Vector Surveillance and Control in Response to Zika

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ZIKA Response: Overview

- Prevention or reduction of Zika virus transmission is completely dependent on the control of mosquito vectors and limiting human-vector contact.
- Entomologic response to Zika virus outbreaks hinges on detection of human case(s), overall response is a group effort involving:
  - Epidemiologists
  - Entomologists
  - Healthcare providers
  - Local public health officials
  - Media, educators
- Zika virus entomologic surveillance and control activities are conducted throughout the season.

Before the Mosquito Season

- Develop state action plan
- Determine high risk areas
- Identify existing resources
- Initiate source reduction
  - Remove discarded containers
  - Cover or modify immovable and large containers to prevent water retention
- Implement education programs for source control
  - Screen windows and doors
  - Homeowner (residence) larval source reduction

Beginning of the Mosquito Season

- Initiate vector surveys to
  - Determine presence or absence
  - Estimate relative abundance
  - Determine distribution; develop detailed distribution maps
  - Vectors surveys are continuous to detect new populations, seasonal variations in abundance and seasonal ranges
- Insecticide resistance profiles
- Continue source reduction efforts; containers are continually discarded
- Maintain education programs
  - Screen windows and doors
  - Personnel protection
    - Insect repellents
    - Avoid exposure
  - Homeowner (residence) larval source reduction

<u>**Guidance**</u> is to Initiate Vector Control When Cases are Detected

- Initiate control around all cases
  - Response to suspected viremia is ideal if symptomatic
  - Response to confirmed viremia regardless if case is travel associated/sexual transmission, or local transmission
- 150 m minimum around case vicinity (home/work)
  - Vector assessment (may not be needed if vector presence is known)
- Adulticide, larvicide, and source reduction
- Focused neighborhood education
- More general education

Principal Activities of a Mosquito-Based Arbovirus Surveillance Program

- Identify and map larval habitats
  - Mapping and monitoring larval habitats provides early estimates of future adult abundance and the information necessary to reduce populations through source reduction
- Monitor adult activity
  - Monitoring species composition, species abundance (density), age structure, and infection rates in adults provides timely data for risk assessment

Advantages of Mosquito-Based Arbovirus Surveillance Programs

- Quick turn-around of results.
  - Samples can be processed within a few days with local, in-house laboratories
- Collecting adult mosquitoes provides information
  - vector species community composition, vector abundance, and infection rates
  - Allows for rapid computation of infection indices to vector control programs
- Maintaining programs over the long-term
  - Provides a baseline of historical data to evaluate risk going forward
  - Guide vector control operations

Limitations of Mosquito-Based Arbovirus Surveillance Programs

- Virus may not be detected in the mosquito population if the infection rates are very low (early in the transmission season) or if only small sample sizes are tested.
- Arboviral transmission ecology varies regionally, and surveillance practices vary among programs (e.g., number and type of traps, testing procedures).
  - Limits the degree to which surveillance data can be compared across regions.
  - Makes setting universal thresholds for assessing risk and implementing interventions impractical.

Container Aquatic Habitats for Zika Vectors

- Water-storage containers (barrels, jars, tanks, cisterns)
- Utensils (pails, tarps)
- Discarded containers (trash)
- Recreation objects (plastic pools, toys, boats)
- Ornamental (fountains, plant pots)
- Animal drinking pans
- Septic tanks
- Water meters
- Treeholes

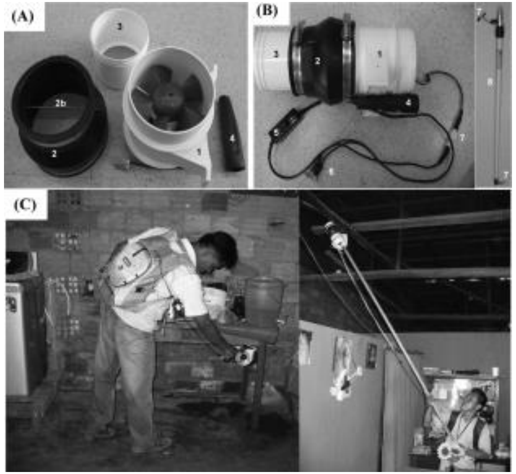
Case Home with Multiple Mosquito Larval Site

