a considerable period of time and have great potential with regard to container mosquito management in the future.

KEY WORDS *Aedes albopictus*, bifenthrin, lambda-cyhalothrin, larvae, plant saucer, tau-fluvalinate

Aedes albopictus (Skuse) is a vector mosquito species that can transmit a variety of arboviruses such as dengue fever, chikungunya, Zika, and others. Introduced in the state of Florida in 1986, this imported species is aggressive, fast flying, and a persistent day-biter of humans (Reiter and Sprenger 1987). *Aedes albopictus* mainly breeds in urban domestic habitats, often in a wide range of artificial containers such as tin cans, bottle caps, tires, vases, small pools, gutters and downspouts that retain water, tree holes, and yard plantings of certain bromeliads. Thus, it presents a great challenge for vector control specialists. The traditional approaches to control *Ae. albopictus*, such as source reduction, larvicides, and adulticides, are not always effective. For instance, the success of source reduction largely depends on the degree of cooperation from participating communities, and is also very labor intensive and costly (Sun et al. 2014). Due to its "skip oviposition" behavior, it is very challenging to dispense larvicide droplets/granular to the individual breeding sites. The direct targeted control of adult mosquitoes, such as barrier treatment and adulticiding, is temporary and unreliable (Trout et al. 2007, Cilek 2008, Fulcher et al. 2015, Britch et al. 2009, 2011). Moreover, because of its diurnal activity, adulticiding during daytime could negatively impact nontarget organisms such as butterflies, bees, and other beneficial insects, and is impractical and ineffective (Farajollahi and Williams 2013, Xue et al. 2013, Bengoa et al. 2014, Drake et al. 2016).

Residual insecticide treatment of water-holding containers has frequently been reported in the literature for dengue prevention against the vector *Aedes aegypti* (L.) (Kalra 1999, Lloyd 2003). Using residual insecticide for the control of *Ae. aegypti* mosquito larvae and resting adult mosquitoes has been credited for a key component of 2 successful *Ae. aegypti* eradication programs in Australia (Whelan et al. 2009). Standfast et al. (2003) reported that outdoor containers (discarded tires, plant saucers, potted plant drip trays, drums, and garden ornaments) treated with bifenthrin provided good control for up to 6 wk. Pettit et al. (2010) found that discarded car tires treated with alpha-cypermethrin and lambda-cyhalothrin prevented larval development up to 22 and 24 wk, respectively. It appears that residual pesticide treatment of water-holding receptacles holds great potential for controlling container-inhabiting mosquito species such as *Ae. aegypti* and *Ae. albopictus*.

Plant saucers are notorious for breeding container mosquito species such as *Ae. albopictus*, ranking 2nd as the most preferable container type for the development of *Ae. albopictus* larvae in the urban environment (Unlu et al. 2013). The objective of this study was to evaluate the residual effectiveness of insecticide-treated plant saucers against *Ae. albopictus*. The potential outcome of this pilot study may lead to developing a long-lasting and cost-effective control technique that can be integrated into container mosquito control programs in the future.

The present study was carried out at the Department of Public Works compound (405 NW 39th Avenue, Gainesville, FL 32609) (29°41′179″N, 082°19′525″W), during the period of July 2018 to February 2019. Three residual insecticides, lambda-cyhalothrin (Lambda 9.7 CS, 9.7% AI; Central Life Sciences, Schaumburg, IL), bifenthrin (Talstar® P, 7.9% AI; FMC Corporation, Philadelphia, PA), and tau-fluvalinate (Mavrik® Perimeter, 22.3% AI; Wellmark International, Schaumburg, IL), were evaluated

