Dengue/Chikungunya Vector Management Plan in Urban Environments

Introduction

This document has been prepared by the Florida Mosquito Control Association's ad hoc "Committee on Dengue/Chikungunya Vector Management and Response". Below is an outline of the suggested general methods to determine location and monitor relative abundance of immature and adult *Ae. aegypti* and *Ae. albopictus* populations while providing guidance on the types of control available. Suggested operational methods for each category of the Plan provides detailed methods that mosquito control programs can pick and choose from for surveillance and control. The members of the ad hoc committee understand that the Dengue/Chikungunya Vector Management and Response Plan is a "living document" and will be updated as information from research and operational experience dictate regarding the biology, ecology, and control of these 2 mosquito vectors.

In urban areas, *Ae. aegypti* and *Ae. albopictus* primarily develop in containers that hold water, as such, management and control require different operational strategies than most Florida mosquito control programs may be familiar with. For example, many other mosquito species that mosquito control programs routinely control (e.g. *Ae. taeniorhynchus, Ae. vexans*, *Psorophora* spp., and *Culex* spp.) may develop in suburban and/or remote (rural) locations. Generally, these species have larval and adult populations that are focal and concentrated, as well as possess bionomics (adult activity periods, larval habitats) that allow mosquitocides to be efficaciously introduced. Most important for a public service agency, mosquito control efforts employed upon these "traditional species" have minimal aversive interaction with human-residential bystanders. Surveillance and control will be different for vectors of WN (*Culex*) compared with dengue/chikungunya vectors (*Aedes*). For example, domestic container *Aedes* surveys are more labor intensive than ditch-line or road-side larval habitat inspections. Moreover, adult surveillance tools are different because *Ae. aegypti* and *Ae. albopictus* are considered "day-biters".

It is suggested that dengue/chikungunya vector management response be based on surveillance and subsequent monitoring of immature and adult *Ae. aegypti* and *Ae. albopictus.* In order to assess population distribution and abundance of both vectors in a target area the following can be used:

1. IMMATURE SURVEILLANCE METHODOLOGY

Survey areas to assess human to mosquito contact risk to aid in decision making on control method (e.g. rank areas from lowest to greatest relative abundance/distribution of immature *Ae. aegypti*/*Ae. albopictus*, especially pupae. The higher the abundance, the greater the risk and need for immediate reduction.)

A. **Peridomestic Container Survey** (see S-1)

- i. Initially, grid area or neighborhood to aid in surveying and documenting location of containers and prioritize areas for control.
- ii. Peridomestic container surveys.
- iii. Larval production surveys.
- iv. Pupal production surveys.
- v. Monitoring should be performed weekly but depends on labor.
- vi. Data from surveys used to determine risk for quantitative indices assessment.

B. **Ovijar Survey** (see S-2)
   i. Initially, grid area or neighborhood to aid in surveying and documenting location of containers and prioritize areas for control.
   ii. Determine species present and potential relative abundance of population.
   iii. Eggs from jars flooded then larvae reared to 4th instar for identification.
   iv. Eggs collected once a week.

C. **OPTIONAL SURVEY: Ovijar as Domestic Container Survey** (use S-1 & 2)
   i. Initially, grid area or neighborhood to aid in surveying and documenting location of containers and prioritize areas for control.
   ii. If enough domestic containers are not available for determining initial immature mosquito populations in sample areas, ovijars can serve as repositories to monitor abundance of larvae/pupae rather than egg abundance.

NOTE: Personnel putting out ovijars MUST be aware of EXACTLY where these containers are placed. Failure to keep good records on this could result in new larval habitat being created.

Reported Action Thresholds in Research Literature for:
Ovijars
In Italy, Carrieri et al. (2012) estimated that 44 *Ae. albopictus* eggs/ovijar was the epidemic threshold for chikungunya outbreaks.

Sticky Ovitrap
Threshold of >2 females/ovitrap indicated increased risk of dengue transmission with *Ae. aegypti* in Australia (Ritchie et al. 2004).

References cited:

Carrieri, M., P. Angelini, C. Venturelli, B. Maccagnani, and R. Bellini. 2010. Aedes albopictus (Diptera: Culicidae) population size survey in the 2007 chikungunya outbreak area in Italy. II: estimating epidemic thresholds. J. Med. Entomol. 49:388-399.

Ritchie et al. 2004. Entomological investigations in a focus of dengue transmission in Cairns, Queensland, Australia, by using sticky ovitraps.

