A Mechanical Insecticide Approach to Non-Chemical, Low-Cost Mosquito Control

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Abstract

Overdependence on the use of insecticides has led to resistance and has created significant challenges in controlling mosquitoes globally. In 2017, the City of New Orleans Mosquito, Termite and Rodent Control Board (NOMTRCB) evaluated an engineered perlite product (Imergard WP, Imerys, Paris, France) against mosquitoes in the field and in the laboratory in Monte Verde, Honduras. Control of the mosquitoes was strictly mechanical and formulation did not contain a chemical insecticide. The objective was to determine the efficacy of a IMERGARD WP when applied inside the structures and at entry point on the exterior and the residual effect in bioassays.

Introduction:

Monte Verde was selected for indoor and crevice treatment with Imergard WP because of the high mosquito populations, high human-exposure to mosquitoes (lack of pest-proofing), disease potential, and good accessibility and willingness of the residents to participate in the study. In 2016 there was local transmission of Zika virus, dengue fever, chikungunya in Monte Verde.

Monte Verde is an economically depressedcommunity of 300 structures on the outskirts of San Pedro Sula, Honduras.The houses do not have screens on the windows or the doors (Figure 1) and have extensive gaps making them vulnerable to mosquito invasion.The people of Monte Verde do not have running water or indoor plumbing and the latrines are outside. Many houses have hand dug wells lined with truck tires (Figure 2). Containers such as buckets and 55 gallon drums are used to store water (Figure 3) when pumps are turned on every 5 to 8 days for 1-hour to distribute water.Every house has an outdoor or indoor basin called a pila which remains filled with water. The stored water is used for cooking, bathing, laundry, dish washing, etc. Every property has numerous containers and standing water that created an ideal habitat for mosquito breeding.


Figure 1. Typical housing structure in in Monte Verde, Honduras.


Figure 2. Well lined with truck tires in in Monte Verde, Honduras.


Figure 3. Mosquito breeding habitat created by standing water in Monte Verde, Honduras.

Novel Technology

Imergard WP is made of amorphous aluminosilicate also known as perlite and originates from lava (Figure 4). Perlite is made from volcanic glass (Figure 5) which contains water in its inner structure. When heated rapidly, the steam produced expands the glass to form a foamed structure (Figure 6). This is then pulverized into a fine powder (Figure 7) and can be mixed with water and applied to a surface as a mechanical insecticide (Figure 8). An adult mosquito generates a static charge while flying and by landing on a surface treated with IMERGARD WP, a static transfer of the mechanical insecticide occurs.


Figure 4. Lava Flow


Figure 5. Volcanic Glass


Figure 6. Foamed structure

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Materials and Methods

A baseline survey was conducted to determine mosquito pressure and population (species of mosquitoes) on 24 houses (Figure 9).Twenty homes were selected for the study.The sites were divided into 2 groups, 10 treatments (Imergard WP), and 10 controls (no treatment). Houses were chosen with similar structure and yard size. Every house had a pila (Figure 10). One pound of Imergard wettable powder was added to a 2 gallon container with 1 gallon of water and agitated by hand (shaken in the container) and a second gallon of water was added to prevent clumping. A Stihl handheld sprayer (model SG31 and SG11, Stihl Corp., Virginia Beach, VA.) was used to apply the treatment.

The interior of each treatment house had Imergard WP applied onto the upper 1/3 perimeter of the walls, window sills, door frames, behind head boards and under beds (Figure 11). It was also applied onto the upper 1/3 perimeter of exterior walls of treatment houses and surrounding outer structures (pilas and overhanging structures, etc.).Each treatment house was sprayed with approximately 2 gallons of the formulation.The product was applied when the weather was dry with little to no wind to prevent drift and allow product time to set.

Figure 9. Housing in Monte Verde

Figure 10. Pilas or basins for washing

Figure 11. Application of Imergard WP

The mosquito population at all sites was monitored twice in one week pre-treatment and ten weeks post-treatment. Mosquitoes were monitored one night per week at each site. Mosquitoes were collected by a BG 2 Sentinel trap (Biogents AG, Regensburg, Germany). BG Sentinel traps were baited with a BG-Lure cartridge (Biogents AG, Regensburg, Germany) and dry ice in a Styrofoam cup was placed next to each BG trap as an added attractant (Figure 12). All collections were brought into the laboratory, frozen and then identified and counted.

Ovicups were placed inside the house and outside the structure to measure mosquito breeding levels in treatment areas versus non treated areas. The cups were serviced once per week and seed germination paper was photographed and eggs were counted (Figure 13).

Bioassays were conducted using a cement substrate (2" x 1" 1/4" chips) to mimic housing material. Half the chips were treated with Imergard WP and allowed to dry. The control chips were not treated.The chips were placed inside each house under the table or bench at each site. Three cement chips were collected weekly from each site for the bioassays. Each cement chip was placed in a plastic bag, labeled and shipped to New Orleans Mosquito Control's laboratory overnight for testing.