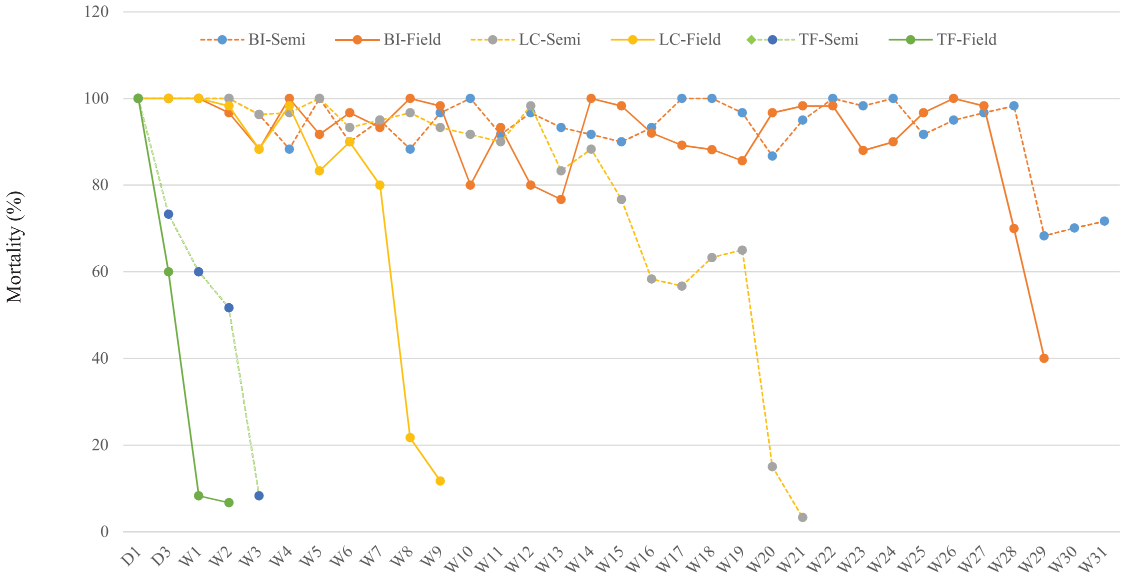

Fig. 1. Twenty-four-hour larval mortality (%) of residual pesticides–treated clay saucers against *Aedes albopictus* larvae under semi–field and field conditions. BI, bifenthrin; LC, lambda-cyhalothrin; TF, tau-fluvalinate.

against larvae of *Ae. albopictus* under semi–field (under carport) and field (open air) conditions. Application rates were 0.8 fl oz/gal/1,000 ft^2 (0.019 g AI/m^2), 1 fl oz/gal/1,000 ft^2 (0.024 g AI/m^2), and 0.5 fl oz/gal/1,000 ft^2 (0.039 g AI/m^2) for Lambda, Talstar, and Mavrik, respectively, which are the maximum application rates. Two kinds of plant saucers were selected for testing, 10-inch Pennington clay saucers (Pennington Garden & Décor, Madison, GA) and 10-inch Vigoro plastic saucers (Vigoro, Atlanta, GA). All insecticides were diluted with distilled water to a 1% stock solution and final concentrations obtained with further dilution. Aliquots (15 ml) of the desired strength dilutions were added to each plant saucer and then the saucer was rotated to ensure the surface was evenly coated. After treatment, plant saucers were air-dried and divided into 2 groups: group 1, placed under a carport (semi–field conditions) and group 2, openly exposed to full sunlight in the environment (field conditions).

After the saucers were allowed to dry completely, 200 ml of dechlorinated tap water and 20 *Ae. albopictus* 3rd instars were added to each saucer. *Aedes albopictus* larvae used for this study were provided by the USDA lab colony (Center for Medical, Agricultural and Veterinary Entomology, USDA, Gainesville, FL). In each test, 5 treated saucers were tested and 5 pesticide-free plant saucers were used for control. Evaluations were conducted in a laboratory at 25–28°C ambient temperature with a photoperiod of 14 h light and 10 h dark. Larval mortality was assessed after 24 h. Moribund larvae (larvae that cannot be induced to move when they are probed with a needle in the siphon or the cervical region) were counted as dead. Saucers treated with insecticide were tested at day 1, 3, and 5, and then weekly until consistently low mortality was recorded for 2–3 wk. After each test, all the plant saucers were returned back to the carport area or open field locations.

No larval mortality was recorded in the control groups under both semi–field and field conditions. Clay saucers treated with bifenthrin and lambda-cyhalothrin provided ≥88% control (mortality) of *Ae. albopictus* larvae for 28 and 14 wk, respectively, under semi–field conditions and yielded a good control (≥80%) for 27 and 7 wk, respectively, under open field conditions. However, saucers treated with tau-fluvalinate provided only 1 day of good control under both semi– and field conditions (Fig. 1).

