

# FIELD EVALUATION OF TALSTAR (BIFENTHRIN) RESIDENTIAL BARRIER TREATMENTS ALONE AND IN CONJUNCTION WITH MOSQUITO MAGNET LIBERTY PLUS TRAPS IN CEDAR KEY, FLORIDA

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## ABSTRACT

The effectiveness of bifenthrin applications to vegetation with and without commercial mosquito traps (Mosquito Magnet Liberty Plus) was evaluated against *Culicoides* biting midges in a residential coastal area located in Cedar Key, Florida. Efficacy evaluations were determined by surveillance trap collections and modified landing rate counts. In general, all treatments provided significant reduction from *Culicoides* biting midge pressure when compared with untreated yards with no traps (control). However, the combination of bifenthrin and Liberty Plus traps proved to be the most successful in reducing *Culicoides* compared with yards with only a Liberty Plus trap. Yards treated with bifenthrin alone or in combination with the Liberty Plus trap were more successful than controls, suggesting that *Culicoides* biting midge population suppression may be obtained through barrier application alone.

Key Words: *Culicoides*, biting midges, bifenthrin, barrier, traps

## INTRODUCTION

Insecticides when applied as barrier sprays to vegetation has proven effective in the suppression of mosquitoes (Fulcher et al. 2015) and can be an effective part of an Integrated Mosquito Management plan (Richards et al. 2017). However, such applications have limited success against *Culicoides* biting midges. Kettle (1949) attempted to control *Culicoides impunctatus* (Goetghebuer) in Scotland by providing a barrier spray of DDT to vegetation at two pounds per acre. Unfortunately, this effort provided no control. Previous studies have reported success with fogging applications of organophosphates or DDT (Trapido 1947, Bruce and Blakeslee 1948). Conversely, Linley and Davies (1971) concluded that fogging was a waste of effort best reserved for emergencies

when a *Culicoides* population reaches intolerable levels.

Biting midge suppression has been shown when adulticiding aerially using ultra low volume (ULV) applications (Breidenbaugh and Szalay 2010). However, these applications are limited to equipment availability, operating costs, and duration of effectiveness. Madden et al. (1946) were able to control *C. furens* (Poey) for three days using 0.28 kg DDT per hectare when applied aerially. Giglioli et al. (1980) reported 95% reduction when applying ULV fenitrothion aerially. Haile et al. (1984) reported that aerial ULV applications with naled provided 99% control for up to three days; the authors concluded that *Culicoides* control could be obtained with sufficient dose and frequency using this product. Linley and Jordan (1992) were able to provide 90% control for adult

*Culicoides* populations when applying insecticide using an aerial ULV machine.

The pesticide industry has moved to more environmentally safe pesticides such as pyrethroids to accommodate Environmental Protection Agency (EPA) regulations. Furthermore, tests have shown that *Culicoides* have a higher mortality rate when exposed to pyrethroids than organophosphates (Kline et al. 1981, Floore 1985). This suggests that the use of pyrethroids could be a vital part of today's IPM program for *Culicoides*. Standfast et al. (2003) used bifenthrin to treat various home external resting surfaces in River Heads, Hervey Bay, Queensland, Australia. Applied as a coarse spray, bifenthrin resulted in a 75 to 97% reduction in biting midge numbers in the first month and a 65% reduction at 6 weeks post-treatment. The authors concluded that the bifenthrin applications were successful in controlling biting midge numbers during peak emergence while satisfying federal concerns about broad-scale insecticide application to sensitive areas.

Adult mosquito traps are commonly used for mosquito surveillance to evaluate treatment methods or monitor mosquito population abundance (WHO 2013, Li et al. 2016, Bazin and Williams 2018, Wilke et al. 2019)). Mosquito traps have also been used with some success as a control technique to reduce mosquito populations using a propane fueled Mosquito Magnet (MM) Pro (Kline 2006). Moreover, mosquito trap collections have recorded large numbers of *Culicoides* biting midges in the capture nets of MM Freedom and Liberty Plus traps (Lloyd et al. 2008) posing the question; can mosquito traps, alone, be used to reduce *Culicoides* biting midge populations?

The objective of this study was to evaluate the efficacy of treating shrubbery surrounding homes with Talstar (7.9% bifenthrin) only or MM Liberty Plus traps alone as well as their combination against *Culicoides* populations

**Study Site.** The study site consisted of a residential neighborhood (Rye Key; 29.153982, -83.0460009) in Cedar Key, Florida. Rye Key is a 5.91 ha is-

land surrounded by the Gulf of Mexico with extensive inlets with black needle rush (*Juncus* spp.) and cordgrass (*Spartina* spp.) marsh located at the northeastern tip of Cedar Key. This site was chosen because of its previous history of consistently producing large populations of *Culicoides* (Lloyd et al. 2008). In addition, access to the neighborhood was limited by an electronic gate reducing the chance of vandalism or theft of equipment. The surrounding flora associated with each site was similar.

