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ABSTRACT. Mass trapping with multiple CO₂- and octenol-supplemented Mosquito Magnet® X traps (MM-X), operated 24 h/day, 7 days/wk, from March through November 2008, at St. Andrews State Park on northwest Florida's Gulf Coast, did not significantly reduce mosquito numbers compared to nontreated control sites. *Anopheles crucians*, *Aedes taeniorhynchus*, *Culex salinarius*, and *Culex erraticus* were the predominant species. *Culex coronator* was also collected for the first time in the park. Failure to reduce a late season outbreak of *Ae. taeniorhynchus* within the trapping area required adulticide application to achieve mosquito control.

KEY WORDS Mosquito traps, mass trapping, Mosquito Magnet, Culicidae, *Culex coronator*

INTRODUCTION

Significant improvements have been made in mosquito and biting midge trapping technology, particularly over the past 10–15 years. Various models incorporating propane as a power and heat source, as well as blends of carbon dioxide, octenol, and other attractants have been developed that catch greater numbers and species (Kline 2002). These innovations have led to the idea that such traps, historically used for surveillance, could be exploited for effective, nontoxic control.

There have been relatively few studies evaluating the efficacy of traps for control. In 2001 and 2002, Henderson et al. (2006) assessed single Mosquito Magnet Pro® traps in rural and urban settings in Manitoba, Canada, and found no significant reduction in mosquitoes. A similar 2000–02 biting midge study employing single Mosquito Magnet Pro traps at residential homes in Panama City, Florida, essentially yielded the same conclusion (Cilek and Hallmon 2005). In 2003, the authors tested single Mosquito Magnet Liberty® traps for mosquito control at residential homes in Sunny Hills, Florida, and found no significant reduction between treated and nontreated homes (Smith and Cope 2004). Collier et al. (2006) reported similar findings in a study conducted in three Louisiana communities using the Mosquito Magnet and Biosensory 500 cc Dragonfly® Biting Insect Traps. These studies led us to believe that multiple traps or “mass trapping” as defined by Kline (2006) would be required if there were to be any likelihood of providing effective control.

An extensive database on the performance of a large variety of mosquito traps has been developed (Smith and Shaffer 2000; Smith 2002; Smith et al. 2002; Smith and Walsh 2003; Smith et al. 2006a, 2008). In these studies, the Mosquito Magnet® X trap (MM-X), predecessor to the propane-powered traps patented by American Biophysics

Corporation and now owned by Woodstream Corporation, collected more mosquitoes than most commercial traps on the market.

The purpose of this study was to assess the efficacy of mass trapping with MM-X traps at one of Florida's most visited state parks.

MATERIALS AND METHODS

Study site

The study was conducted under Florida Department of Environmental Protection (FDEP) permit in a 52-ha (128 acre) site at St. Andrews State Park, Panama City Beach, Florida (30°7.52737'N, 85°44.09924'W). The site is bounded by a paved road surrounded by a camping area, salt marsh, and a lagoon to the north and by coastal beach scrub and the Gulf of Mexico to the south. Fresh/brackish water marshes are located on the north side of the study site, which was divided into four, 13-ha (32-acre) plots referred to as S1–S4. Traps were deployed on the south-most 4–6-ha (10–15-acre) portions of the plots (Fig. 1).

Baseline mosquito surveillance

Eight 500 ml/min compressed CO₂-baited, 6-V American Biophysics Corporation (ABC) surveillance light traps (Fig. 2a) were deployed, 2 per plot, to monitor populations throughout the study. The traps were positioned with a Bushnell Yardage Pro Sport® laser range finder ~55–64 m (60–70 yards) apart (Fig. 1) and were operated 24 h twice per week (normally Monday and Thursday), starting 1 month prior to deployment of MM-X control traps. These traps were powered by two parallel-connected, 6-V 12-amp h gel cell batteries, were set for constant fan on, and were light controlled by photocell. Constant CO₂ was provided from 9-kg (20 lb) cylinders equipped

