EVALUATION OF A PORTABLE BACKYARD MOSQUITO MISTER AGAINST CULEX PIPIENS AND *AEDES ALBOPICTUS* IN ISRAEL

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ABSTRACT. The magnitude of mosquito reduction and coverage area of the Terminix ALLCLEAR Backyard Mosquito Mister, a portable backyard mosquito mister, was evaluated using ALLCLEAR Naturals (geraniol and citric acid) and ALLCLEAR Synergized Plus (permethrin+piperonyl butoxide) products against host-seeking Culex pipiens and Aedes albopictus. The application dispersal pattern of the mister unit for a multi-directional and single-directional wind scenario resulted in a coverage area that far exceeded the product manufacturer's listed coverage area. Overall biting pressure reduction at the periphery of 200 m^2 and 300 m^2 experimental plots was signi□cantly reduced for both species with both products. In light of these results, the backyard portable mosquito mister can be considered an alternative to stationary systems applying the same products with multiple nozzles that may be aesthetically unappealing and/ or economically unfeasible to the homeowner.

Key Words:. Culex pipiens, Aedes albopictus, misting system, geraniol

I. INTRODUCTION

Globally, mosquitoes are a nuisance and public health concern because they are important vectors of the pathogens responsible for malaria, West Nile fever, and dengue (Eldridge & Edman 2004, Service 1993). Mosquito population control and personal protection methods are the best measures to protect against mosquito-borne infection due to a lack of effective medical treatments for some of these diseases (Curtis 1992, Gupta and Rutledge 1994). Consequently, numerous products that reduce the biting pressure and increase personal protection, such as repellents and traps, are currently on the market (Revay et al. 2012). One method that has a considerable amount of attention by manufacturers and pest control professionals is the misting system. These automatically timed systems provide an envelope of protection against host-seeking mosquitoes within a de□ned area, e.g. residential backyards (Cilek et al. 2008).

Misting systems provide an alternative to using topically applied repellents because one of the most commonly used products, DEET (N,N-diethyl-3-methylbenzamide), has been reportedly linked with neurotoxic and allergenic effects in humans (Osimitz & Murphy 1997, Qiu et al. 1998). Although many misting systems are programmed for automatic application of an adulticide they can be manually turned on by the user during peak mosquito activity, e.g.. dusk and dawn, or when the user is outdoors poten-

tially providing protection from host-seeking mosquitoes in the immediate area.

While the use of automated systems for protection against host-seeking mosquitoes seems like a viable alternative, there has been very little scientific data to support their use in residential areas. The majority of commercially available systems consist of a series of multiple spray nozzles connected through a continuous loop of tubing to a reservoir tank containing an insecticide. However, new portable devices are currently on the market that may potentially provide the same type of application without the need for installation of a stationary system which may be aesthetically unappealing and/or economically unfeasible to the homeowner. One such portable product is the Terminix® ALLCLEAR Backyard Mosquito Mister, a device that claims to provide control of mosquitoes for up to 190 m^2. Thus, the purpose of this study was to determine the magnitude of mosquito reduction (and associated coverage area) provided by this product when applying either ALLCLEAR Naturals (active ingredients, AI, geraniol and citric acid) or ALLCLEAR Synergized Plus (AI permethrin plus piperonyl butoxide) against host-seeking Culex pipiens L. and Aedes albopictus (Skuse).

II. MATERIALS AND METHODS

Tests were performed in the northern Mediterranean coastal plain of Israel in suburban Haifa. The study took place from mid-June to mid-July 2012 just after sunset from 20:00 to 22:00. Weather conditions consisted of clear skies with early evening temperatures ranging from 27° to 30°C. Air movement was verified by smoke cartridges at a distance of 100 m to the experimental set ups and carefully observed during the experiments (air speed 0-8 km/h and non-directional). No unfavorable weather conditions were observed during the trial periods.

The equipment tested was Terminix ALLCLEAR Backyard Mosquito Mister (Figure 1), with either ALLCLEAR Naturals (AI 6.8% geraniol, 0.7% citric acid) or ALLCLEAR Synergized Plus (AI 10% permethrin, 10% PBO). The test unit was charged and operated as suggested by the manufacturer. Products were stored less than one month in the laboratory at ambient room conditions before they were tested.

Quantification of the mist dispersal pattern covered by one application of the unit was evaluated in open parkland under single and multi-directional wind conditions. Clear Din A-4 plastic sheets (3M, PP2200, St. Paul, MN) were mounted on wooden poles, 0.5m above the ground, with individual sheets positioned on the far side of 3m × 3m plots in a 30m × 30m square with the unit in the center. To facilitate observation of the mist dispersion pattern, we added 1% blue food dye to pure water. After one 4 min standard spray application, sheets were recovered and examined with a magnifying glass (3x) for droplet coverage. Sheets with 10 or more droplets were regarded as positive. The procedure was repeated 6 times. Single direction wind conditions were assessed similarly but the experimental set up was slightly modified with the unit upwind at the periphery of a 42 m × 42 m square, allowing wind to carry the mist over the test area.

