Control of Aedes aegypti and Ae. albopictus

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Background:

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*Historically "efforts" against Aedes aegypti and albopictus by mosquito control programs in Florida been focused upon <u>public education</u> (media, schools, public events, etc.), very <u>focal</u> <u>premise sanitation</u> in response to resident's "service requests" and some night time <u>truck</u> <u>spraying</u> (ULV adulticiding) – admittedly more public relations than effective wide area mosquito control



Background (cont.)

- Little if any authority to enter onto private properties without permission of resident
- Code Enforcement laws generally do not include mosquito breeding containers
- Because of the very strong privacy rights in the U.S., there is reluctance of political bodies to support strong "sanitation ordinances" (Fred Soper's approach in Brazil was strong-handed and forced his will upon the citizens ... but successful!!)
- Resistance to pyrethroids very common in *Aedes aegypti* populations

Background (cont.)

- Dengue, once a common epidemic occurrence, was "eradicated" from Florida in the late 1940's;
- From the 1980's onward increasing number of imported cases but no documented local transmission until "reemergence" in Key West outbreak in 2009 (22 local cases) and 2010 (66 local cases); Zika: approx. 300 locally acquired cases in 2016-current (most in SE Florida); (Sidebar 36,000 in P.R.)
- Majority of Florida residences, even those in lower income areas, have screens and air conditioning which provide significant protection by restricting *Aedes aegypti* to "exophilic behavior" (unlike much of South America and the Caribbean) – Key West and many areas of SE Florida are more "island lifestyle", making it "higher risk", particularly with large number of visitors/tourism
- Since "reemergence" of Dengue in Florida in 2009... and appearance of Chikungunya in the Caribbean in 2013 and now Zika in 2016..... Florida programs re-evaluating available methods and efficacy on Aedes aegypti and albopictus populations
- Yes we know that "premise sanitation" is the best form of domestic mosquito control...... But....



•25,000 acre block
•Scope of Problem: 2-person teams; 20min/home; 6hr field day = 18homes per day = 6 acres/day

Need 11.5 years for 2 people to make a complete sanitation operation
Or need 140 employees to make the complete inspection every 30-days
Cost - \$7.0 million in direct/indirect employee costs

Re-Evaluation of Existing Strategies

- Manatee County Mosquito Control District (Southwest FL) has an operating budget of \$4.0 million and a workforce of 30 (10 field inspectors) to cover a 750 square mile county (50+ square miles urban) with 350,000 residents
- Considered all control methods that might provide <u>wide area coverage</u> without the need to access private properties and utilizing existing equipment and techniques
 - Small droplet larviciding from our truck-mounted cold aerosol equipment
 - Ground adulticiding (space spraying) using our truck-mounted cold aerosol equipment
 - Small droplet aerial larviciding (helicopter)
 - Aerial adulticiding (helicopter)
- Not considering any "hand-application" (backpack sprayers) platforms or ATSB, GMO, Wolbachia, or trap-and-kill stations since these techniques are labor intensive, slow developing, expensive and generally aren't applicable to widearea population control nor can be rapidly employed in a disease response

Truck applications of Larvicides....



Evaluation: Small droplet truck larviciding (2010)

- Equipment calibrated to deliver Altosid 5% (methoprene IGR) at 4 oz/ac and droplet size of approximately 50-75 microns (Dv0.5)
- Spray applications performed post sunset (avoid traffic, public outdoor activities)
- Results: Good/acceptable level of larval mortality in sentinel larvae placed in the treatment area but observed <u>no overall population-level reduction</u> as compared to control populations
- Why? Poor chemical coverage due to low/negligible winds at night, particularly in wooded neighborhoods; too many cryptic breeding habitats

Truck-based adulticiding (2013)

- Very common technique used throughout Florida mosquito control programs for general mosquito control
- 15-20 million acres treated annually in Florida
- Primarily targeting mosquitoes with crepuscular & nocturnal activity periods Not aegypti/albopictus
- Most programs use pyrethroid formulation
- High pyrethroid resistance in local Aedes aegypti led to use of Fyfanon ULV (96.5% malathion) at 0.75 oz/ac (maximum labeled rate) and a droplet size of 15 microns





2013: Efficacy of Weekly Daytime-Ground ULV Adulticide - Fyfanon 97% upon Ae. aegypti/albopictus Populations



2013: Efficacy of Weekly Night-Ground ULV Adulticide - Fyfanon 97% upon Ae. aegypti/albopictus Populations

Truck Applied Adulticides

• Disadvantages:

- Slow (only treat a few hundred acres per evening)
- Relies upon ambient winds (at the ground-level) to carry spray cloud (little in nocturnal periods)
- Often need multiple spray events in a short window to be effective (1-2x per week)
- Higher public exposure to the spray operations; more complaints (as compared to aerial applications)