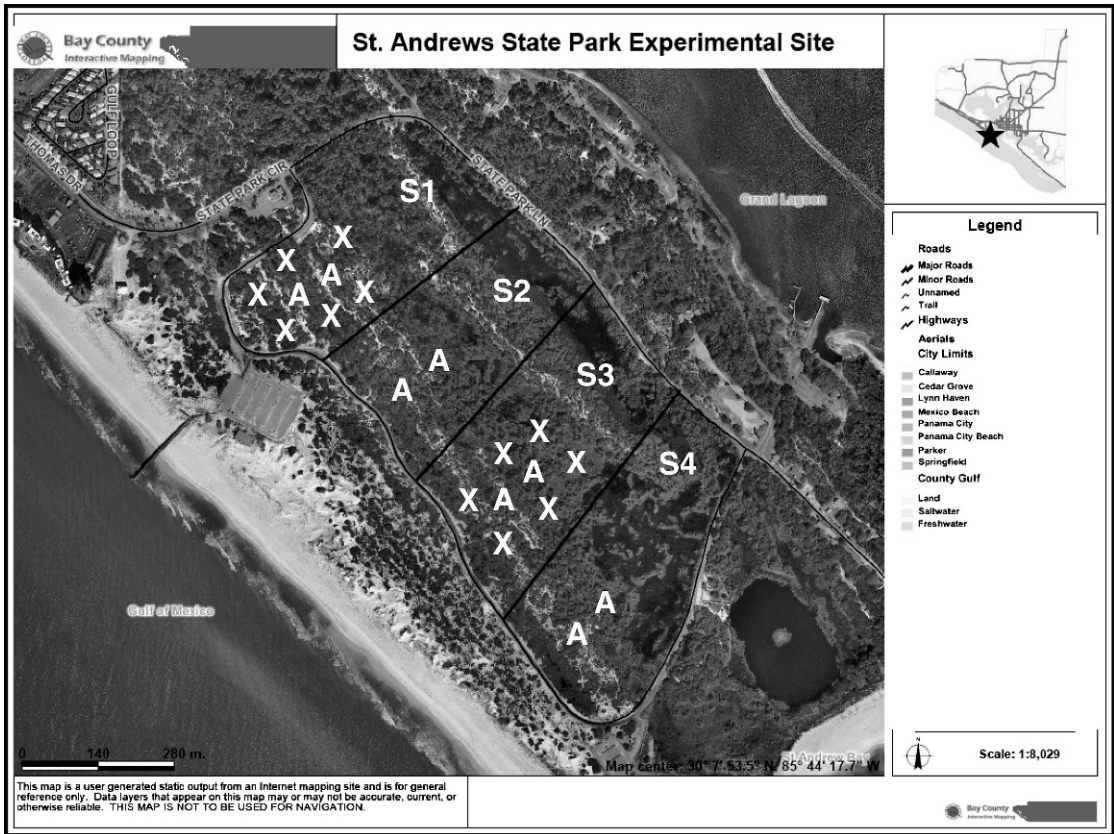


Fig. 1. The 52-ha (128-acre) St. Andrews State Park experimental site with 4 study plots (S1–S4, delineated by perimeter road and lines) and trap configuration (“X” = MM-X traps and “A” = American Biophysics Corporation [ABC] surveillance traps).

with 15-psi Norgren regulators and 0.3-cm (1/8”) black polyethylene hoses fitted with 10- μ m filters and .007 flow restrictor orifices. Cylinders were weighed to verify delivery of between 1.4 and 1.8 kg (3.0 and 4.0 lbs) of CO₂ per 24-h period and changed as needed. Mosquito collection nets were removed after each day of trap operation and placed in a freezer for subsequent sorting, species identification, and counting.

The ABC traps operated very reliably throughout the study; however, on rare occasions, squeaky motors and/or other mechanical problems required repairs. These were conducted immediately or at least within 24 h. There were only 3 instances where no mosquitoes were collected due to windy, cold weather in the early part of the study. Data variation was minimized by excluding these days and by calculating trap capture means by dividing total number collected by number of trap collections (n).

Experimental design

Treatment and control sites were alternated monthly (Fig. 1). Each of 2 treatment sites

contained six, 12 V MM-X traps supplied with compressed CO₂ emitted at 500 ml/min (0.7–0.9 kg [1.5–2 lbs]) during the crepuscular and nighttime hours via a Hock 12 V trap/CO₂ photocell controller board installed beneath the trap cap (Fig. 2b). The same regulator, tubing, orifice, and filter system described for the ABC traps were used. CO₂ cylinders were weighed daily to ensure constant flow rate and were replaced as needed. The traps were supplemented with Woodstream Corporation octenol cartridges inserted into the base of each trap. Octenol was replenished every 21 days according to manufacturer’s instructions. The MM-X traps were positioned 55–64 m (60–70 yards) apart in a circle 55–64 m (60–70 yards) from the center location between the ABC traps and operated 24 h/day, 7 days/wk. Two serially connected, 6-V 12-amp h gel cell batteries were used to power the traps. During weekends, 2 pairs of serially connected batteries were parallel connected to the traps for continuous unattended operation. The MM-X traps were rotated monthly through all sites in a 4 treatment \times 4 location Latin-square and operated continuously over 8 months from the 1st week in April 2008 until the



Fig. 2. (a) American Biophysics Corporation (ABC) surveillance light trap. (b) MM-X control trap.