Similarly, plastic saucers treated with the bifenthrin and lambda-cyhalothrin provided good control (≥80%) up to 29 and 14 wk, respectively, under semi–field conditions and 17 and 6 wk (≥85%) under field conditions (Fig. 2). Again, saucers treated with tau-fluvalinate provided only 1 day of good control.

Among the 3 residual pesticides, bifenthrin provided the longest control whereas tau-fluvalinate provided the least. Saucers treated with bifenthrin and lambda-cyhalothrin provided less control under open field conditions than the ones held at semi–field conditions. Clay saucers achieved similar longevity as the plastic saucers under semi–field conditions, but longer under open field conditions. It is believed that clay saucers tend to absorb excess water/moisture than the plastic ones, presumably, resulting in longer residual control than the plastic ones under field conditions.

Larval control has been and continues to be a key component of successful container mosquito species

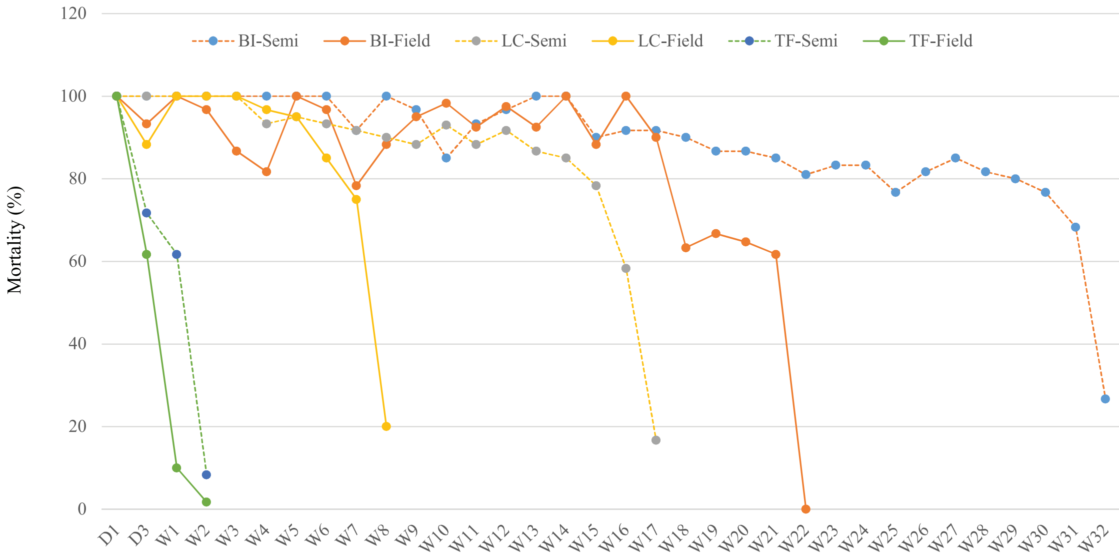

Fig. 2. Twenty-four-hour larval mortality (%) of residual pesticides–treated plastic saucers against *Aedes albopictus* larvae under semi–field and field conditions. BI, bifenthrin; LC, lambda-cyhalothrin; TF, tau-fluvalinate.

control (Gubler 1989, Ooi et al. 2006, Whelan et al. 2009, MacCormack-Gelles et al. 2020). Traditionally, the prevention of mosquito production in containers has heavily relied on source reduction (Unlu et al. 2013), sealing of water storage receptacles to exclude entry by mosquitoes (Seng et al. 2008), and using residual larvicides to treat potable water containers (Thavara et al. 2009). Results from this study show that plant saucers treated with residual insecticides can provide long-term larval control. The cost for application is minimal when compared with other, more labor-intensive control methods. Sun et al. (2014) reported that the cost for source reduction is \$659.65/ha, and backpack applications, including labor, are \$159.88/ha. The estimated cost to treat individual saucers is less than \$0.50 each. Thus, applications of residual insecticides to plant saucers have great potential to be one of the integrated mosquito management methods for container mosquito control in the future.

