Surveillance and Control of *Aedes aegypti* and *Aedes albopictus* in California: An Update

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Aedes albopictus and Aedes aegypti have arrived AND become established in California

Aedes albopictus
2011: Los Angeles County

Aedes aegypti
2013: Madera, Fresno, San Mateo Counties
**Aedes albopictus: Previous Detections in CA**

- **1946**: Los Angeles
  - Military cargo ship from Philippines
- **1971**: Oakland
  - Cargo ship with tires from Vietnam
- **1987**: Oakland
  - Tires shipped from Hawaii
- **2001**: Los Angeles County
  - Lucky Bamboo shipped from China
  - 15 infestations in 6 counties at nurseries; federal embargo
  - Local eradication efforts were successful...sort of
- **2004**: Orange County
  - Boat shipped from Hawaii
El Monte, LA County  2011
Trailer Park: Resident Service Request on Sept. 2
September 5-9, 2011

33 / 63 (52%) ovitraps positive
Good micro-habitat breeding sources
October 27 - Approx. 8 mi$^2$
Approximately 50 sq. miles
(130 sq. km)
Origin of *Aedes albopictus* in LA?

- Population genetics study with UC Irvine collaborators, published July 2013
- Mosquitoes collected in 2001 and 2011 shared similar genetics and were similar to specimens from south China
- Population likely represents descendants of the 2001 lucky bamboo introduction that remained undetected for over a decade
Aedes aegypti: Previous Detections in CA

• 1910-1912: San Diego County, San Francisco (Angel Island)

• 1979: San Mateo County, near SFO airport
  – Single 4\textsuperscript{th} instar larva collected in marsh during routine surveillance

• 1987: San Mateo County
  – Single dead 2\textsuperscript{nd} instar larva in a shipment of tire casings from Miami FL
Madera Index Site
residential neighborhood
with large backyards,
pristine landscaping, lots of
potted plants

June 7 – CO₂ = 3F
June 11 – BG = 17F, 33M
Additional surveillance tools used

- BG Sentinel
- Ovitraps
- Autocidal Gravid Ovitrap (AGO)
  Supplied by CDC Dengue Branch
Aedes aegypti Mosquito Detection Sites in California 2013-2015

Year of first detection

- **2013**
- **2014**
- **2015**

12 Counties
Origin of *Aedes aegypti* in California? (Madera, Fresno, San Mateo Counties)

- Population genetics study with Jeffrey Powell (Yale), published July 2014
- High genetic variation in CA specimens suggests multiple founders
- Genetically most similar to specimens collected from New Orleans / Houston
- Mode of introduction remains unknown
Aedes aegypti and Aedes albopictus Mosquitoes in California
113 cities (74 Aedes aegypti and 38 Aedes albopictus)

Aedes aegypti and Aedes albopictus Detection Sites by County/City

- Alameda
  - Hayward
  - Fresno
  - Clovis
  - Firebaugh
  - Fowler
  - Fresno
  - Kerman
  - Mendota
  - Sanger
  - Tranquility*
  - Imperial
  - Andrade*
  - Brawley
  - Calexico
  - El Centro
  - Heber*
  - Holtville
  - Imperial
  - Seeley*
  - Kern
  - Arvin
  - Arvin

- Los Angeles
  - Alhambra
  - Avocado Heights*
  - Arcadia
  - Avocado Heights*
  - Azusa
  - Baldwin Park
  - Bradbury
  - Covina
  - Duarte
  - El Monte
  - Glendora
  - Irwindale
  - La Cañada Flintridge
  - La Mirada
  - La Puente
  - La Verne*
  - Los Angeles
  - Monrovia
  - Monterey Park
  - Pico Rivera
  - Rosemead
  - San Dimas*
  - San Gabriel
  - Sierra Madre
  - South El Monte
  - South Whittier*
  - Temple City
  - West Covina
  - Whittier*

- Madera
  - Madera
  - Madera Ranchos*
  - Parkwood*

- Orange
  - Anaheim
  - Costa Mesa
  - Garden Grove
  - Orange
  - Lake Forest
  - Mission Viejo
  - Santa Ana
  - Huntington Beach
  - Los Alamitos