3rd week in November 2008. Weekly mosquito collections were placed in 0.95-liter (1 qt) zip-lock bags, numbered by location/date, and placed in a freezer. Since the predominant species were of similar size, the total number collected was estimated by counting the number of mosquitoes in several representative 10-ml samples and determining an average of 250. Dividing the total volume (placed in a 100-ml graduated cylinder) by 10 and multiplying by 250 yielded the estimate. Accuracy of this estimate was not critical since the MM-X traps were used for control purposes only. All species and prevalence data were acquired from the ABC traps.

Statistical analysis

Experimental variables were tested for departure from the normal distribution and $x + 1$ log transformed where necessary. Analysis of variance (Sokal and Rohlf 1981) conducted with Statistica Version 8.0 (StatSoft Inc. 2008) was used to determine differences between treatment means for each monthly rotation. Results were considered significant at alpha level of 0.05.

Weather data

Meteorological data were collected from the time treatments were initially deployed in April throughout the entire study period. Precipitation

was measured weekly from rain gauges deployed at the center of each of the 4 sites. Temperature, humidity, wind speed, and direction were acquired through Weather Underground® (<http://www.wunderground.com>) from the North Lagoon weather station located 3.2 km (2 miles) northwest of the park.

RESULTS

Meteorology

St. Andrews State Park received record rainfall during late winter and spring, causing the park to flood from February through April. During the summer, the floodwaters receded, and the park dried to the point where there was very little standing water. Later in the fall, precipitation increased considerably. Temperature and humidity fluctuated within normal historic ranges. Wind speed averaged between 0 and 8 kph (0 and 5 mph), with maximums ranging between 14.5 and 19.3 kph (9 and 12 mph) and gusts averaging around 19.3–24.1 kph (12–15 mph). Prevailing wind direction for most of the study was a sea breeze from the south.

Mosquito surveillance

The predominant mosquito species in order of abundance in the ABC light traps were *Anopheles*