The efficacy of saucers treated with residual insecticides under open field conditions showed more rapid loss than those held under semi–field conditions. Unfavorable environmental factors such as the effect of ultraviolet radiation (exposure to sun), temperature, and precipitation all have a negative effect on the longevity of the insecticides (Ebeling 1963, Edwards 1975, McDowell et al. 1994, Allan et al. 2009). Ultraviolet light is an extremely destructive source of energy that promotes the breakdown of many chemicals and plays an important role in terms of the persistence of pesticides that are exposed to it. Temperature is another very significant factor that can break down pesticides. During the testing months of July to September, the average daily temperature in Gainesville, FL, was >32°C. (Weather data acquired from the Weather Underground website during the study at https://www.wunderground.com/weather/us/fl/gainesville/KFLGAINE64. This weather station is located at the Department of Public Works compound where the experiment was carried out.) Heavy rainfall can also wash off the deposition of pesticide on the surface of the treatment area. Allan et al. (2009) reported that bifenthrin-treated plants exposed to full sunlight and heavy rainfall clearly showed more rapid loss of efficacy than those held under shade and light rainfall. Heavy rainfall was recorded during the testing period (a total of 815 mm of rainfall); therefore, it is not surprising to see that their efficacy was lost quicker than those held under semi–field conditions, which is also in agreement with previous reports (McDowell et al. 1994, Mulrooney and Elmore 2000).

To our knowledge, this is the 1st study to report that incorporated residual pesticides to plant saucers directly controls *Ae. albopictus* larvae. To impregnate residual insecticides into the saucers is a logical extension to current cultural practices that may confer 2 important benefits, namely producing indirect mortality of females when ovipositing on the surface of the treated container, as well as the direct reduction of mosquito larvae hatching from the water in the treated saucers. Therefore, incorporating a residual pesticide into a variety of water-holding receptacles may hold great promise for controlling *Ae. albopictus* in these environments in the future.

The authors thank Sara Brennan and Ivy Grob, Gainesville Mosquito Control technicians, for their technical support during this study.

REFERENCES CITED

Allan AA, Kline DL, Walker T. 2009. Environmental factors affecting efficacy of bifenthrin-treated vegetation for mosquito control. *J Am Mosq Control Assoc* 25:338–346.

Bengoa M, Eritja R, Lucientes J. 2014. Ground ultra-low volume adulticiding field trials using pyrethroids against *Aedes albopictus* in the Baix Llobregat Region, Spain. *J Am Mosq Control Assoc* 30:42–50.

Britch SC, Linthicum KJ, Wynn WW, Aldridge RL, Walker TW, Farooq M, Dunford JC, Smith VL, Robinson CA, Lothrop BB, Snelling M, Gutierrez A, Wittie J, White G. 2011. Longevity and efficacy of bifenthrin treatment on desert-pattern US Military camouflage netting against mosquitoes in a hot-arid environment. *J Am Mosq Control Assoc* 27:272–279.

Britch SC, Linthicum KJ, Wynn WW, Walker TW, Farooq M, Smith VL, Robinson CA, Lothrop BB, Snelling M, Gutierrez A, Lothrop HD. 2009. Evaluation of barrier treatments on native vegetation in a southern California desert habitat. *J Am Mosq Control Assoc* 25:184–193.

Cilek JE. 2008. Application of insecticides to vegetation as barriers against host-seeking mosquitoes. *J Am Mosq Control Assoc* 24:172–176.

Drake LL, Gibson J, Smith ML, Farooq M, Sallam MF, Xue RD. 2016. Evaluation of DeltaGard® ground application against *Aedes albopictus* in a residential area in St. Augustine, Florida. *J Am Mosq Control Assoc* 32:160–162.

Ebeling W. 1963. Analysis of the basic properties involved in the deposition, degradation, persistence and effectiveness of pesticides. *Pestic Residue* 3:35–163.

Edwards CA. 1975. Factors that affect the persistence of pesticides in plants and soils. *Pure Appl Chem* 42:39–56.

Farajollahi A, Williams GM. 2013. An open-field efficacy trial using Aquaduet™ via an ultra- low-volume cold aerosol sprayer against caged *Aedes albopictus*. *J Am Mosq Control Assoc* 29:304–308.

Fulcher A, Farooq M, Smith ML, Li CX, Scott JM, Thomson E, Kaufman PE, Xue RD. 2015. Evaluation of a new spraying machine for barrier treatment and penetration of bifenthrin on vegetation against mosquitoes. *J Am Mosq Control Assoc* 31:85–92.

Gubler DJ. 1989. *Aedes aegypti* and *Aedes aegypti* borne disease control in the 1990s: top down or bottom up. *Am J Trop Med Hyg* 40:571–578.

