

Characterizing the Relative Effects of Misting Formulations on *Culex pipiens* using a Potter Precision Spray Tower

October, 2013

MistAway Systems



Why Study This?

There is a need to establish a fact base in order for Mosquito Misting as a control application to evolve, improve and to be practiced more professionally.

- Field practices are driven by experience, intuition and word of mouth. Anecdotes about techniques that work or don't work contain too many variables to draw reliable conclusions.
- There is no empirical basis for standard application rates (dilutions, coverage, duration, misting time, etc.) and thus no basis for what measures will improve system performance:
 - Change insecticide? Increase concentration?
 - Increase mist duration? Increase nozzle count?
 - Mist at a different time of day?
- There is a growing range of both conventional and exempt misting formulations making efficacy claims which may or may not be founded.

Study Objectives

- Characterize the relative effectiveness in killing mosquitoes of a number of popular misting formulations as a function of Dilution and Dose.
 - Employ laboratory setting to remove as many other variables as possible
 - Use a simple, repeatable protocol
- Look for insights that would improve how Misting is practiced in the field.
- Identify needs for further study

The study was conducted at the entomology laboratory at Washington State University - Northwestern Washington Research & Extension Center in Mount Vernon, WA.



- **Site:** WSU NWREC is located in the Skagit Valley, between Seattle and Bellingham, Washington.
- **Principal Researcher** - Beverly S. Gerdeman Ph.D.
- **Entomology Professor**– Lynell K. Tanigoshi Ph.D

***Culex pipiens* larvae and pupae were shipped overnight from Cornell's Mosquito Laboratory then transferred to plastic rearing trays inside sleeve cages to contain emerging adults. Larvae were fed standard larval diet from Carolina Biological. Adults were maintained on 20% sugar water solution.**



5-6 days after emergence, adults were aspirated from the sleeve cage and transferred into 2 oz plastic condiment cups covered with nylon netting, which served as the testing arenas.



The bioassays were performed using a Potter Precision Spray Tower (Burkard Scientific Ltd), which applies precise and uniform deposits of spray over a small circular area (3.5" diameter.)



Potter Precision Spray Tower

©MistAway Systems - All Rights Reserved

The test arenas containing mosquitoes are centered on the stage at the bottom of the tower. A known volume of dilute insecticide is pipetted into a glass vial at the top. Switching a lever pneumatically raises the stage and the insecticide is atomized at 15 psi from a nozzle at the top of the tower. Following the application, the stage lowers and the mosquitoes (arenas) are removed for observation.

Bottom of Tower

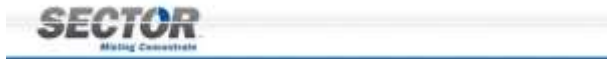


Top of Tower

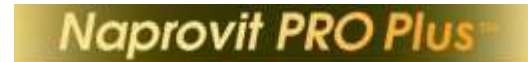


The study evaluated the efficacy of seven insecticides formulated for mosquito misting systems - four Conventional formulations and three Exempt formulations.

Conventional Formulations



Exempt Formulations



Efficacy was evaluated for each insecticide at four Dilutions: Field Rate (recommended label rate), ½ Field Rate, ¼ Field Rate and 1/8 Field Rate. The table below compares the four dilutions tested for Riptide, which ranged from 455 parts per million pyrethrins at the Field Rate down to 57 ppm at 1/8 Field Rate.