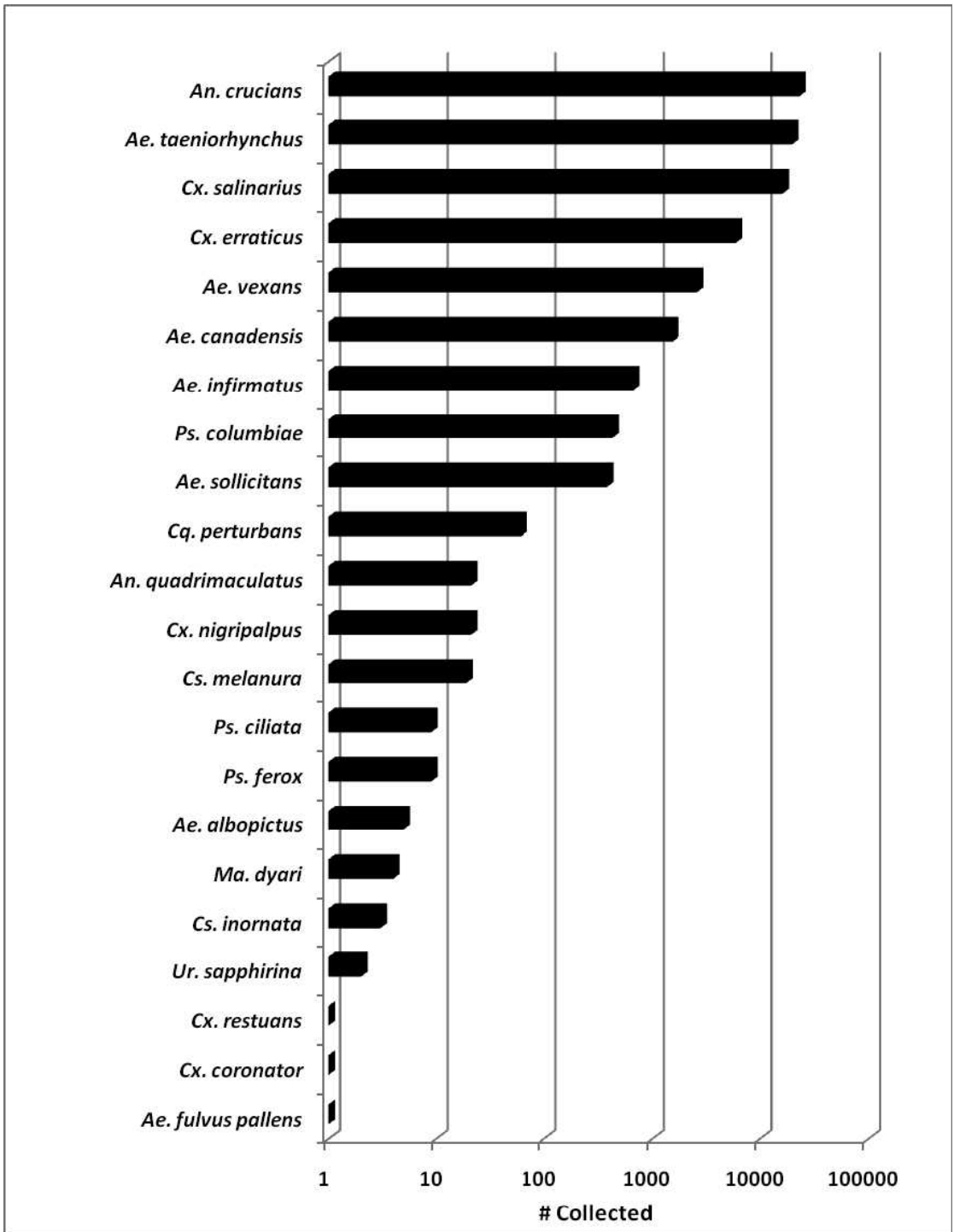


Fig. 3. Log scale of mosquito species composition collected over 9-month study period in American Biophysics Corporation (ABC) surveillance traps at St. Andrews State Park.

crucians Wiedmann, *Aedes taeniorhynchus* Wiedmann, *Culex salinarius* Coquillett, *Culex erraticus* Dyar and Knab, *Aedes vexans* Meigen, and *Aedes canadensis* Theobald (Fig. 3). One specimen of

Culex coronator Dyar and Knab, newly introduced to Florida (Smith et al. 2006b), was also collected for the first time in the park. The first 4 species accounted for 92% of the mosquitoes

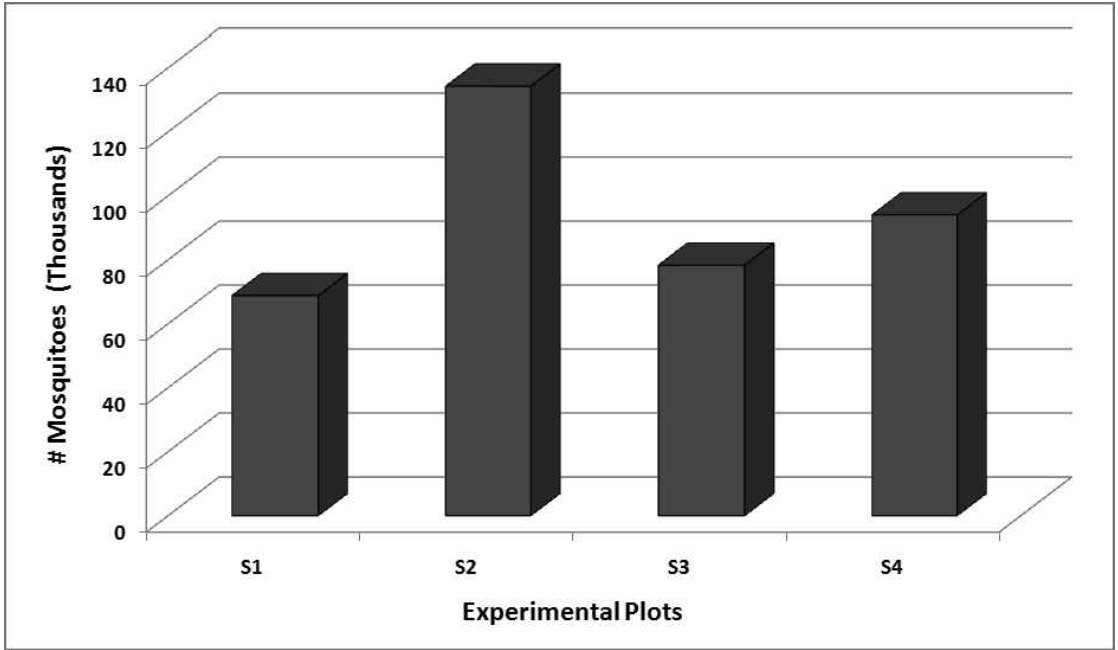


Fig. 4. Total estimated number of mosquitoes extracted by MM-X traps over 8-month period in 4 experimental plots.

collected. The total number of mosquitoes removed by the MM-X traps was estimated to be 375,250 for all 4 sites (S1–S4) (Fig. 4). Fewer numbers of mosquitoes collected at S1 and S3

were attributed to the site rotation schedule. MM-X traps were not operated at these sites during peak *Ae. taeniorhynchus* emergence in November.