Cement substrates were placed into 9 ounce plastic cups (Schneider Paper Products, Inc. New Orleans, Louisiana) with mesh lids to allow mosquitoes to rest on the treated cement (Figure 14). The three species of mosquito used in the bioassays were *Aedes aegypti, Aedes albopictus* and *Culex quinquefasciatus*. A cotton ball soaked in a 10% sugar water solution was placed on top of the mesh screen of every bioassay cup to provide a food source. Mosquitoes were then placed in a temperature (80 ºF) and humidity (78%) regulated room. Mosquito mortality was monitored at 1 hour and 24 hours.

Figure 12. BG2 Sentinel trap was used to collect adult mosquitoes.

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Figure. 13. ***Aedes*** **eggs were counted once a week.**

Results

The predominant species of mosquitoes collected included *Aedes aegypti*, *Culex quinquefasciatus,* and *Coquelletidia perturbans.* Adult *Aedes aegypti* mosquitoes were identified from the collected BG2 Sentinel traps. The collections showed slight reduction in the adult mosquito population of *Aedes aegypti* after the first two weeks of application with Imergard WP (Figure 15). Mosquito populations increased after a Tropical depression on June 20thand other rain events during the 10 week trial.

Interior ovicups in the treatment group showed significant reduction in oviposition (mosquito egg laying) over the course of the twelve week study as compared to the exterior ovicups (Paired t-test, df = 96, P = <0.001) in Table 1.

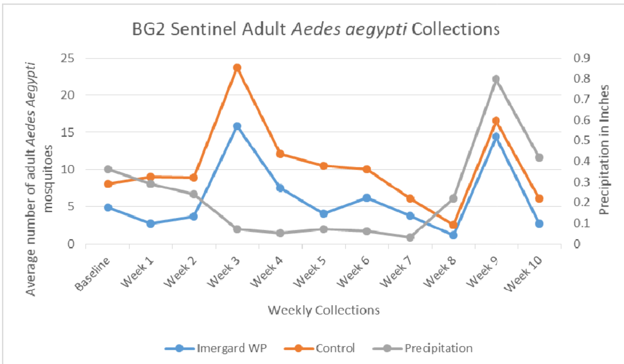

Figure 15. ***Aedes aegypti*** **collection and precipitation in Monte Verde, Honduras Maythrough August 2017**

Interior Ovicup Averages	Baseline	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Wettable Powder	28.6	22.3	11.9	18.7	11.5	19	19.5	3.9	8.1	7.8	1.89
Control	22.4	13	25.8	31.7	42.5	26.9	40.3	15.1	21	14.7	12.5
Exterior Ovicup Averages	Baseline	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Wettable Powder	22.25	27.4	33	46.9	78.5	46.3	49.5	19	23	20.6	17.8
Control	51.1	11.5	68	35.8	47.6	30	56.9	40	65.3	10	23.7

Table 1. Interior and exterior ***Aedes aegypti*** **egg counts deposited on seed germination paper placed in ovicups.**

Bioassays: Imergard bioassays with cement chip substrates shipped from Honduras demonstrated less than 10% mortality against *Aedes aegypti* over the course of the study, less than 5% mortality in *Aedes albopictus,* and 1% mortality in the *Culex quinquefasciatus*.To verify the shipping process did not interfere with the efficacy of the treatment, cement chips were treated in New Orleans and evaluated.The results were similar.

Summary

In treatment houses, ovicups saw a significant reduction in oviposition in structures treated with Imergard WP. The houses were made of many types of materials including cinder blocks, wood and metal.The substrate on to which Imergard is sprayed can result different residual activity.The treated cement chips did not produce a residual activity.However, in 2016 a similar trial was conducted in New Orleans using southern yellow pine. Imergard had a 96% mortality rate against *Aedes aegypti*, a mortality rate of 85% against *Aedes albopictus* and a 93% mortality rate against *Culex quinquefasciatus* in the bioassay, 8 weeks after application.

The BG2 Sentinel collections in Imergard treated sites slightly declined compared to the untreated control, however, results were not significant.Test sites were surrounded by untreated properties and migration of mosquitoes from neighbors (untreated houses) was likely as every property has numerous containers and standing water that create an ideal habitat for mosquito breeding.

Imergard has several attractive qualities.The product is inexpensive to produce, can overcome insecticide resistance, and is a minimal risk product.Mosquito control is not always affordable, accessible, or is restricted in many parts of the world.A non-chemical, low-cost option would provide greater access to mosquito control around the world.

References:

1. WHO Guidelines for Testing: Mosquito Adulticides for Indoor Residual Spraying and Treatment of Mosquito Nets,

2. http://apps.who.int/iris/bitstream/10665/69296/1/WHO_CDS_NTD_WHOPES_GCDPP_2006.3_eng.pdf

3. Trout RT, Brown GC, Potter MF, Hubbard JL., Efficacy of two pyrethroid insecticides applied as barrier treatments for managing mosquito (Diptera: Culicidae) populations in suburban residential properties. J Med Entomol. 2007 May; 44(3):4707.