- Orange (continued)
  - Mission Viejo
  - Newport Beach*
  - Santa Ana
  - Riverside
  - Cathedral City*
  - Coachella
  - Corona
  - East Hemet*
  - Riverside
  - San Jacinto
  - San Bernardino
  - Colton
  - Montclair
  - Upland
  - San Diego
  - Bonita*
  - Chula Vista
  - Coronado*
  - El Cajon
  - Escondido
  - Imperial Beach
  - Lakeside*
  - La Mesa
  - La Presa*
  - Lemon Grove
  - National City
  - Oceanside
  - San Diego
  - Spring Valley*
  - Tecate*
  - Vista
  - Carlsbad
  - San Diego
  - San Mateo
  - Atherton
  - Menlo Park
  - Tulare
  - Exeter

* New detection location within the previous four weeks
*Unincorporated Census-Designated Places

$ Aedes aegypti and Aedes albopictus

- Aedes aegypti
- Aedes albopictus

- Alameda
- San Mateo
- Orange
- San Diego
- Riverside
- Imperial

- Alhambra
- Avocado Heights*
- Bell*
- Bellflower
- Bell Gardens
- Commerce
- Downey*
- East Los Angeles*
- Florence-Graham*
- Huntington Park
- La Mirada
- Los Angeles
- Maywood
- Monterey Park
- Paramount*
- Pico Rivera
- Rosemead
- South Gate
- South Whittier**

- New detection location within the previous four weeks
- Unincorporated Census-Designated Places
Aedes mosquitoes, Los Angeles County

http://cdph.ca.gov
Month of first detection of *Aedes* mosquitoes 2011 - 2015

- **Ae. aegypti**
- **Ae. albopictus**

New Cities / Census-Designated Places
Method of first detection of *Aedes* mosquitoes 2011 - 2015

- **Resident Service Request**
- **Property Inspection**
- **Aedes Ovitrap**
- **Aedes Adult Trap (BGS)**
- **Aedes Adult Trap (AGO)**
- **Arbovirus Surveillance Trap (gravid)**
- **Arbovirus Surveillance Trap (CO2)**
- **Other**

**Number of First Detections**

- **Ae. aegypti**
- **Ae. albopictus**
Control Challenges

• Biology of *Aedes aegypti* and *albopictus*
  – Eggs resistant to drying
  – Breed in artificial containers; cryptic sites
  – Day biters; readily enter dwellings

• Insufficient resources to find, eliminate and/or treat all sources

• Difficult to educate community and elicit ongoing source reduction

• Rapid and ongoing reintroduction of *Aedes* eggs and adults into an area post-treatment
Overview of Aedes Control

**Immature control**
- Major categories
  - Container cleaning (bleach/wash/dump)
  - Container manipulation (polystyrene beads)
  - Container treatment
  - Social campaigns (education, source reduction)
  - Environmental Management
  - Legislation
- Container treatment
  - Insecticides
    - Temephos
    - Diflubenzuron
    - Bti
  - Biologicals
    - Copepods
    - Larvivorous fish
- Bleach
- Methoprene
- Pyriproxyfen

**Adult control**
- Major categories
  - Space spraying
  - Indoor residual spraying
  - Personal protection
- Space spraying: Truck ULV, Low-flying aircraft, hand-held portables, perifocal treatment
- Personal protection
  - DEET
  - Picaridin
  - Bed nets
  - Consumer products
- Indoor residual spraying
- Emergence → Mating → Sugar Feeding → Blood Feeding → Resting → Egg Laying
- RIDL and sRIDL → Toxic sugar baits
- Behavior modification
  - Wolbachia
  - Other within-tissue symbionts
  - Paratransgenesis
  - Antipathogen genes without drive
- Lethal Ovitrap → Auto-dissimulation

**Methods under Development**
- New entomopathogenic fungi
- Molecular insecticides, medea/HEGs, new insecticides
Examples of Strategies Used in CA

✓ All agencies focus on community education and source reduction (scrub, cover, dump, discard)

Madera County
• Larvicides (Bti)
• Absorbent gel in vases (cemetery)
• Residual barrier sprays (deltamethrin)