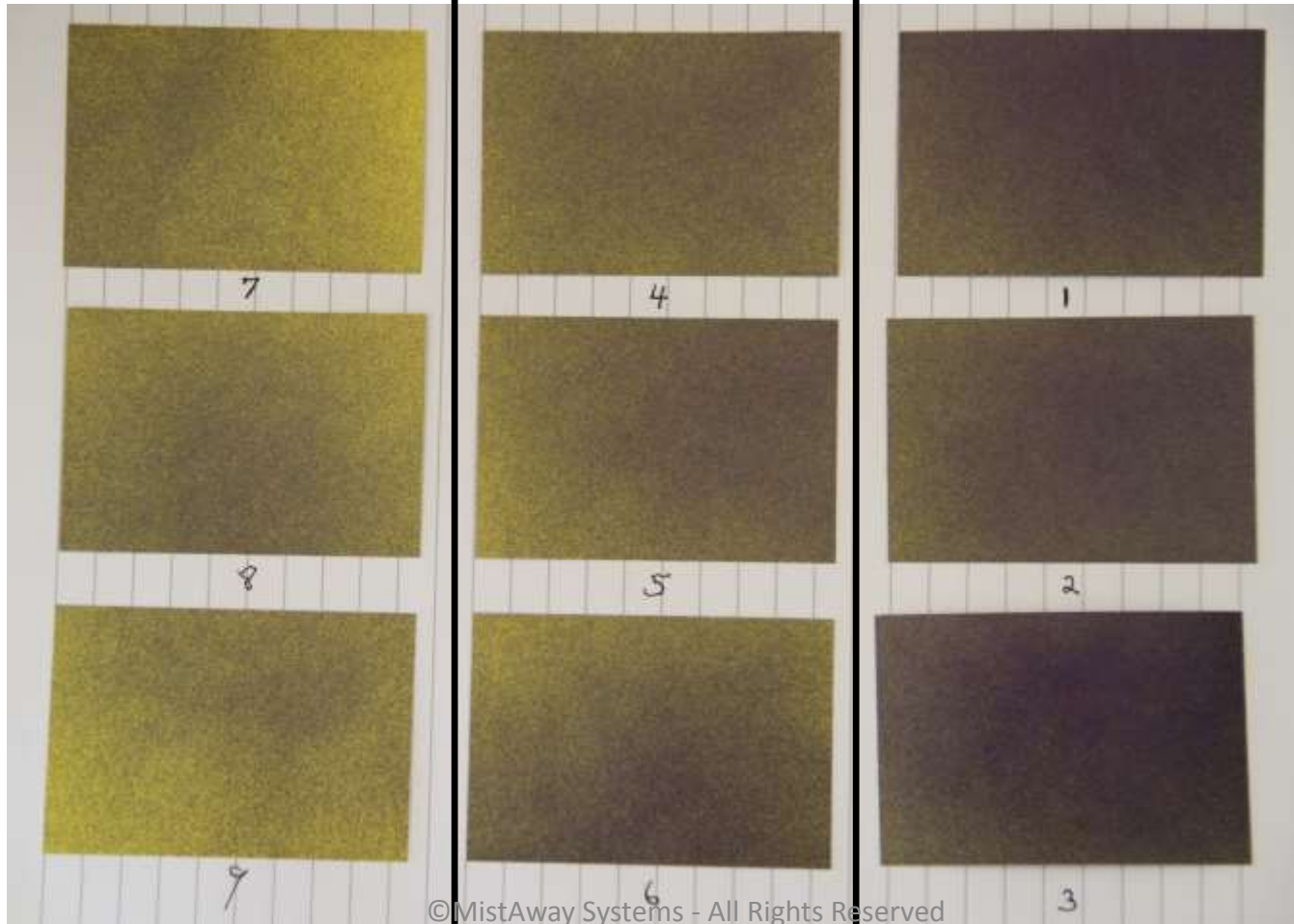
Dilution Makeup	Active In Concentrate	Pts Conc/ Pts Dilution	Actives in Dilution (ppm)
Field	5%	0.5gal/55gal 1/110	455
½ Field		1/220	227
¼ Field		1/440	114
1/8 Field		1/880	57

Efficacy at each Dilution was evaluated at three Coverage Rates - Light, Medium and Heavy – which corresponded to the volume of dilute insecticide atomized by the tower. The photos of water sensitive paper below illustrates how coverage increases as the volume atomized increases.

**Light Coverage
(0.25 ml dilution)**

**Medium Coverage
(0.5 ml dilution)**

**Heavy Coverage
(1.0 ml dilution)**



So, for each insecticide there were twelve “runs”, corresponding to four Dilutions at each of three Coverage Rates. Each insecticide was tested in order of increasing concentration, from 1/8 Field Dilution to Field Dilution. A “control” was treated with 1 ml (Heavy Coverage) of deionized water prior to testing, and no mortality was observed.

PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
Field			
(1/2 Field)			
(1/4 Field)			
(1/8 Field)			

Three mosquitoes (of either sex) were placed in a cup and exposed to a given Dilution and Coverage Rate in the tower. Following exposure, mosquitoes were observed (still in the cup) until 100% mortality was recorded. Mosquitoes were considered “down”/dead when they lay on their side and appeared incapable of returning upright. The time until the last mosquito in each cup went down (TULD) is used to characterize relative effectiveness in the table below.

PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
Field	#	#	#
(1/2 Field)	#	#	#
(1/4 Field)	#	#	#
(1/8 Field)	#	#	X

Number in each cell indicates minutes elapsed after mist until last mosquito died

Color Coding

- All Dead in 0 – 5 minutes
- All Dead in 6 – 15 minutes
- All Dead in >15 minutes
- X – some survivors after 24 hours

The mosquitoes subjected to Riptide, went down very quickly across all Coverage Rates at the Field and ½ Field Dilutions – with no apparent reduction in effectiveness at the ½ Field Dilution. Even at ¼ Field Rate, TULD values were similar with Heavy Coverage. They increased as Coverage and concentration decreased.



Concentrate

- Natural Pyrethrins: 5%
- PBO: 25%

Field Dilution

- Conc to make 55 G (gal): 0.5
- Natural Pyrethrins (ppm): 455
- PBO (ppm): 2275

PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
455 (Field)	3/1	2/2	5/2
227 (1/2 Field)	3/3	2/1	4/2
114 (1/4 Field)	3/1	6/1	9/6
57 (1/8 Field)	8/3	10/2	28/6

In comparing Riptide to Vampyre, there are no significant differences in TULD values, except at the very lowest Dilution x Coverage “run” despite Vampyre’s significantly higher level of PBO.



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
455 (Field)	3/1	2/2	5/2
227 (1/2 Field)	3/3	2/1	4/2
114 (1/4 Field)	3/1	6/1	9/6
57 (1/8 Field)	8/3	10/2	28/6

Concentrate

- Natural Pyrethrins: 5%
- PBO: 25%

Field Dilution

- Conc to make 55 G (gal): 0.5
- Natural Pyrethrins (ppm): 455
- PBO (ppm): 2275



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
545 (Field)	2/0	2/0	4/2
273 (1/2 Field)	3/0	4/1	3/2
136 (1/4 Field)	3/0	2/6	9/3
68 (1/8 Field)	7/1	10/5	14/6

Concentrate

- Natural Pyrethrins: 3%
- PBO: 30%

Field Dilution

- Conc to make 55 G (gal): 1.0
- Natural Pyrethrins (ppm): 545
- PBO (ppm): 5450

Sector appears to work slower than Riptide, with higher TULD values across most Coverage Rates and Dilutions. And in contrast to Riptide, TULD values are significantly higher at Medium and Light Coverage Rates at the ½ Field Dilution.



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
455 (Field)	3/1	2/2	5/2
227 (1/2 Field)	3/3	2/1	4/2
114 (1/4 Field)	3/1	6/1	9/6
57 (1/8 Field)	8/3	10/2	28/6

Concentrate

- Natural Pyrethrins: 5%
- PBO: 25%

Field Dilution

- Conc to make 55 G (gal): 0.5
- Natural Pyrethrins (ppm): 455
- PBO (ppm): 2275



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
909 (Field)	4/2	5/4	7/4
455 (1/2 Field)	5/5	11/6	8/15
227 (1/4 Field)	7/6	8/11	20/8
114 (1/8 Field)	12/6	10/9	11/28

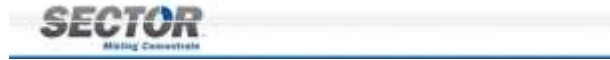
Concentrate

- Permethrin: 10%
- PBO: 10%

Field Dilution

- Conc to make 55 G (gal): 0.5
- Permethrin(ppm): 909
- PBO (ppm): 909

In comparing Sector to Vector-Ban (with no PBO), there is not much difference in TULD values when the Coverage is Heavy. But when coverage is Medium or Light, and at lower Dilutions, the TULD values for Sector are lower.