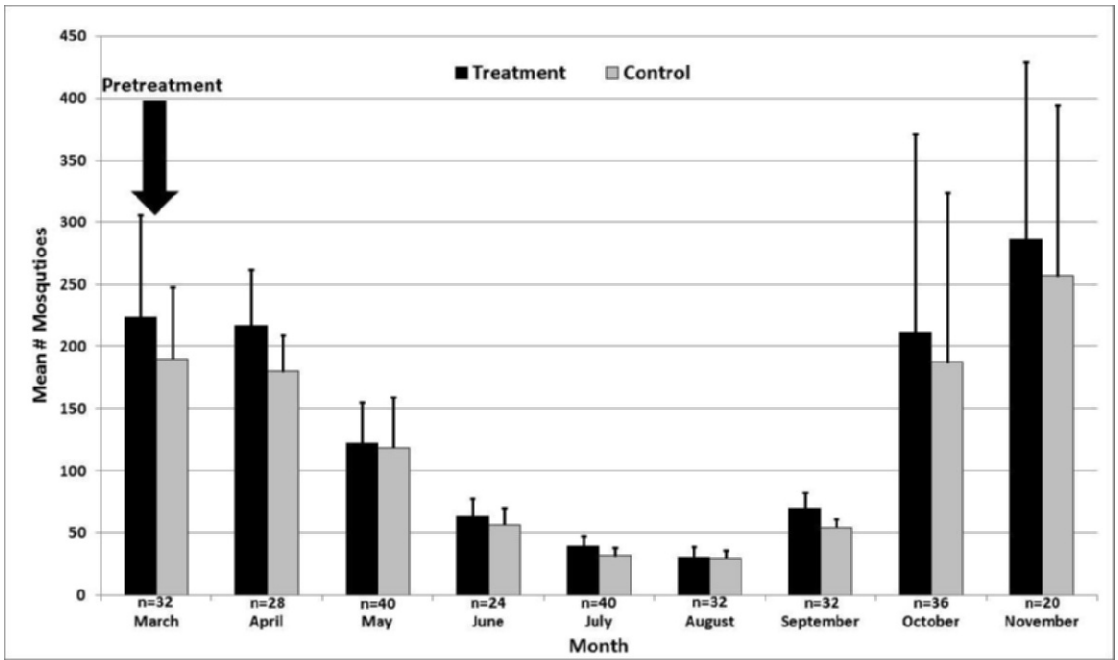


Fig. 5. Mean number of mosquitoes caught in American Biophysics Corporation (ABC) surveillance traps (+/- 95% confidence interval) in treatment and control sites over 9-month study period (n = number ABC trap collections per month).

The monthly mean numbers of mosquitoes collected in the ABC surveillance traps in treatment and control sites are presented in Fig. 5. Greater pretreatment (i.e., the time period prior to deployment of the MM-X traps) and posttreatment numbers in March and October, respectively, are attributed to increased rainfall and tide levels. The mean numbers of mosquitoes captured were not significantly different in treatment and control sites for any of the months studied.

DISCUSSION

Kline (2006) conducted a mass trapping project on 3 small islands known as Atsena Otie in the big bend region of the Florida Gulf Coast. Albeit anecdotal, he reported Mosquito Magnet Pro traps to be effective in controlling black salt marsh mosquitoes, *Ae. taeniorhynchus*. However, results were not as promising in another study conducted in a residential area of Gainesville, Florida (Kline, unpublished data).

Based on our findings, control was not achieved using the configuration of MM-X traps as utilized in this project. The MM-X traps did not significantly reduce mosquito numbers compared to control sites. Numbers removed appear to have been a minor percentage of the total. During the latter part of this study, the mosquito problem was so severe that park management called to request spraying because many of the campers were complaining and/or leaving the park. It was clear the trapping effort was not effectively reducing the mosquito population.

The goal of achieving nonpesticidal control of mosquitoes is a worthy pursuit. Based on these findings, it appears that more traps, smaller treatment area, and/or lower mosquito populations will be required.

This study emphasizes the importance of maintaining pesticial options available for control. Had this been a disease situation, reliance on traps would have jeopardized the health and safety of the park workers and visitors. Furthermore, the amount of labor and CO₂ required in maintaining this 24 h/day, 7 days/wk trapping network was substantial, clearly exceeding the cost of several pesticide applications.

ACKNOWLEDGMENTS

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Woodstream Corporation supplied the octenol used in this study.

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