Overview of State Ovitrap Survey of Container Aedes (2016)

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NC Mosquito-borne Pathogens

• **Zoonotic**
  – (Animal-Mosquito-Human)
    La Crosse virus*
    West Nile virus
    Eastern Equine Encephalitis virus
    Saint Louis Encephalitis virus

• **“Anthroponotic”**
  – (Human-Mosquito-Human)
    Chikungunya*
    Dengue*
    Malaria
    Zika*

*Transmission is primarily by container-inhabiting *Aedes*
Arboviral Disease: NC Acquired

FIGURE 1.
La Crosse Virus

- Isolated in 1960’s in La Crosse, Wisconsin
  - Bunyavirus (California serogroup virus)
- Only acquired through the bite of a mosquito
  - Eastern-tree hole mosquito (principle vector; daytime active)
- LACv is the most common arboviral cause of pediatric encephalitis in the US
Invasive Vectors

**Aedes albopictus: “Asian Tiger Mosquito”**
- Can transmit La Crosse virus
- Readily feeds on Humans
- Aggressive, Daytime Feeder

**Aedes japonicus: “Asian Bush Mosquito”**
- Can transmit La Crosse virus
- Feeds on Humans
- Less Aggressive, Daytime/Evening Feeder

East TN: LACv IRs for *Ae. japonicus* (0.63) were lower than *Ae. triseriatus* (2.72) and *Ae. albopictus* (3.01) (Westby et al., 2015)
Mosquito-borne Disease: Travel

Introduced (Exotic) Mosquito-Borne Disease
Humans: NC 2011-16

- Dengue
- Chikungunya
- Zika
- Malaria

*DEN/CHIK/Malaria Data Not Shown

Data: NCDHHS (10/2016)
Anthropogenic Arboviruses

- Introduced/Epidemic Transmission
  - Human-Mosquito-Human
- CHIKv: Alphavirus
- Dengue: Flavivirus
- Zika: Flavivirus

- Peridomestic Transmission
  - *Aedes* mosquitoes
    - *Aedes aegypti*
    - *Aedes albopictus*
Zika/DEN/CHIK Vectors

• *Aedes aegypti*
  – Very closely associated with people
  – Does not depend greatly on vegetation
  – Indoor/outdoor (resting, biting, oviposition)
  – Urban/suburban/rural areas
  – Greater resistance to desiccation
  – Main DEN/CHIK/Zika vector

• *Aedes albopictus*
  – Less dependent on people
  – Rests in/near vegetation
  – Outdoor mosquito
  – Suburban/rural areas
  – Greater cold hardiness
  – In some areas, may be main DEN vector

Both: Container Inhabiting

Adapted from R. Barrera (DB/CDC)
Aedes aegypti and Aedes albopictus Mosquitoes: Geographic Distribution in the United States

Aedes aegypti

Aedes albopictus

Slide from H. Savage (CDC)
Aedes albopictus (1993-1997)
Aedes aegypti (Reported Occurrence by County: 1995-2016)

“Estimated Potential Range of Aedes aegypti”

Survey Purpose

- **Update Distribution Records**: Designed to update distribution records of container-inhabiting *Aedes* species in selected North Carolina counties.

- **Expand beyond existing adult surveillance in state**: Include counties that are in metropolitan statistical areas (MSAs), or other areas likely to be at higher risk for transmission of arboviruses by *Aedes* mosquitoes.

- **Targeted approach**: Use ovitraps to establish broad temporal trends and relative species abundance while increasing the probability of detecting the presence of *Aedes aegypti* at surveyed locations.
## Container-inhabiting *Aedes* (NC)

<table>
<thead>
<tr>
<th>Species</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aedes aegypti</em></td>
<td>Rare recent reports, uncertain distribution Primary Zika vector</td>
</tr>
<tr>
<td><em>Aedes albopictus</em></td>
<td>Commonly found throughout state, no recent state-wide data Suspected/expected Zika vector</td>
</tr>
<tr>
<td><em>Aedes atropalpus</em></td>
<td>Previously common, no recent state-wide data</td>
</tr>
<tr>
<td><em>Aedes hendersoni</em></td>
<td>Uncommonly reported, uncertain distribution (expect state-wide)</td>
</tr>
<tr>
<td><em>Aedes japonicus</em></td>
<td>Common in mountains and piedmont, recent evidence near coast</td>
</tr>
<tr>
<td><em>Aedes triseriatus</em></td>
<td>Commonly found throughout state, no recent state-wide data</td>
</tr>
</tbody>
</table>