Aerial Applications of Larvicides



Typical Aerial Larviciding at MCMCD

- Routinely utilized method in treating coastal swamp habitats of our major pest species, *Aedes taeniorhynchus*, the "Black Salt Marsh Mosquito"
- Daytime applications; low level and using a liquid formulation with large droplets in the 500-1000 micron range (1mm rangethat deposit very close to the aircraft flight line
- Applied to concentrated mosquito breeding
- Utilize "environmentally friendly" actives: Bti, Spinosad, methoprene

AERIAL LARVICIDING

"Targeting mosquito larvae" Only spray mosquito breeding sites Day time operation Chemical heavily diluted in water (5-50 l/ha)

Big Droplets ("Rain Drops") or Solid formulations (granules) "DEPOSIT" Spraying 5-20 meters altitude 15-30 meters swath



Aerial Larviciding for Aegypti? (2011-2012)

- But could this method be adapted to treat scattered/cryptic container habitats of *Aedes aegypti* in an urban environment?
- From a "public acceptance" standpoint "YES"we are already using night-time aerial adulticiding over many urban/suburban/rural areas from an altitude of 150 feet utilizing both NVG's and specialized flight guidance systems for accuracy and safety.
- But We want larger droplets than aerial adulticides that will "deposit" but small enough that that could move with prevailing air currents and deposit into containers in both open and sheltered areas.
- After much trial/error research, we compromised on a droplet size of approximately 100-150 microns (Dv0.5)

2011: Efficacy of Aerial Larviciding upon Ae. aegypti/albopictus Populations (Values Indicate Average # of Eggs & Larvae at 15 Sampling Sites within each group)



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Efficacy of Aerial Adulticide Applications on Aedes aegypti Populations

2012 - Aerial Daytime Adulticiding in Cortez Village



Night-Aerial Adulticiding for Ae. aegypti/albopictus???

Will it work on a day-active mosquito?

And why switch from a "day-spray" activity previously shown to be successful?



2013: Efficacy of Night-Aerial ULV Applications on Aedes aegypti populations - Night Applications



Discussion

- The practices of nocturnal aerial adulticiding appears to have a significant population level impact upon <u>exophilic mosquitoes</u> when appropriate <u>droplet sizes</u> and <u>spray techniques</u> are used.
- Not a great deal of observed difference between "evening" (presunset) and night (post-sunset) aerial spray events.
- Would this be enough to truncate a Dengue epidemic or local transmission?

Back to the Real World:

If we had a Local case of Dengue or Chik What Would We Do? What Technique Would be Most Efficacious?

- 2014 Evaluated Efficacy of:
 - Surveillance-based Aerial Adulticide, vs.....
 - Surveillance-based Aerial Adulticides + Aerial Larvicide
 Applications (think "IPM" for domestic mosquitoes)
 - Malathion
 - Altosid 5%













Effects of Aerial Larviciding and Adulticiding on *Ae. aegypti* Populations - 2013 - 2015 (Myakka, FL)



Effects of Aerial Larviciding and Adulticiding on *Ae. aegypti* Populations - 2013 - 2016 (Myakka, FL)



Concerns & Criticisms

- Small study area only 150 acres
- Vegetative habitats not similar to urban cores where Zika vectors would typically be found
- No tall buildings or marine/water influences to spray operations
- Treating a rural agricultural community with dis-similar attitudes towards aerial spraying as may be found in an urban core

2017: Large Scale Evaluation of Domestic Mosquito Control

- Anna Maria Island, FL
- Tourist destination with all of the typical "issues" for an aerial mosquito control operation in an urban-core a largely naive human population with spray mission influenced by marine winds & thermal currents off ocean
- Very high Ae. aegypti population (amongst the highest in the County)
- Population sizes evaluated several times per week "Before/After" within "Control/Treatment" areas
- Applied Fyfanon and Altosid 5%

Map of Treatment area





2017: Effects of Aerial Larviciding and Adulticiding on *Ae. aegypti* Populations on Anna Maria Is. (FL)



2017: Effects of Aerial Larviciding and Adulticiding on *Ae. aegypti* Populations on Anna Maria Is. (FL)



Altosid Field Bioassay

- 10 dry Petri dishes placed in treatment area
- Flooded with habitat water and 10-15 wild-strain A.A. larvae in the laboratory
- 7/13/17 aerial larvicide event: 80.0% emergence inhibition
- 7/27/17 aerial larvicide event: 97.8% emergence inhibition

Summary

- Sanitation Best "theoretical" approach but doesn't work in practice due to poor access and poor public participation
- (Optimized) Truck adulticiding may be effective in small geographic areas but limited to small scale mosquito control approaches; may have poor acceptability in many residential areas
- Aerial larviciding is effective but costly and doesn't target active vectors
- Aerial adulticiding is very effective but gains are short-lived
- IPM approaches (ie active surveillance + aerial larvicides + aerial adulticide) yield excellent long-term control