

## SCIENTIFIC NOTE

### FIELD EFFECTIVENESS OF A METOFLUTHRIN FAN-BASED EMANATOR AND DEET AS REPELLENTS AGAINST *Aedes vigilax* IN SOUTHEAST QUEENSLAND, AUSTRALIA<sup>1</sup>

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**ABSTRACT.** A field study to compare a formulation containing 40% deet (*N,N*-diethyl-3-methyl benzamide) in ethanol (Bushman™) and a battery-powered fan emanator with a chemical strip containing 31.2% metofluthrin (OFF!® Clip-On™) was conducted at Redcliffe, Queensland, Australia, in February 2016. The 40% deet provided 100% protection against mosquitoes for 5 h until tests ceased, while the OFF! Clip-On device provided only 42.2–60.8% protection against *Aedes vigilax* during the same period.

**KEY WORDS** *Aedes vigilax*, deet, metofluthrin, spatial repellent, Queensland

The use of devices emanating active ingredients has recently been advocated to provide spatial repellency against mosquitoes. Recent laboratory and field studies have been undertaken to evaluate the protection provided by emanators in reducing contact between humans and biting vectors of disease (Rapley et al. 2009, Ritchie and Devine 2013).

Recent field tests in Cairns, Australia, have been undertaken to investigate the use of metofluthrin in plastic items, and have shown these items have potential to control *Aedes aegypti* (Skuse), the main vector of dengue in northern Queensland (Buhagiar et al. 2017a, 2017b; Darbro et al. 2017).

The OFF!® Clip-On™ battery-powered emanator was released commercially in Australia during 2015, following studies conducted in the USA showing its effectiveness (Xue et al. 2012, Bibbs and Xue 2016). The use of spatial repellents, such as the OFF! Clip-On device, have been suggested as products to protect against mosquito-borne arboviruses and malaria in the future (Achee et al. 2019).

The current field study was undertaken to compare the effectiveness of OFF! Clip-On device with a formulation of deet (*N,N*-diethyl-3-methyl benzamide), an active ingredient that has been used in topical repellent formulations against mosquitoes for >50 years (Frances 2015).

In the study, 2 formulations were used: 1) OFF! Clip-On emanator (SC Johnson, Sydney, Australia) containing 31.2% metofluthrin in a replaceable strip, which was purchased at a supermarket in Brisbane, Queensland. The emanator was also purchased commercially, and new chemical strips were used each day of the test; and 2) Bushman™ (North Queensland Laboratories, Cairns, Australia) contain-

ing 40% deet in ethanol in a nonpressurized spray applicator. The container was weighed before and after application to determine the amount used.

The study was conducted at Redcliffe Airport (27°7'S, 153°8'E), located 30 km north of Brisbane, Queensland, in February 2016. This site has been used in several previous studies (Frances et al. 2009, 2014). Three volunteers participated in the test and each wore a long-sleeved shirt and trousers, a screened jacket (Bug Out Outdoor Wear, Wauwatoosa, WI), and surgical gloves. The trouser legs were rolled up to the knee, and running shoes, without socks, were worn to allow mosquito access to lower legs. A single volunteer applied deet formulation according to label instructions to the exposed legs at 1745 h, 1 h before the commencement of tests. A single volunteer used the OFF! Clip-On emanator according to label instructions. The fan-based emanator was placed onto the hip, and a new (freshly opened) chemical strip was used on each night of testing. The emanator was turned on 5 min before the commencement of testing and turned off when not in use. The final volunteer was untreated (control). Tests were commenced at 1845 h on each of 3 nights, when volunteers entered the test area, sat in predetermined positions approximately 3 m apart, and collected all mosquitoes biting on the lower legs for 10 min, followed by a 50-min break in a nearby hangar building free from mosquitoes. Tests were replicated and randomized over 3 nights so that all volunteers evaluated each treatment and with untreated control once. Percent protection by each repellent was calculated, using the following formula:

Percent protection = (total collected on control) – (total collected on treatment)/total collected on the control × 100.

<sup>1</sup> Mention of a commercial product does not constitute an endorsement by the Australian Defence Force.

