Characterization and efficacy of VectoBac® WDG applications targeting container-inhabiting mosquitoes utilizing Unmanned Aerial Vehicles

Keira J. Lucas[1(CO)], Peter Brake[1(CO)], Sara Grant[1], Leanne Lake[2], Rachel B. Bales[1], Richard Ryan[1], Nate Phillips[1], Patrick Linn[1]

[1]Collier Mosquito Control District, 600 North Road Naples, FL 34104, [2]Valent Biosciences, Libertyville, IL
CO – Contributed equally to this work

Introduction

Unmanned Aerial Vehicles (UAV) represent a novel tool for mosquito control operations. The potential for UAV usage has rapidly expanded to different operational activities, including enhanced larval and mosquito surveillance methods (Hass-Stapleton, 2019), habitat mapping (Carrasco-Escobar, 2019; Hardy, 2017) and precise application of control materials. Small-scale applications of control materials using UAVs has successfully been used to target agricultural pests and pathogens (Hunter, 2019; Qin, 2016; Wang, 2019; Xiao, 2019), and adult mosquito populations (Li, 2016). Recently, the Collier Mosquito Control District began incorporating UAVs into our Integrated Pest Management Program, including the adoption of the PrecisionVision® 13 (PV13) UAV outfitted with the PrecisionVision® Liquid Application System (Leading Edge Aerial Technologies) (Figure 1A). Here we report the application and efficacy of VectoBac® WDG (Vallent Biosciences) using the Disricts PV13 UAV.

