Evaluating aerial ultra-low volume (ULV) adulticiding applications for *Aedes spp.* control

CITY OF NEW ORLEANS

Brendan Carter, Sarah Michaels, Cynthia Harrison, and Claudia Riegel

City of New Orleans Mosquito and Termite Control Board

CITY OF NEW ORLEANS

Abstract: Urban populations of *Aedes aegypti* and *Aedes albopictus*, potential vectors of both chikungunya and Zika viruses, are present in New Orleans, Louisiana in abundance. To control both mosquito species, the City of New Orleans Mosquito and Termite Control Board (NOMTCB) utilizes aerial adulticide missions as an important tool in their integrated pest management (IPM) program. During the summer of 2015, an ultra-low volume (ULV) aerial application of Dibrom® (naled; AMVAC Chemical Corporation, Newport Beach, CA) at 0.5 oz/acre was tested for efficacy against laboratory-reared, field-derived caged *Aedes* mosquitoes. Paired cages were placed in open and sequestered areas, including under raised homes and in dense vegetation, in two urban neighborhoods with high human density and abundant mosquito populations. Aerial applications against caged *Aedes aegypti* in open locations resulted in 90.1-90.7% average mortality and 81.6-97.9% in sequestered locations. *Aedes albopictus* mortality was 73.6%-99.6% in open locations and 66.3%-92.0% in sequestered locations. In addition, Tinopal® fluorescent dye (BASF Corporation, Florham Park, NJ) was mixed with Dibrom® and fluorescent droplets were captured utilizing rotating aerosol droplet samplers (John W. Hock, Gainesville, FL) and Teflon®-coated slides. Droplet analysis was conducted using Dropvision® (Leading Edge Associations, Inc., Fletcher, NC). Fluorescent droplets were present in the treatment areas only. Droplet collections were low, despite high mortality. This work demonstrates that aerial adulticide applications can rapidly reduce *Aedes* populations in outdoor open environments and cryptic sequestered resting sites. However, it is important that insecticide resistance studies are conducted routinely to determine the susceptibility of the mosquito population to the insecticide in use. The NOMTCB will continue to utilize aerial ULV adulticide applications against *Aedes* species in partnership with other intervention strategies including biological control and community involvement to mitigate abundant mosquito populations and reduce risk of vector-borne disease.

Background: The mission of the City of New Orleans Mosquito & Termite Control Board (NOMTCB) is to protect the residents and guests of New Orleans from nuisance mosquito species and disease vectors including *Aedes aegypti* and *Aedes albopictus.* The two Zika vectors exist in various populations densities throughout the city (Figure 1). These urban container-breeders will breed in a variety of locations include cemetery jars, household trash and debris, planters, and illegally dumped tires among others. This trial investigated the efficacy of aerial adulticide applications on susceptible, field-collected *Aedes* mosquitoes from New Orleans, LA. Some research studies have shown aerial adulticide space spraying to be ineffective against *Aedes* mosquitoes potentially due to the applications time (Bonds et al., 2012). Previous research by the NOMTCB suggests that multiple aerial adulticide applications may be necessary for *Aedes spp.* control during arboviral outbreaks (Andis et al., 1987). In addition, this study investigated whether aerial applications can effectively reach and kill mosquitoes resting in harborage sites such as under raised homes or under dense vegetation.

Figure 1: Map representing *Aedes aegypti* density in New Orleans, LA based on the ratio of *Aedes aegypti* to total *Aedes* based on 2013 ovitrap collections

Methods: This aerial efficacy trial was conducted at dusk during the summer of 2015 utilizing Dibrom® mixed with fluorescent Tinopal® (1 gm/L) against field-collected, susceptible caged *Aedes aegypti* and *Aedes albopictus*. The aerial application was conducted by a twin engine Britten Norman Islander with flat fan 8001 spray nozzles and on-board real time information systems (Figure 2). The application rate was 0.5 oz/acre.

Three zones were created in New Orleans, LA in neighborhoods with high *Aedes* mosquitoes. populations (Figure 3). Zone A and Zone B served as treatment zones. Field-derived, susceptible *Aedes aegypti* and *Aedes albopictus* were aspirated into cages and were placed in open and sequestered sites through each neighborhood. Fifteen to twenty female mosquitoes were utilized in each cage (Figure 4). Sequestered locations included underneath raised houses and heavy vegetation (Figure 5). The open and sequestered sites were paired by house or land parcel.

Fluorescent droplets were collected on 25 mm Teflon®-coated slides with motorized droplet impinges. Spinners were placed in three open and three sequestered locations in each zone. Slides were read by Mark Latham (Manatee County Mosquito Control, Manatee County, Florida) and Peter Connelly (AMVAC Environmental Products, Fletcher, NC) the following day utilizing the DropVision® software. Meteorological data was also obtained to measure environmental stability.

The aerial application lasted for about 45 minutes. Cages and spinners were left for 1 hour post-treatment. After the 1 hour period, the mosquitoes were knocked down with dry ice and were transferred to clean cups. Mortality readings were taken at 1 hour and 24 hours post-treatment. Spinners were placed into a secure container and taken to the lab for reading the following day. Surveillance pre- and post-trial was conducted using Biogents Sentinel 2 (BGS-2) traps.