**Treatments.** Treatment one was a MM-Liberty Plus® trap (Liberty Plus), baited with an octenol cartridge manufactured by Wood Stream Corporation (Lititz, PA). The Liberty Plus trap was set up per manufacturers recommendations to run continuously during the study. The Liberty Plus is a propane powered, counter-flow geometry trap that encapsulates a hybrid power fueled by propane that generates heat, moisture, and approximately 550 ml/min combusted CO<sub>2</sub>. The average surface temperature of this trap was 37.1°C with plume temperatures between 33.3 to 40.6 °C. The Liberty Plus has a push-button start with lights that indicate when the machine is operating and if service is needed.

Treatment two was a Talstar® (7.9% bifenthrin) (FMC, Philadelphia, PA) application to shrubbery surrounding the home. The insecticide was applied at max label rate (29.6 milliliters per 3.8 liters, 3.8 liters per 92.9 square meters) using a Solo® (Newport News, VA) backpack sprayer delivering the insecticide dilution in low volume. Retreatment of applications following manufacturer's label instructions of once every four weeks. Treatment three was a combination of the Liberty Plus trap as described in treatment one and Talstar application as described in treatment two. Treatment four was a control with locations under normal

conditions without traps or insecticide. The study was conducted between March and October 2009. All residences in the study were at least 50 m from one another.

**Data Collection.** Two different assessments were incorporated during the study at each residential location. One surveillance sticky trap was placed at each location between the house and treatment. Traps were constructed of a 15.2 x 15.2 cm sheet of Web Trap® adhesive papers (Applica, Miami Lakes, FL) mounted onto a wooden stake secured 1m above the ground and baited with 0.45 kg of dry ice housed in a cooler on the ground (John W. Hock, Gainesville, FL). Collections were obtained every 1-2 days to record biting midge capture for that time period. The surveillance sticky trap was baited with dry ice every 1-2 days and placed at the location before dusk. A flyswatter count was taken every 1-2 days per week during the study at each residential location for 3 minutes using a 15.2 x 15.2 cm section cut from a sheet of Web Trap® adhesive paper (Applica, Miami Lakes, FL) and used to swat pursuing *Culicoides* from the air.

The Liberty Plus trap nets were collected and replaced with a replacement net 1-2 days per week throughout the study. Each Liberty Plus net removed from traps were placed into individual one-gallon plastic Ziploc bag, and any insects inside traps but outside nets were vacuumed and placed inside the respective Ziploc bag. Each Ziploc bag was labeled individually with location, date, and trap identifier. The propane tanks were changed every 18 days. The octenol cartridges were changed every 21 days.

Swatting count were conducted every 1-2 days per week from each location, covered in clear cellophane wrap and labeled with location, date, and treatment information. Surveillance sticky papers were collected every 1-2 days per week from each location and replaced with a new

paper. The collected surveillance sticky papers were covered in clear cellophane wrap and labeled with location, date, and treatment information.

Once collections were returned to the laboratory they were stored in a -20 °C freezer until processed. If the number of *Culicoides* captured was estimated to be more than 500, an aliquot was extrapolated from the total capture and weighed. The weight of the aliquot was divided into the total captured weight and the quotient was multiplied by the number of *Culicoides* identified and counted in the aliquot. If the number of *Culicoides* was estimated to be below 500, the entire collection was identified and counted. Samples were identified to species and counted (Blanton and Wirth 1979).

**Data Analysis.** Data were initially normalized by conversion to  $\log_{10}(n+1)$  then subjected to ANOVA (SAS 2003) using the following model statements: Method = Swatting Treatment Week; Method = Sticky Treatment Week; Treatment = Control Method Week; Treatment = Liberty Plus Method Week; Treatment = Liberty Plus/Talstar Method Week; Treatment = Talstar Method Week; where dependant variables represented numbers of biting midges captured. Method was one of the surveillance methods used to determine biting midge pressure, treatment was one of the four assigned control measures, and week was one of the 20 trapping weeks of the study. Means were separated with the Ryan-Einot-Gabriel-Welsch Multiple Range Test (REGWQ), and unless otherwise stated,  $P < 0.05$  (SAS 2003). Although  $\log_{10}(n+1)$  values were used for the analyses, actual means are reported in the text, and tables.