2. ADULT SURVEILLANCE METHODOLOGY

Determine areas of high risk to aid in decision making for control method (e.g. areas with greatest abundance/distribution of adult *Ae. aegypti* and *Ae. albopictus* would be considered high risk and in need of immediate control).

A. **Peridomestic Container Adult Mosquito Surveillance-Sticky Ovitrap** (see S-3)
   i. Initially, grid area or neighborhood to aid in trap placement.
   ii. Adult population abundance determined by counting the number of adults stuck to adhesive sheet in jar. Provides immediate real-time data.
   iii. Traps are monitored weekly for mosquitoes and sticky sheets are replaced weekly or less frequently depending on trap used.

B. **Peridomestic Container Adult Mosquito Surveillance-BG Sentinel Trap** (see S-3)
   i. Initially, grid area or neighborhood to aid in trap placement.
   ii. Samples adults “on the wing”, 24 h collections.

iii. Battery operated suction trap place on ground in shaded areas where mosquitoes rest.

iv. Trap can be used with lures.

v. Note: BG Sentinel traps are far more efficient at collecting *Ae. aegypti* compared with CDC light traps.

Reported Action Threshold in Research Literature for BG Sentinel Traps:
Fonseca et al. (2012) reported that ≥5 *Ae. albopictus* females in BG traps was their threshold for adulticiding.

References cited:

Fonseca et al. 2012. Area-wide management of *Aedes albopictus*. Part 2: Gauging the efficacy of traditional integrated pest control measures against urban container mosquitoes. Pest Management Science 69:1351-1361.

3. **CONTROL RESPONSE** against *Ae. aegypti* and *Ae. albopictus*

A. ADULTICIDES

It should be noted that adulticiding is never 100% effective and mos**t Districts should rarely expect more than 90-95% population reduction** when aerial applications are performed under ideal conditions. This means that 5-10% of the older mosquito population remains and functions to maintain potential disease cycling if transmission were to occur.

1. AIRCRAFT-ULV APPLICATION

Manatee Mosquito Control District Tests 2012-2014

- Fyfanon applications at 2.7 to 3.0 fl oz/ac
- Rotary Aircraft calibrated VMD of about 30 microns (high pressure system)
- Airspeed: 105 mph and swath width: 430 ft.
- Evaluation method: landing rate counts and caged mosquitoes

Results:

- Multiple season-long field trials over the past 3 years have documented approximately 95% *Ae. aegypti*/*albopictus* population reduction with aerial applications of Fyfanon. Little difference appears evident with spray events taking place pre-sunset vs. post-sunset**.**

OPERATIONAL NOTE: Multiple adulticide applications should be made within a short period of time for effective disease suppression (2 or 3 applications within a 7-10 day period) when transmission is occurring in order to kill the oldest mosquito vectors. It is recommended that aerial applications of a locally-preferred chemical be used (products with the A.I. malathion, naled or synthetic pyrethroid are all appropriate assuming target susceptibility).

2. TRUCK-ULV APPLICATION

i. Manatee Mosquito Control District Tests 2013

- Equipment: Gasoline-powered London Fog 18-20 ULV machine producing VMD droplets of ca. 15 microns.

- Application rate: 0.75 oz/acre.
- Field populations evaluated weekly via ovitraps.

Results:

- Weekly ground applications of Fyfanon found 76% reduction of *Ae. aegypti* populations (as indicated by ovitrap data) when applications were made 45 min before sunset.
- Similiarly, weekly applications of Fyfanon found 68% reduction of *Ae. aegypti* populations when applications were made 30 min after sunset. Difference in mortality is likely related to decreasing environmental winds.

OPERATIONAL NOTE: Poor mortality was largely related to poor chemical distribution (drift) in nocturnal periods and lower wind speeds.

Additionally, while this field trial observed a substantial population reduction, it should be noted that overall population remained high enough to maintain a human-disease cycle if transmission were occurring. As such, a local District may consider multiple ground-adulticide missions in a very short period of time (2 applications in 4 days or 3 within 7 days). It is imperative to quickly eliminate as many of the older population of disease vectoring mosquitoes as quickly as possible.

ii. USDA/RUTGERS ASIAN TIGER MOSQUITO AREA-WIDE STUDY

- Field research (2012) Duet applied at nighttime (between 0130 and 0630) from Cougar ULV truck-mounted ground equipment.

Results:

- 85% control of adult *Ae. albopictus* when applications were spaced 1 or 2 days apart at mid-rate of 42.7g/ha. Single applications at full-rate (86.2g/ha) achieved only 73% control.
- BG Sentinel traps were used to assess control effectiveness (Farajollahi et al. 2012).