Table 1. Mean ( $\pm$  SE) number of *Aedes vigilax* landing per 10 min on untreated (control) volunteers during hourly collections at Redcliffe, February 2016.

Hours after repellent application	Mean $\pm$ SE biting of mosquitoes
1	57.0 $\pm$ 22.1
2	24.0 $\pm$ 14.3
3	34.7 $\pm$ 19.5
4	33.7 $\pm$ 21.3
5	52.3 $\pm$ 33.8

The mean application rate of Bushman (deet) was  $3.51 \pm 1.5$  g per 2 legs. A total of 826 mosquitoes were collected during the study, and the main species was *Aedes vigilax* (810, 99%). The overall mean biting rate of *Ae. vigilax* on ethanol-treated (control) volunteers was  $40.5 \pm 9.3$  bites per 10 min (Table 1). The mean number of mosquitoes collected throughout the collection period was uniform (1-way ANOVA  $F_{4, 10} = 0.35$ ,  $P = 0.84$ ).

The protection provided by the 2 repellents was significantly different using a 2-way ANOVA ( $F_{1, 20} = 16.2$ ,  $P < 0.001$ ; Fig. 1). Bushman deet provided 100% protection for at least 5 h when the tests ceased. The OFF! Clip-On emanator provided relatively poor protection (42.2–60.9%).

The purpose of this study was to compare the protection provided by deet and the emanator. The study showed that deet was effective for at least 5 h after application, confirming earlier results (Frances 2013, Frances et al. 2014). In this study the OFF! Clip-On emanator provided relatively poor protection against *Ae. vigilax* (Fig. 1).

Spatial or area repellents create a 3-dimensional zone from which biting arthropods are repelled or within which they fail to bite (Kline and Strickman 2015). Bibbs and Xue (2016) noted that at a minimum airflow (wind) of 5 km/h the OFF! Clip-On emanator caused mortality in mosquitoes placed 0.3 m away from it. However, the emanator was not effective when 5–8 km/h of airflow occurred. In the current study wind speed was not recorded; however, during the 3 nights of testing the wind was variable and was still or a slight breeze. The advantages of spatial repellents include protection of several people with a single product, ease of use, and no need to apply formulations to the skin. Metofluthrin-containing products have been marketed recently in Australia. A product containing metofluthrin-impregnated paper strips was shown to reduce the landing and biting of *Aedes aegypti*, especially within 1 m of emanators, in houses in Cairns (Darbro et al. 2017). The OFF! Clip-On emanator was released in Australia in 2015, and actively marketed (television, magazine, and radio advertisements) in 2016–17, but has not been actively marketed in the 2 summers since.

The biting density of *Ae. vigilax* has not been studied extensively (Jansen et al. 2015), as it is

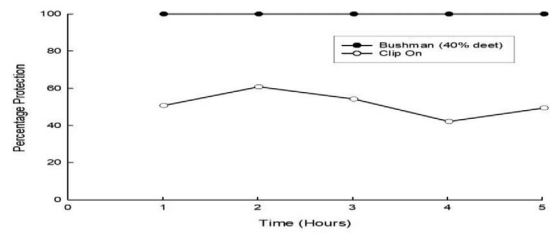


Fig. 1. Percent protection provided by Bushman™ (40% deet) and OFF!® Clip-On™ emanator (31% metofluthrin) against *Aedes vigilax* at Redcliffe, February 2016.

renowned as a vicious biter. During the current study the biting rate of *Ae. vigilax* was again recorded as high, with a mean rate (extrapolated) of 240 bites/h (Table 1), and maximum rate (extrapolated) of 640 bites/h. The density of mosquitoes recorded in this study was relatively high, and the study showed that Bushman deet provided 100% protection for at least 5 h against this important pest and vector species, confirming earlier studies at this site (Frances et al. 2014).

The current study has shown that relatively poor protection was provided by the OFF! Clip-On emanator against *Ae. vigilax*. However, the use of spatial or area repellents has a number of advantages over the topical application of formulations, and with continued active research will eventually result in more effective emanator and chemical systems (Achee et al. 2019).

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