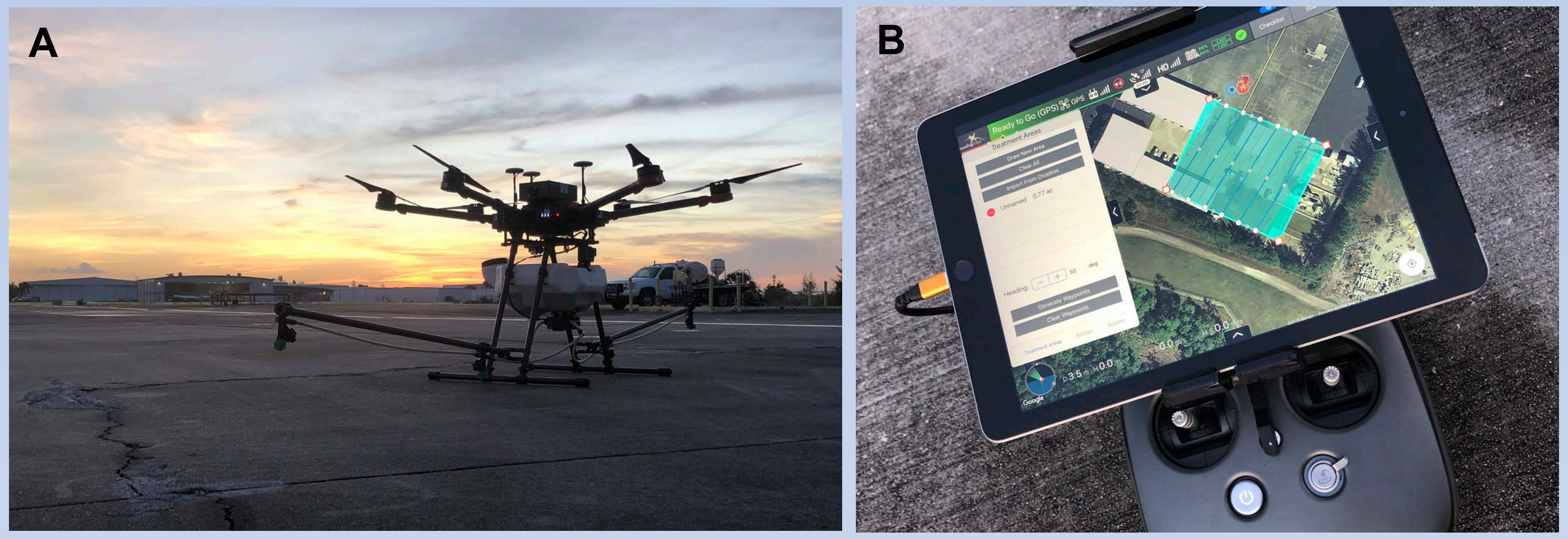
Methods

The Districts PV13 UAV Liquid Application System was equipped with four flat-fan TeeJet nozzles (#800067) capable of producing extra fine droplets for WALS™ applications of a 12% VectoBac® WDG suspension and calibrated for an application rate of 0.5 lbs/acre. For droplet characterization and accompanying larval assays, two sampling lines were established – one to assess droplet distribution into the wind (narrowest swath) and another taking into account cross wind (widest swath). The "into the wind" format included a 75 ft sampling line placed perpendicular to the wind with UAV applications occurring toward the wind at the 36 ft station. Twenty-five card sampling stations were set at 3 ft intervals, with larval assay cups every six feet between the 15 ft and 69 ft stations. The "cross wind" design included a 200 ft sampling line placed parallel to expected wind pattern with UAV applications occurring perpendicular to the sampling line at the 30 ft station. Forty sampling stations were established every 5 ft intervals along the sampling line, with larval assay cups being placed every 10 feet between the 30 ft and 120 ft sampling stations. All applications were made prior to sunrise to maximize ground deposition of small droplets.

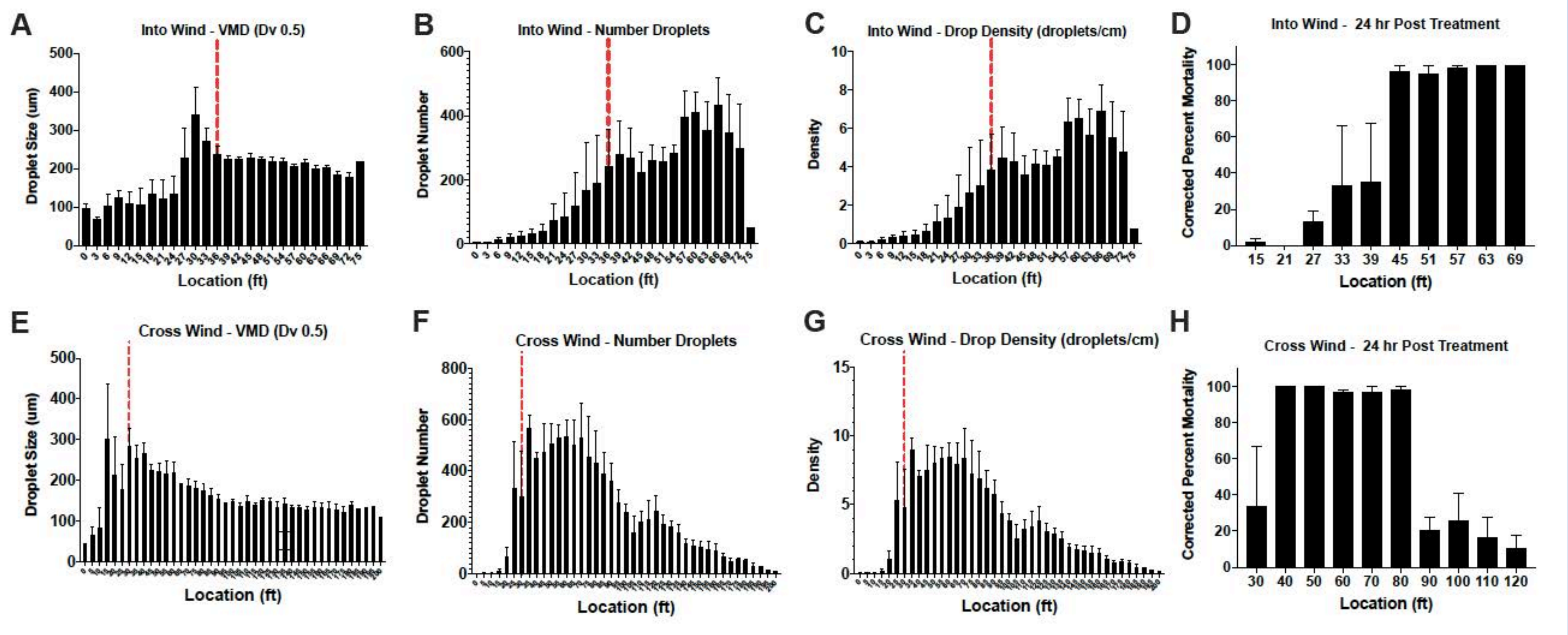
A field trial was performed in conjunction with an operational treatment (Figure 3A) of a one-acre treatment block in an urban industrial park known to harbor large number of container inhabiting mosquitoes. The habitat contained abundant debris, with emergent vegetation. Treatment blocks and applications were created using the PrecisionVision® iOS app (Figure 1B). Larval assay cups were randomly placed within the one-acre treatment block to simulate containers in cryptic habitats. Pre- and posttreatment larval dips, landing rates and BG-trap (Biogents AG) data was also collected. An application using the PV13 UAV was made at a rate of 0.5 lbs/acre of the 12% suspension of VectoBac® WDG at an application height of 30 ft above canopy/buildings (75 ft above ground).