B. LARVICIDES

Larviciding will certainly supplement adulticides and provide better long-term control. But it needs to be remembered that *Ae. aegypti/albopictus* larval habitats can be as widely diffuse and similar in geographic range as the adult population meaning that a larvicide spray-area can often times be as large as the adulticide spray-area. This differs from other mosquito species such as *Ae. taeniorhynchus* where larval habitat is isolated and concentrated so larvicides can be effectively performed at significant cost savings. This said, several field investigations have researched efficacy of larviciding techniques upon domestic mosquitoes:

1. AERIAL ULV APPLICATION

Manatee Mosquito Control District Tests 2013

- Product used: Altosid Liquid Larvicide 4 oz/ac diluted to 20 oz/min application rate with airspeed of 50 mph and swath of 200ft.
- Reason for use: 1) efficacy, 2) easy of handling and application, 3) ability to apply neet, 4) no residual deposition or staining on household- or yard-products, and 5) low evaporative rates.

Results

- Approximately 76% population reduction after 3 consecutive bi-weekly aerial applications; applications made at night (9pm-1am).
- Night applications are preferred because of typical low thermal, wind and human activity.

OPERATIONAL NOTE: Similar efficacy may also be observed with liquid *Bti* with care towards appropriate droplet sizing to minimize drift while also considering potential for large droplet staining, see below:

Key West Mosquito Control District 2013

- Applying Vectobac WG (37.4%) at 0.5lb/acre, now operationally used by District.
- Dilution-1.0 lb product:1.0 gal of water.

Results

- Observing about 50% efficacy on larval *Ae. aegypti* with aerial applications made at 100ft AGL with a 200ft lane separation. Droplets are approximately100 microns.

2. GROUND (Truck) APPLICATION-ULV

Manatee Mosquito Control District Tests 2010

- Product used: Altosid® Liquid Larvicide (ALL) Concentrate (SR-5)
- Weekly applications made midnight-2 am (to avoid pedestrian/fog truck interactions).
- *Ae. aegypti* population dynamics (eggs & larvae) monitored.

Results

- Compared with nearby control data, no apparent population reduction was observed.

OPERATIONAL NOTE: Manatee MCD personnel speculate low efficacy was a result of low atmospheric wind within residential communities and resultant poor distribution of the larvicide through the treatment area, especially within more cryptic and numerous mosquito breeding sites.

However, Manatee MC District stated that those programs facing *Ae. aegypti/albopictu*s problems should not discount this application methodology especially for those districts where environmental “wind” allows for sufficient chemical distribution in nocturnal periods such as Caribbean locations.

3. GROUND APPLICATION-BACKPACK

A two-person team can effectively treat no more than 5-15 acres per day in an urban environment using a backpack to larvicide container habitats (one person making homeowner contact, opening gates, locating habitat and second performing spray activities).

In a disease epidemic situation where hundreds of acres need to be quickly treated, such labor intensity may be prohibitive and should be one of the last chemical application methods considered.

Long-lasting granular materials such as spinosad, *Bti,* or methoprene are available.

4. GROUND APPLICATION-HAND APPLIED TO CONTAINERS

Note: several products, especially slow release formulations are available, that contain, but not limited to: spinosad, *Bti,* or methoprene.

USDA/RUTGERS ASIAN TIGER MOSQUITO AREA-WIDE STUDY[1]

- Field study in 2008, applied a 1 pellet of Agnique plus 1 pellet of Altosid together in 5-gal buckets provided 95% control for 32 days and 50% larval control an additional 50 days (Nelder et al. 2010).

- In a similar field study, by this team during 2009, Vectobac WDG applied at 16 mg/liter of water to 5-gallon buckets with larval *Ae. albopictus* resulted in 100% control for 3 weeks (Farajollahi et al. 2013).

References cited:
[1]http://asiantigermosquito.rutgers.edu/Control.html

Farajollahi, A., Williams, G., Condon, G., Kesavaraju, B., Unlu, I., and Gaugler, R. 2013. Assessment of a direct application of two *Bacillus thuringiensis israelensis* formulations for immediate and residual control of *Aedes albopictus*. Journal of the American Mosquito Control Association. 29(4): 385-388.

Nelder MP, Kesavaraju B, Farajollahi A, Healy SP, Unlu I, Crepeau T, Raghavendran A, Fonseca DM, Gaugler R. 2010. Suppressing *Aedes albopictus*, an emerging vector of dengue and chikungunya viruses, by a novel combination of a monomolecular film and an insect growth regulator. American Journal of Tropical Medicine and Hygiene 82(5):831-837.