Kalra NL. 1999. *Prevention and control of dengue and dengue haemorrhagic fever. WHO regional publication. SEARO* [Internet]. Geneva, Switzerland: World Health Organization [accessed July 26, 2010]. Available from: http://www.searo.who.int/LinkFiles/Regional_Guidelineson_Dengue_DHF_prevention_&_control_searo-29.pdf.

Lloyd LS. 2003. *Best practices for dengue prevention and control in the Americas. Strategic Report 7* [Internet]. Arlington, VA: Environmental Health at USAID [accessed July 26, 2010]. Available from: http://www.ehproject.org/PDF/Strategic_papers/SR7-BestPractice.pdf.

MacCormack-Gelles B, Neto ASL, Sousa GS, do Nascimento OJ, Castro MC. 2020. Evaluation of the usefulness of *Aedes aegypti* rapid larval surveys to anticipate seasonal dengue transmission between 2012–2015 in Fortaleza, Brazil. *Acta Trop* 205:105391. doi:10.1016/j.actatropica.2020.105391

McDowell LL, Willis GH, Southwick ML, Smith S. 1994. Methyl parathion and EPN washoff from cotton plants by simulated rain. *Environ Sci Technol* 18:423–427.

Mulrooney JE, Elmore CD. 2000. Plant and environmental interactions: rainfastening of bifenthrin to cotton leaves with selected adjuvants. *J Environ Qual* 29:1863–1866.

Ooi E, Goh K, Gubler DJ. 2006. Dengue prevention and 35 years of vector control in Singapore. *Emerg Infect Dis* 12:887–893.

Pettit WJ, Whelan PI, Mcdonnell J, Jacups SP. 2010. Efficacy of alpha-cypermethrin and lambda-cyhalothrin applications to prevent *Aedes* breeding in tires. *J Am Mosq Control Assoc* 26:387–397.

Reiter P, Sprenger D. 1987. The used tire trade: a mechanism for the worldwide dispersal of container breeding mosquitoes. *J Am Mosq Control Assoc* 3:494–501.

Seng CM, Setha T, Nealon J, Chantha N, Socheat D, Nthan MB. 2008. The effect of long-lasting insecticidal water container covers on field populations of *Aedes aegypti* (L.) mosquitoes in Cambodia. *J Vector Ecol* 33:333–341.

Standfast H, Fanning I, Maloney L, Purdie D, Brown M. 2003. Field evaluation of Bistar 80SC as an effective insecticide harborage treatment for biting midges (*Culicoides*) and mosquitoes infesting peridomestic situations in an urban environment. *Bull Mosq Control Assoc Aust* 15:19–33.

Sun D, Williges E, Unlu I, Healy S, Williams GM, Obenauer P. 2014. Taming a tiger in the city: comparison of motorized backpack applications and source reduction against the Asian tiger mosquito, *Aedes albopictus*. *J Am Mosq Control Assoc* 30:99–105.

Thavara U, Tawatsin A, Asavadachanukorn P, Mulla MS. 2009. Field evaluation in Thailand of spinosad, a larvicide derived from *Saccharopolyspora spinosa* (Actinomycetales) against *Aedes aegypti* (L.) larvae. *Southeast Asian J Trop Med Public Health* 40:235–242.

Trout RT, Brown GC, Potter MF, Hubbard JL. 2007. Efficacy of two pyrethroid insecticides applied as barrier treatments for managing mosquito (Diptera: Culicidae) populations in suburban residential properties. *J Med Entomol* 44:470–477.

Unlu I, Farajollahi A, Strickman D, Fonseca DM. 2013. Crouching tiger, hidden trouble: urban sources of *Aedes albopictus* (Diptera: Culicidae) refractory to source-reduction. *PLoS ONE* 8:1–12.

Whelan PI, Kulbac M, Bowbridge D, Krause V. 2009. The eradication of *Aedes aegypti* from Groote Eylandt NT Australia 2006–2008. *Arbovirus Res Aust* 10:188–199.

Xue RD, Smith ML, Qualls WA. 2013. Field evaluation of truck-mounted thermal fog of DUET™ and Aqualuer® using different solvents against *Aedes albopictus*. *J Am Mosq Control Assoc* 29:301–303.