Results

Figure 1: (A) Collier Mosquito Control District's PrecisionVision 13 (PV13) UAV outfitted with the PrecisionVision Liquid Application System. TeeJet nozzles (#800067) capable of producing extra fine droplets were utilized for WALS™ applications of a 12% VectoBac® WDG. (B) The PrecisionVision® iOS app was used for mission planning and aerial applications using the PV13 drone.



Droplet and Swath Characterization



Operational Treatment & Field Trial

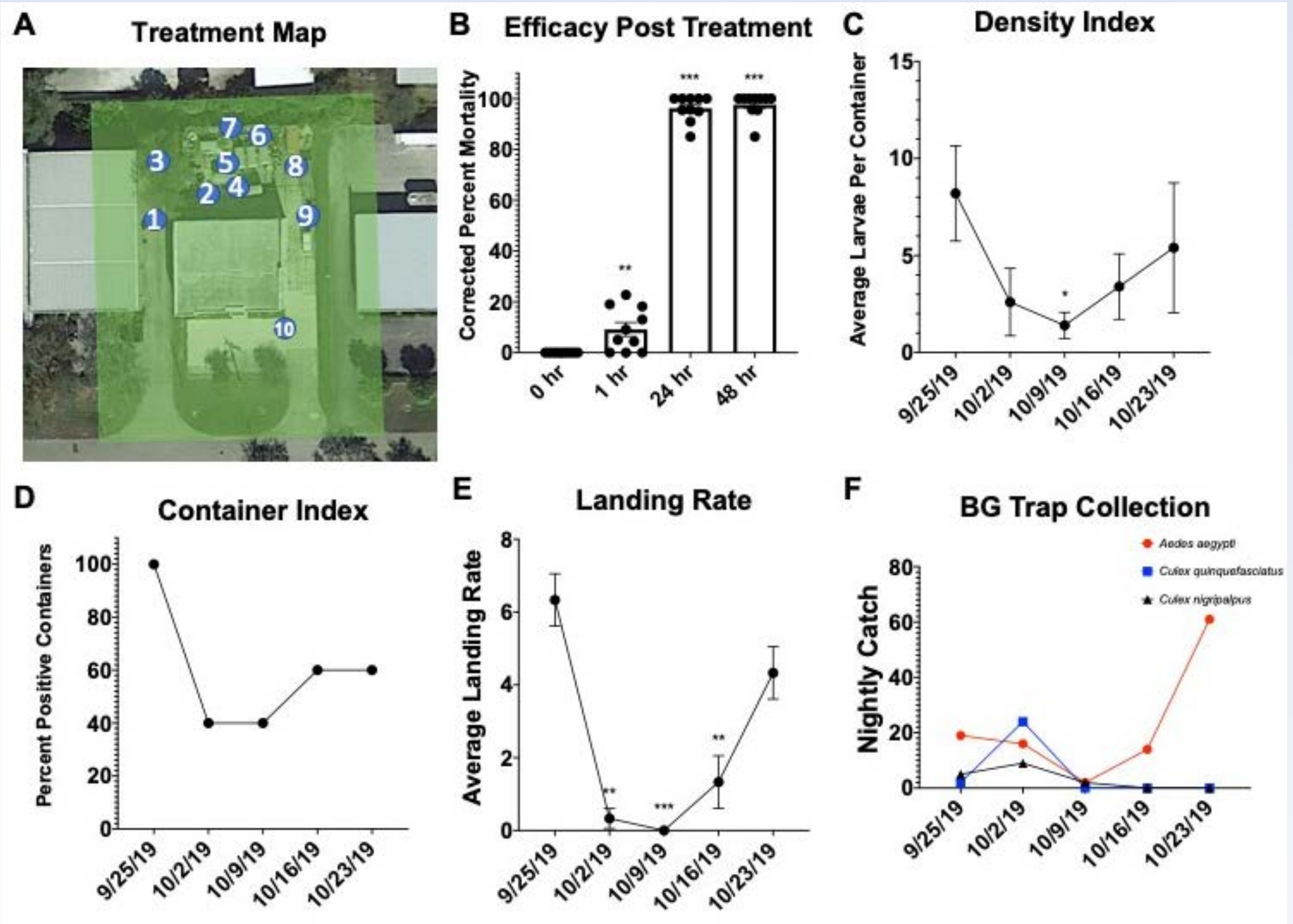


Figure 2: Droplet characterization and larval mortality for into wind (A-D) and cross wind (E-H) designs. (A) Average Volume Median Diameter (VMD), (B) average number of droplets and (C) average drop density across collection stations of into wind characterization. (D) Larval mortality assays across collection stations of into wind characterization. (E) Average Volume Median Diameter (VMD), (F) average number of droplets and (G) average drop density across collection stations of cross wind characterization. (D) Larval mortality assays across collection stations of cross wind characterization. Data represents three replicates and are shown as mean ± SEM.

Figure 3: Operational Treatment results. (A) One-acre treatment map and cup placements within industrial park. (B) Corrected percent mortality at 1 hr, 24 hrs and 48 hrs post treatment. (C) Average larvae per containers (Density Index), (D) percent positive containers (Container Index), (E) Average landing rate and (F) BG-trap collections determined weekly for 4 weeks post treatment. Graphical and statistical analysis were performed using GraphPad Prism 8. Data represents three replicates and are shown as mean ± SEM where appropriate. A two-tailed student's t-test was performed to indicate statistical significance where appropriate; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Conclusions

The "into the wind" design resulted in an average VMD of 216.67 ± 4.78 across all three replications. Droplet size was greatest near the flight line (36 ft station); however, droplets were relatively larger in size from 30-75 ft (Figure 2A), which may represent drift of the product to changing wind direction or variable flow between the spray system booms. Average drop number and drop density followed a similar pattern (Figure 2B-C). Larval assays displayed mortality of greater than 90% between the 45 to 69 ft stations, indicating an effective narrowest swath of approximately 24 ft on average (Figure 2D).