Evaluation of mosquito efficacy (i.e. biting pressure) was conducted within a residential backyard (450 m^2) in suburban Haifa. This area was largely protected from strong air movement by buildings and vegetation. In accordance with US EPA test guidelines, the study site exhibited a minimum biting pressure of 1 bite/minute of at least two different mosquito genera (EPA 1999). Common nuisance mosquitoes at the experimental and nearby control sites were Cx. pipiens and Ae. albopictus. Treatment and control sites were separated by 800m. Each product was evaluated under multi directional wind conditions at the periphery of areas of 200, 300 and 400 m^2 plots with the unit in the center of the yard. ALLCLEAR Naturals concentrate evaluation commenced two hours after a single mist application, and for ALLCLEAR Synergized PLUS concentrate six hours after application. The difference in

Figure 1. Terminix® ALLCLEAR Backyard Mosquito Mister and spray plume.

time intervals for testing was based on the manufactures instructions for each product. Similar evaluations occurred in non-treated control plots with the unit dispersing a water mist without active ingredients.

Six volunteers, two females and four males, were enlisted for this study. The volunteers were fully informed of the nature, objective, and procedures of the test including any physical and mental health conse-

quences that were reasonably foreseeable as a result of exposure to the test products. Tests were conducted according to EPA guidelines (EPA 1999). During evaluation, participants were not informed which mister was delivering active material. Volunteers were seated in chairs, as motionless as possible, facing towards the mister with one arm extended at a 45-degree angle, resting on thighs, in front of them. One forearm was exposed while suitable clothing protected the rest of body. In each trial, all volunteers rotated two times through single test stations and the control; n = 12 for 200, 300 and 400 m over three consecutive days. Each evening, one of the distances was tested; landing rates were evaluated for five minutes which enabled the group of volunteers to finish one trial in a half hour. Mosquitoes that either attempted to land, probe, and/or bite a volunteer's forearm were collected by assistants using hand nets and later recorded on data sheets. Assistants were fully protected by clothes and a topical repellant (Deepwoods Off!, AI 23.8% DEET, SC Johnson, Racine, WI) while standing behind the volunteers at a distance of about 1 m. A garden lantern (50 Watt, 8 feet distance from each collection site) provided adequate lighting during testing to enable the volunteers and assistants to observe any mosquitoes attempting to land.

Mean biting reduction at each distance between the different products and controls were compared using Student's t-test (GraphPad Software Inc., La Jolla, CA).

III. RESULTS AND DISCUSSION

Dispersal pattern of the Terminix ALLCLEAR Backyard Mosquito Mister during multi directional wind conditions resulted in an average mist coverage area of 540 ± 8.1 m^2. The single directional wind evaluation resulted in an average coverage area of 610 ± 13.3 m^2. Both wind evaluations resulted in a coverage area that far exceeded the product manufacturer's listed coverage area of 190 m^2.

Mosquito biting pressure at the control site was considered high during the entire testing period and ranged from 11.78–21.89/5 minutes for Cx. pipens and 9.94–17.39/5 minutes for Ae. albopictus. We considered that the overall biting pressure reduction at the periphery of our 200 m^2 experimental plot to be significantly effective with ALLCLEAR Naturals ($t = 13.2$, $df = 1$, $P = 0.04$) and ALLCLEAR Synergized Plus ($t = 14$, $df = 1$, $P = 0.05$) compared with controls (Table 1). Moreover, the unit provided significantly greater reduction of biting pressure with either active ingredient at the periphery of 300 m^2 plots (ALLCLEAR Naturals $t = 12.2$, $df = 1$, $P = 0.05$; ALLCLEAR Synergized Plus $t = 11.3$, $df = 1$, $P = 0.03$) compared with controls. At the periphery of 400 m^2 plots the total biting pressure was still

Table 1. Mean percent reduction of Culex pipiens and Aedes albopictus biting pressure[1] after using two products[2] at different distances when applied by the Terminix ALLCLEAR Backyard Mosquito Mister.

		% Reduction		
Mosquito species	Distance (m)	ALLCLEAR Naturals	ALLCLEAR Synergized Plus	Untreated Control (raw means only)
Culex pipiens	200	91.4	91.6	21.8
	300	65.6	69.8	11.7
	400	52.4	55.7	13.6
Aedes albopictus	200	82.1	87.2	17.3
	300	58.6	62.6	9.9
	400	46	42.5	15.5
Combined species	200	87.2	91.7	39.2
	300	62.4	66.5	21.7
	400	49.1	48.7	29.2

[1]Biting pressure evaluated at 5 min intervals.
[2]ALLCLEAR Naturals evaluated at 2h, ALLCLEAR Synergized Plus evaluated at 6h.

reduced by nearly 50%. Currently accepted manufacturer guidelines require candles, coils, vaporizing mats, or other such products to provide at least a 50% repellency rate to make a reliable claim that the product repels mosquitoes (Govere and Durrheim 2007). Therefore, the effective coverage of the Terminix ALLCLEAR Mosquito Mister, in our study, exceeded the manufacturer claims of approximately 200 m^2.

We support the use of the ALLCLEAR Naturals product containing geraniol in the mister. A previous study evaluating another formulation of geraniol in a Terminix® ALLCLEAR Mister Lantern, demonstrated 80% mosquito biting reduction up to 91m^2 comparable with our ALLCLEAR Naturals application (Revay et al. 2012). Geraniol, a plant-derived alcohol, is considered completely safe for use and appears on the US Food and Drug Administration "Generally Regarded as Safe" list and is classified by the US EPA as a minimum risk pesticide under section 25(b) of the Federal Insecticide, Fungicide, and Rodenticide Act (EPA 2012).

IV. ACKNOWLEDGEMENTS

This research study was conducted according to protocol number AMCD 10-13-2005 as approved by the Anastasia Mosquito Control Board of Commissioners for use of human subjects in this project. Volunteers gave informed consent prior to participation in the study. The authors and AMCD do not endorse any of the products evaluated in this report for the control of mosquitoes.

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