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
909 (Field)	4/2	5/4	7/4
455 (1/2 Field)	5/5	11/6	8/15
227 (1/4 Field)	7/6	8/11	20/8
114 (1/8 Field)	12/6	10/9	11/28

Concentrate

- Permethrin: 10%
- PBO: 10%

Field Dilution

- Conc to make 55 G (gal): 0.5
- Permethrin(ppm): 909
- PBO (ppm): 909



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
909 (Field)	4/2	8/2	10/5
455 (1/2 Field)	5/2	7/4	17/5
227 (1/4 Field)	10/6	11/4	9/6
114 (1/8 Field)	6/5	13/7	41/12

Concentrate

- Permethrin: 10%
- PBO: 0%

Field Dilution

- Conc to make 55 G (gal): 0.5
- Permethrin(ppm): 909
- PBO (ppm): 0

For both of the Exempt Essentria formulations, at all Dilutions and Coverage Rates, there were still mosquitoes surviving 24 hours after exposure.



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
2000 (Field)	X	X	X
1000 (1/2 Field)	X	X	X
500 (1/4 Field)	X	X	X
250 (1/8 Field)	X	X	X

Concentrate

- Rosemary Oil: 18%
- Cinnamon Oil: 2%
- Lemongrass Oil: 2%

Field Dilution

- Conc to make 55 G (gal): 0.5
- All Actives (ppm): 2000



PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
3864 (Field)	X	X	X
1932 (1/2 Field)	X	X	X
966 (1/4 Field)	X	X	X
483 (1/8 Field)	X	X	X

Concentrate

- Rosemary Oil: 10%
- Geraniol: 5%
- Peppermint Oil: 2%

Field Dilution

- Conc to make 55 G (gal): 1.3
- All Actives (ppm): 3864

In contrast, the exempt Naprovit PRO Plus, had some efficacy at Heavy Coverage rates at both Field and ½ Field Dilutions. For lower concentrations and less Coverage, there were still mosquitoes surviving 24 hours after exposure.

Naprovit PRO Plus™

PPM Active	Heavy Coverage	Medium Coverage	Light Coverage
1600 (Field)	8/29	8/110	31/X
800 (1/2 Field)	8/2	X	X
400 (1/4 Field)	X	X	X
200 (1/8 Field)	X	X	X

Concentrate

- Sodium Laurel Sulfate: 6.4%
- Soybean Oil: 1.6%
- Corn Oil: 0.8%

Field Dilution

- Conc to make 55 G (gal): 1.0
- All Actives (ppm): 1600

Preliminary Conclusions – For mosquitoes only

- Riptide is just as effective at a ½ Field Dilution (1 quart in a 55 gallon drum) as it is at Field Dilution (1/2 gallon in a 55 gallon drum)
- Vampyre isn't any more effective than Riptide. The incremental PBO (and associated cost) doesn't seem to pay off.
- In contrast to Riptide, Sector isn't as effective when it is diluted from Field Rate to ½ Field Rate unless the Coverage Rate is Heavy (which translates to increased nozzle density and/or longer mist durations at the lower concentration)
- In contrasting Sector with Vector-Ban, there does seem to be incremental effectiveness from the PBO in Sector.
- Though not as effective as the conventional formulations, you could expect comparable control with Naprovit Pro Plus if the systems were installed and operated to yield Heavy Coverage (increased nozzle density, longer mist durations)
- Unless the Essentria IC3 and MC formulations are more effective as repellents than the other formulations (not tested), you should not expect comparable control.

Further Study Ideas

- Mosquitoes – make any changes to the protocol that would improve the study and firm up the validity of recommendations to modify field practice
- Mosquitoes – structure study to understand in misting
 - residual efficacy in misting
 - repellancy
- Midges/Sand flies – same study
- Barn Flies – same study