*Considered medically important due to arbovirus transmission risk*

### Other mosquitoes that may be found in containers:
Examples include: *Anopheles barberi, Anopheles crucians, Anopheles punctipennis, Culex pipiens s.l., Culex restuans, Culex nigripalpus, Culex salinarius, Culex territans, Orthopodomyia spp. Toxorhynchites spp.*, and others
Project Timeline (Year 1)

- **Preparation (April-May 15)**
  - Establish communication between university partners/LHD:
    - Confirm local capabilities and needs (e.g., larval identification)
    - Determine sampling locations within the county/base

- **Supplies (April-October)**
  - April: Order supplies as appropriate for larval collections
  - May: Receive ovitraps from university (delivery by mail)
  - Continuous: Order/receive additional supplies as needed throughout the mosquito season.

- **Collections**
  - May-October: Ovitrappping and larval collections

- **Shipping/Identification**
  - May-October

- **Reporting**
  - County-level Reporting: Ongoing as requested
  - University “roll up” reporting (June, August, October)
  - Final Statewide Report (Due December)
**Ovitrap Collections:** Container-inhabiting *Aedes* eggs collected using “ovitraps”. Weekly or bi-weekly collections sent to the university labs for hatching and identification.
A: Gather materials for assembly

B: Assemble the ovitrap. Secure the ovistrip with a paper clip.

C: Add tap water (Fill to the drain hole)
A: Use twine, paracord, or "zip ties" to secure your trap

B: Secure your ovitrap at the ground level

Place the trap at the ground-level, in a well-protected, shaded area

Ovitraps should be placed at fixed places (May-Oct.). Discuss with your local university contact to determine appropriate sites to place the traps.
A: Remove ovitrip from the trap, gently fold and place in whirlpak
B: Label whirlpak appropriately (see protocol)
C: Place in padded shipper and return to assigned university*

*if shipping is delayed, wrap the ovistrip in a moist paper towel
2016 Ovitrap Participants

• **East Carolina University (Richards)**
  – Brunswick, Onslow, New Hanover, Pitt, Gates, Currituck, (DOD: Camp Lejeune, SJAFB)

• **North Carolina State University (Reiskind)**
  – Edgecombe, Wake, Forsyth, Guilford, Cumberland

• **Western Carolina University (Byrd)**
  – Buncombe, Cabarrus, Henderson, Haywood, Mecklenburg, Transylvania
A metro area contains a core urban area of 50,000 or more population. Each metro area consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties that have a high degree of social and economic integration (as measured by commuting to work) with the urban core.

Participating agencies were invited based on population densities, existing infrastructure/expertise, or previously planned surveys. ★ = Participating County/Agency
To date, more than 278,202 Aedes spp. eggs have been received by the universities and 62,637 mosquitoes have been identified to species by microscopy. At present, no Aedes aegypti have been identified in the submissions. More than 99.9% of the ovitrap collections are represented by 3 species: 80.7% (n=50,564) of the identified Aedes are Aedes albopictus, 10.8% (n=6,778) are Aedes triseriatus, and 8.4% (n=5,236) are Aedes japonicus. The percentages of Aedes japonicus and Aedes triseriatus vary regionally, but Aedes albopictus is the primary container inhabiting Aedes in the participating counties according to the ovitrap data. Temporal trends and relative abundance data will be assessed both regionally and at a county level for distribution in Dec 2016.

<table>
<thead>
<tr>
<th>University</th>
<th>Eggs</th>
<th>Identified</th>
<th>Ae. albopictus</th>
<th>Ae. triseriatus</th>
<th>Ae. japonicus</th>
<th>Ae. aegypti</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECU</td>
<td>88,556</td>
<td>15,904</td>
<td>14,922</td>
<td>719</td>
<td>263</td>
<td>0</td>
</tr>
<tr>
<td>NCSU</td>
<td>123,164</td>
<td>24,699</td>
<td>22,370</td>
<td>1,584</td>
<td>745</td>
<td>0</td>
</tr>
<tr>
<td>WCU</td>
<td>66,482</td>
<td>21,975</td>
<td>13,272</td>
<td>4,475</td>
<td>4,228</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>278,202</td>
<td>62,637</td>
<td>50,564 (80.7%)</td>
<td>6,778 (10.8%)</td>
<td>5,236 (8.4%)</td>
<td>0</td>
</tr>
</tbody>
</table>
Ex. Brunswick County Data (‘16)