The "cross wind" format resulted in an average VMD of 235.67 ± 22.95 across all three replications, with the greatest number of droplets accumulating between the 30 ft and 90 ft stations (Figure 2F-G). Droplet size was also largest near the flight line (30 ft station) with droplets extending beyond the 200 ft station (Figure 2E). Larval assays displayed mortality of greater than 90% between the 40 to 80 ft stations, indicating an effective swath of 40 ft on average (Figure 2H).

In field trials (Figure 3A), nearly 100% efficacy was achieved within 24 ($p < 0.0001$) and 48 hrs ($p < 0.0001$) post-treatment in larval assay cups (Figure 3B). Larval density appeared lowest at 2-weeks post-treatment ($p = 0.0283$), with larval density reestablishing by 4-weeks post-treatment (Figure 3C). By 1-week post-treatment, the percent of positive containers in the area reduced by 60% and remained low during the duration of surveillance activity in the area (Figure 3D). Landing rates were significantly reduced by 1-week post-treatment $p = 0.0015$) and remained low for 3 weeks, with the population reestablishing within 4-weeks post-treatment. Trap collections depicted a decreased trend in *A. aegypti* adults by 2-weeks post-treatment, with the population reestablishing within 3-weeks post-treatment.

References

Carrasco-Escobar *et al.* (2019) *PLoS Negl Trop Dis 13:e0007105.*
Hardy *et al.* (2017) Parasit Vectors 10:29
Hunter *et al.* (2019) Pest Manag. Sci. doi: 10.1002/ps.5651.
Li *et al.* (2016) J. Am. Mosq. Control Assoc. 32(1): 59-62.
Qin *et al.* (2016) J Crop Prot 85:79–88.
Wang *et al.* (2019) Pest Manag. Sci.75(6): 1546-1555.
Xiao *et al.* (2019) Pest Manag. Sci. doi: 10.1002/ps.5635.

Acknowledgements

The authors thank the Collier Mosquito Control District (CMCD) Board of Commissioners and all the employees at CMCD who participated in sample collection and technical assistance. We also thank Candace Royals (Valent Biosciences) for initiating the collaborative work with Valent Biosciences to perform spray system calibration and characterization.