## RESULTS

Analysis of data by calendar week yielded no significant difference among treatments and weeks for all *Culicoides*, *C. furens*, and *C. mississippiensis* captured. Significant differences in the sticky surveillance and swatting count methods used to survey all *Culicoides* from March to October 2009 were observed ( $F = 18.10$ ,  $df = 3, 19$ ,  $p < 0.0004$ ). Sticky sur-

veillance trap method consistently captured more *Culicoides* than the swatting counts.

Four species of *Culicoides*: *C. barbosa* (Wirth and Blanton), *C. furens* Poey, *C. melleus* (Coquillett), and *C. mississippiensis* Hoffman were collected from sticky traps, flyswatters, and MM Liberty Plus traps (Tables 4-1, 2). There was no significant difference among treatments and weeks or surveillance methods and weeks when overall total abundance was considered on sticky traps. However, all treatments, significantly reduced total abundance of midges compared with controls from those traps (Table 4-3). However, total *Culicoides* reduction was not significantly different between Talstar application with and without the Liberty Plus. Two major species (*C. furens* and *C. mississippiensis*) were collected in large enough numbers to be statistically analyzed. *Culicoides furens* reduction was similar to that for previously mentioned for total *Culicoides* species on sticky traps. All treatments significantly reduced *C. mississippiensis* abundance compared with controls but were not different from one another (Table 4-3). Also, there was no difference in the number of *Culicoides* collected in Liberty Plus traps with or without the Talstar application (Table 4-4).

Significant differences in *C. furens* captured on sticky traps among treatments were observed ( $F=11.95$ ,  $df=3$ ,  $79$   $p<0.0001$ ). The sticky surveillance trap located at the Talstar treatment area caught less *C. furens* than the control and Liberty Plus treatment areas. There were no differences between surveillance sticky traps located at the Talstar and Liberty Plus + Talstar areas. Significant differences in total *C. mississippiensis* captured among treatments (Control, Liberty Plus, Liberty Plus + Talstar, Talstar) from March to October 2009 were observed ( $F=4.45$ ,  $df=3$ ,  $79$   $p<0.0071$ ). The surveillance sticky trap located at the control treatment area captured more *C. mississippiensis* than any surveillance sticky trap located at the other treatment areas. There were no differences in surveillance sticky traps located at the Talstar, Liberty Plus + Talstar, and Liberty Plus treatment areas.

## DISCUSSION

The objective of this study was to determine if an insecticide barrier treatment alone or in conjunction with commercially available traps could provide protection against host-seeking biting midges. Providing a residual insecticide barrier around an area for protection against mosquitoes is not a novel technique (Ludvik 1950, Quarterman et al. 1955, Helson and Surgeoner 1983, Anderson et al. 1991, Perich et al. 1993, Frances 2007, Trout et al. 2007, Cilek 2008, Britch et al. 2009, Qualls et al. 2012, Bibbs et al. 2016). However, barrier treatments with a residual insecticide for protection against *Culicoides* has been understudied (Kettle 1949, Standfast 2003) and the author is unaware of any other study that evaluates the combination of commercial traps and barrier treatments to protect against *Culicoides*.

In general, all treatments provided significant reductions from biting midge pressure when compared to the control. However, the two treatments utilizing Talstar were more successful (89-98% reduction) than the Liberty Plus trap treatment alone (68% reduction). Previous studies have shown similar success using Talstar against mosquitoes to protect military tents (Frances 2007), park recreation areas (Cilek 2008) and even desert environments with sparse vegetation (Britch et al. 2009). In this study, the insecticide barrier treatment provided the greatest reduction in *Culicoides* numbers captured on the surveillance traps. The combination treatment provided the next best reduction. The Liberty Plus trap provided the least *Culicoides* reduction, but was still significantly better than the control treatment. Standfast (2003) reported similar success in Australia (97% reduction) when they treated all surfaces on and surrounding the homes of their treatment sites with Bistar (bifenthrin). The authors conducted one bifenthrin application on vegetation, fence panels, and walls of the homes that they intended to protect from *Culicoides*. The authors monitored the population reporting a decrease in effectiveness (60% reduction) 4-6 weeks after treatment. We were able to produce our results with treatment of the surrounding vegetation alone indicating

that it is possible to receive near-maximum biting midge suppression with reduced insecticide exposure for up to 4 weeks.