Fresno County
• Lethal ovitraps (CDC AGO trap)
• Residual barrier sprays (quick rebound)
• Spinosad (Natular) for yard drains

➢ Note: documented pyrethroid resistance
Los Angeles County
  • Backyard space spraying (Duet – pyrethroids)
    – Done in response to service requests; includes surrounding homes
    – Cannot sustain; getting up to 90 service requests/day
  • Larviciding with Bti (LV – Vectobac WDG)
    – Early morning only; spray in backyards
    – Problem: Underground storm drains

San Diego County
  • Larviciding; adulticiding in response to travel-associated cases
Response: Travel-Associated Case

- Conduct door-to-door inspections within 150 meters around a case-patient’s home and eliminate larval habitats
- Treat with long-lasting larvicide any water-holding containers that cannot be dumped, covered, or discarded
- Educate the public to continually eliminate larval habitats
- Encourage the public to use insect repellents, window and door screens, and air conditioning to reduce risk of getting mosquito bites
Initiate adult mosquito control

• Treat the outdoors within 150 meters around a case-patient’s home with adulticide
  – Include residual and spatial insecticide treatments
  – Repeat as necessary to reduce vector abundance
• Initiate/maintain adult sampling to estimate adult mosquito abundance and evaluate effectiveness of insecticide treatments
• Test mosquitoes for viruses (UC Davis)

- Intensify efforts if case is locally transmitted and escalate further if a cluster of cases
Travel-Associated Zika Cases and Aedes Detections in San Diego County*

* Aedes may not be found throughout the contiguous area indicated in gray.

Zika Cases as of 19 September 2016
- Aedes aegypti
- Aedes albopictus

Approximate Aedes Infestation Area as of 19 Sept 2016

Sources: Esri, HERE, DeLorme, USGS, Intermap, i-cubed, Guinea, NGAN, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MappyIndia, OpenStreetMap contributions, and the GIS User Community.
Innovative Control Approaches

Two concepts were evaluated in California in 2015

• A *Wolbachia* - based strategy: Los Angeles County
• Auto-dissemination of insect growth regulators strategy: Fresno County

Mosquitoes are good at:

✓ finding each other for mating
✓ finding cryptic sources of water for breeding
Wolbachia-Infected Male Aedes albopictus

• Previous research
  ➢ When naturally-occurring Wolbachia bacteria in Aedes albopictus is replaced with one that occurs naturally in other mosquitoes (Wolbachia pipiens), and infected males mate with wild females, eggs fail to hatch

• Approach similar to the “sterile male technique”

• Wolbachia-infected Aedes reared in KY and shipped to LA; male mosquitoes released twice weekly
Aedes albopictus abundance in treated and control sites, Los Angeles County, 2015
Auto-Dissemination Augmented by Males (ADAM) Control Concept

- Mass-produced male mosquitoes are treated with the larvicide pyriproxyfen, an insect growth regulator (IGR)
- Released males indirectly spread the IGR to larval development sites by contaminating female mosquitoes during mating
- Males also directly disseminate pesticide to target areas - even when populations of females mosquitoes are low

Mains et al. PLoS-NTD 2015
Aedes aegypti abundance: Treated and controls sites, Fresno County, 2015
Future Potential?

• Both *Wolbachia* and ADAM strategies have potential to reduce populations of *Aedes* mosquitoes

• Neither is considered a stand-alone system at this time, but both may be useful components of an integrated vector management program

• More work is needed to determine maximum efficacy, long-term sustainability, and costs

• Additional research is ongoing in 2016
2016 ....and Beyond

- Keep pressure on existing infestations to slow spread
  - Aerial and ground-based applications of larvicides and adulticides, coupled with public education
  - Container breeding habits and desiccant resistant eggs pose challenges

- Explore innovative methods to enhance control of *Aedes aegypti* and *Aedes albopictus* in California

- Risk of local disease transmission is low, but possible
  - *Aedes* surveillance and control are critical to minimize risk of local transmission
Acknowledgements

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Consolidated MAD
Delta VCD
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Madera County MVCD
San Diego County VCP
San Gabriel Valley MVCD
San Mateo County MVCD