25,473 *Aedes* eggs collected, 5,929 identified to species (23.3% hatch/ID rate)
199 ovitrap submissions; Mean egg/trap: 128 (range: 0-851)
No *Aedes aegypti*
16,554 *Aedes* eggs collected, 2,270 identified to species (13.7% hatch/ID rate*)
174 ovitraps submissions; Mean egg/trap: 95 (range: 0-831)
No *Aedes aegypti*

*33% hatched upon receipt; revised rate: 22%*
14,867 total *Aedes* eggs collected, 4,276 identified to species (29.3% ID rate)
129 ovitrap submissions; Mean egg/trap: 116 (range: 0-782)
No *Aedes aegypti*
Buncombe Co. (Site 5)

May 22nd = Epi week 21
Oct. 23 = Epi week 43
Buncombe Co.
(Site 5)

- **Aedes triseriatus**
  - Buncombe County (Site 5)

- **Aedes japonicus**
  - Buncombe County (Site 5)

- **Aedes albopictus**
  - Buncombe County (Site 5)

- 1,680 *Aedes* eggs collected
- 476 identified to species (28.3% hatch/ID rate)
- 20 ovitrap submissions
- Mean egg/trap: 84 (range: 0-364)
- No *Aedes aegypti*
Summary

- Data collection (rearing/identification) is on-going, but wrapping up. Data presented here are preliminary.
- 3,251 Ovitrap collections submitted
- 278,202 eggs submitted; 62,637 mosquitoes reared/identified
- >99.9% of ovitrap collections are represented by 3 species
  - *Aedes albopictus* (80.7%, n=50,564)
  - *Aedes triseriatus* (10.8%, n=6,778)
  - *Aedes japonicus* (8.4%, n=5,236)
- Relative abundance varies regionally
- *Ae. albopictus* is the primary container-inhabiting *Aedes* in NC
Going Forward…

• **Final Report (Dec. 2016)**
  – Ovitrap Data Summary (County Level)
    • Temporal Trends (Weekly Oviposition Activity)
    • Relative Abundance
    • Hatch/Identification Rates
  – Larval Collections
    • Participating Counties
    • Other efforts (Academia, Citizen-Scientists)

• **Review and Plan for 2017**
  – Solicit feedback from participants
  – Improve timely reporting (web interface?)
  – Address workflow (lab) - molecular screening of unhatched eggs
  – Consider additional sampling strategies (e.g., “pulse” increase of traps)
Thanks to all involved!

- Health Departments/ENVH
- Public Works
- DPH (CDB/ENVH)
- Universities
- Citizen efforts
Epidemic Transmission

Mosquito feeds - acquires virus

Extrinsic incubation period

Viremia

0 5 8 12 16 20 24 28 DAYS

Mosquito refeeds - transmits virus

Intrinsic incubation period

Viremia

0 5 8 12 16 20 24 28 DAYS

Illness

Human #1

Illness

Human #2

Consider these transmission dynamics in the context of laboratory diagnostics.
**Transmission Amplification Potential**

**A.** *Per Os Infection*

**B.** Disseminated Infection Rates

**C.** Transovarial Transmission Rates

**D.** Filial Infection Rates

[Images of bar graphs showing infection rates for different species]

The proportion of infected mosquitoes that are orally exposed (infected) and then become infectious (virus in saliva) is called the vector competence. The time period from exposure to infectious is called the extrinsic incubation period.

**Midgut Infection Barrier**
1 => establish an infection in the midgut epithelium
2 => replicate in the midgut epithelium cells

**Transmission Barriers**
5 => infect salivary glands
6 => escape into the lumen of the salivary gland

**Midgut Escape Barrier**
3 => pass through the basal lamina
4 => replicate in other organs and tissues
Vectorial Capacity

\[ C = \frac{ma^2 (P^n)V}{(-\ln P)} \]

ma = bites per human per day (biting rate)
P = probability of daily survival
n = extrinsic incubation period
V = vector competence (innate transmission efficiency)
Zika Virus

- Flavivirus named after Zika forest, Uganda
  - Isolated in 1947 (*Rhesus*) and 1948 (*Ae. africanus*)
  - Global travel has resulted in the introduction of this virus into Europe, Americas, Pacific Islands, etc.

Selected images from H. Savage/John Paul Mutebi (CDC)
Zika in US (Oct. 26th)
Henderson County Ovitrap Data (2016)

2,346 total *Aedes* eggs collected, 443 identified to species (18.9% hatch rate)
45 ovitrap submissions; Mean egg/trap: 52 (range: 0-326)
No *Aedes aegypti*