Figure 2: Britten-Norman Islander

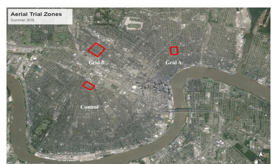

Figure 3: Aerial trial treatment zones in New Orleans, LA

Figure 4: Placing mosquito cages in the treatment zone

Figure 5: Open versus sequestered cages and spinners

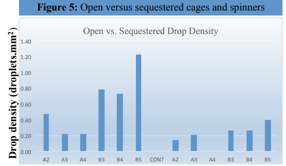

Figure 10: Open versus sequestered droplet density (number of droplets/mm²)

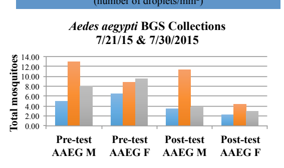

Figure 11: *Aedes aegypti* BGS-2 Collections

Results: Mortality amongst both open and sequestered mosquitoes was mostly high. Mortality in treated cages were corrected using Abbott's formula (Abbott, 1925).

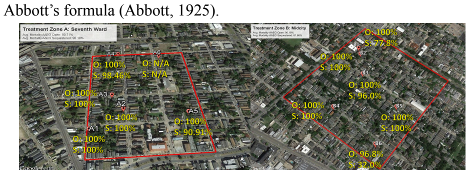

Figure 6: *Aedes aegypti* mortality by site in Treatment Zone A and B

Aedes aegypti

For *Aedes aegypti* in open cages, we achieved 90.71% and 97.87% corrected mortality in Zone A and Zone B, respectively (Figures 6 & 8). In the control *Aedes aegypti* mosquitoes, three mosquitoes died most likely due to the transfer process. There was no other mortality in control mosquitoes. The non-corrected mortality for open *Aedes aegypti* cages in Zone A was 100%. Mortality for sequestered *Aedes aegypti* was 90.18% in Zone A and 81.86% in Zone B.

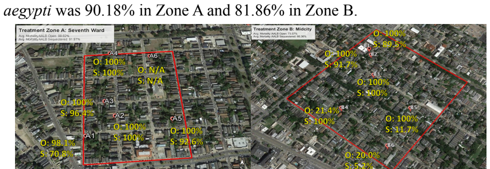

Figure 7: *Aedes albopictus* mortality in Treatment Zone A and B

Aedes albopictus

For *Aedes albopictus* in open site cages, we achieved 99.62% corrected mortality in Zone A but only 73.57% mortality in Zone B (Figures 7 & 9). In sequestered cages, mortality in Zone A and Zone B were 91.97% and 66.36%, respectively.

	Open Cages	Sequestered Cages
Grid A	90.71%*	97.87%
Grid B	90.18%	81.66%

Figure 8: Average percent mortalities for *Aedes aegypti*

	Open Cages	Sequestered Cages
Grid A	99.62%	91.97%
Grid B	73.57%	66.36%

Figure 9: Average percent mortalities for *Aedes albopictus*

Droplets & Meteorology

Fluorescent droplets were present in the treatment zones, but in small numbers (Figure 10). The average number of droplets per slide was 11.8 droplets with the highest number of drops found as 32. No droplets were present in the control area. No droplets were present in the control pre-treatment, however non-fluorescent droplets were found in the treatment zones post-treatment. The weather was conducive for aerial applications with 7-15 mph winds aloft and 3-7 mph winds at ground level.

Surveillance

Trapping with BGS-2 traps showed a decrease in wild *Aedes aegypti* populations immediately after application (Figure 11). A decrease was not seen in wild *Aedes albopictus* populations.

Conclusions

Overall, the aerial treatment was effective against both open and sequestered *Aedes aegypti* and *Aedes albopictus*. The mortality amongst sequestered mosquitoes was still reasonably high, however future research is needed to determine the mortality threshold needed for control of wild *Aedes* mosquitoes. Aerial applications are capable of delivered ultra-low volume droplets to mosquitoes in sequestered locations, however subsequent trials may help elucidate the low numbers of fluorescent droplets. Aerial adulticide applications are an effective control method in an integrated mosquito management plan (IMM) for *Aedes* mosquitoes.

References

Abbott, W.S. (1925). A method of computing the effectiveness of an insecticide. J. Econ. Entomol.; **18**:265-267.

Andis, M.D., Sacket, S.R., Carroll, M.K., Bordes E.S. (1987) Strategies for the emergency control of arboviral epidemics in New Orleans. J. Am Mosquito Control Assoc.; **3**(3):125-130.

Bonds, J.A. (2012)Ultra-low volume space sprays in mosquito control: a critical review. Med Vet Ent; **26**(2):121-30.

Acknowledgments:

The authors thank Dr. Janet McAllister (Centers for Disease Control and Prevention), Peter Connelly (AMVAC Environmental Products), and Mark Latham (Manatee County Mosquito Control District).