When total *Culicoides* and individual species were evaluated, there were significant differences in surveillance methods used, and treatment effects. Swatting counts were not effective at assessing the host-seeking biting midge population. The short duration (3 minutes) assigned to the swatting counts was not sufficient for determining the true host seeking biting midge pressure. In addition, it is not reasonable to spend the time that seems to be required for pressure assessment. Furthermore, timing and climatic events can severely skew pressure assessments that are conducted for short periods of time. The modified sticky surveillance trap was more efficient with pressure assessment and less labor intensive. This method provided a survey for the entire time that a treatment was implemented. However, there is a substantial cost involved (\$1.50 per kilogram) with refilling dry-ice every 24-48 hours. The sticky surveillance trap is an efficient tool for biting midge pressure assessment, but needs to be refined to reduce costs.

The Liberty Plus trap used in the combination treatment captured more *Culicoides* than the Liberty Plus trap alone. It is uncertain as to why this phenomenon occurred. Although the trap capture results are not significant, it is important to discuss the pos-

sibilities resulting in increased trap capture for the combination treatment. It is possible that the insecticide treatment dramatically reduced the amount of resting harborage available due to behavioral avoidance; therefore the *Culicoides* will be more likely to fly towards a trap that produces an attractant plume rather than rest on a surface treated with insecticide, creating a push-pull protection system. Another possibility is the addition of the Liberty Plus trap in combination with the insecticide treatment is attracting or pulling in the biting midges from outside the protected area actually attracting biting midges that may not have normally traveled to the home.

The results from this study suggest that the Liberty Plus trap, Talstar and Talstar/Liberty Plus (combination) treatment will reduce the *Culicoides* population pressure around homes. However, to maximize suppression and response time for protection from *Culicoides*, insecticide treatment alone is the most efficient and economically effective population management technique. Commercial traps may have potential for long term (3-5 years) control programs by providing an alternative control solution to manage insecticide resistance and potentially decreasing a pestiferous population over time. Further evaluations utilizing insecticide applications and commercial traps as a combination treatment are needed.

**Table 4-1.** Total number of *Culicoides* species caught in Cedar Key, FL, from March to October 2009 using four modified sticky surveillance traps and swatting counts.

Species	Sticky surveillance traps	Swatting paper	% of total <i>Culicoides</i> captured
<i>C. furens</i>	56,779	1,709	88.85
<i>C. mississippiensis</i>	6,328	251	9.90
<i>C. barbosai</i>	532	0	0.84
<i>C. melleus</i>	262	0	0.41
Grand Total	63,901	1,960	100

**Table 4-2.** Total number of *Culicoides* species caught in two MM-Liberty Plus traps in Cedar Key, FL from March through October 2009. n = 60

Species	No. of <i>Culicoides</i> spp. captured	% of total <i>Culicoides</i> Captured
<i>C. furens</i>	77,910	92.63
<i>C. mississippiensis</i>	4,898	5.82
<i>C. barbosai</i>	843	1.02
<i>C. melleus</i>	449	0.53
Grand Total	84,100	100

**Table 4-3.** Mean number of *Culicoides* species captured on modified sticky surveillance traps placed at each treatment site in Cedar Key, FL from March through October 2009. n = 80; p < 0.05

Treatments	Total <i>Culicoides</i>	<i>Culicoides furens</i>	<i>Culicoides mississippiensis</i>
Control	2024 ± 440a	1905 ± 411a	890 ± 325a
Liberty Plus	864 ± 322b	234 ± 79b	205 ± 79b
Liberty Plus + Taster	45 ± 13bc	38 ± 11bc	119 ± 46b
Talstar	25 ± 11c	29 ± 20c	6 ± 3b

Within a column, means followed by the same letter designate no significant difference (alpha=0.05).

n= the number of trap replicates for the corresponding time period.

Within a column, degree of freedom for species captured error for each treatment is 79; treatment df = 3

Data were log (n+1) transformed prior to analysis using an ANOVA with trapping method (sticky surveillance trap) and treatment in the model. Significance among treatments analyzed with Ryan-Einot-Gabriel-Welsch multiple range test.

**Table 4-4.** Mean trap capture comparison between the MM-Liberty Plus and MM-Liberty Plus+ Talstar treatments in Cedar Key, FL from March through October 2009. n = 60; p < 0.05

Species	MM-Liberty Plus	MM-Liberty Plus+ Talstar
<i>Culicoides</i> spp.	1,972 ± 520	2,232 ± 462
<i>C. furens</i>	1,948 ± 516	2,184 ± 460
<i>C. mississippiensis</i>	24 ± 14	48 ± 23

Within a row, there were no significant differences between MM-Liberty Plus trap collection means (alpha=0.05).

n= the number of trap replicates for the corresponding time period.

Within a column, degree of freedom for species captured error is 59; trap df = 1.

Data were log (n+1) transformed prior to analysis using an ANOVA with trapping period (method) and trap treatment in the model. Significance between traps analyzed with Ryan-Einot-Gabriel-Welsch multiple range test.

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