Vector Surveillance Tools

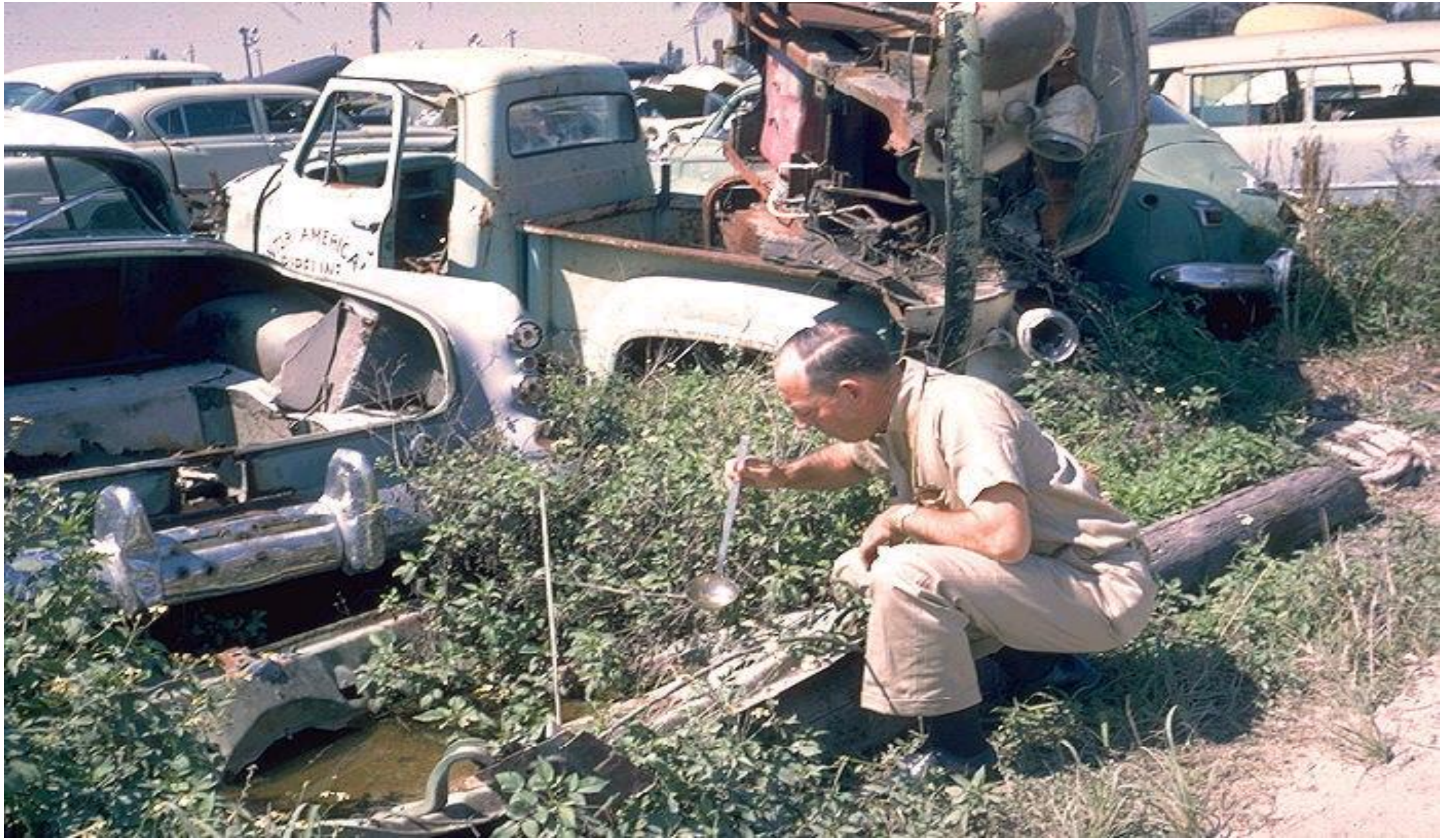
- Ovitraps (presence/absence; eggs/trap)
- Electromechanical aspirators
- Sticky traps for gravid mosquitoes
- Electromechanical traps for adult mosquitoes

  - Larval indices (house, Breteau, container indices)

  - Pupal surveys (pupae/house)



Larval (larvae and pupae) Surveillance



Larval Surveys

- Most widely used (requires little training)
- Provide a vague idea of mosquito abundance
- Assume most aquatic habitats of *Ae. aegypti* are in and around households
- Presence/absence data
  - House index = percentage of houses with at least one mosquito larva
  - Breteau index = number of larvae positive containers per 100 houses
  - Container indices = percentage of containers with water that contain mosquito larvae
- Rely on visual search of containers; may miss cryptic aquatic habitats
- Requires relatively small sample sizes (100 – 200 houses)
- May require entering houses; time consuming, impractical
- Does not always predict adult mosquito abundance and disease

Pupal Surveys

- Number of pupae are more predictive of adult mosquito abundance
- Provides an absolute measure of population density (e.g., pupae/hectare)
- Allows identification of most productive containers for targeted control
- Relies on visual search of containers with water; misses cryptic aquatic habitats
- Require large sample sizes for reliable estimates (1000 – 3000 houses); labor intensive
- Species identification of either pupae or adult mosquitoes require trained personnel

Limitations of Larval and Pupal Surveys

- Reliance on visual inspections for aquatic habitats; may miss cryptic habitats
- *Ae. aegypti* habitats vary from place to place; difficult to target

  - Australia (service man holes and pits, wells, mines, septic tanks, storm drains, sumps, roof gutters)

  - Colombia (storm drains throughout the city)

  - Puerto Rico (septic tanks, water meters, storm drains)

  - Brazil (elevated water tanks, roof gutters, and water holding roofs)

  - Mexico (storm drains, catch basins)

Adult Mosquito Surveillance

- Ovitraps
  - Track gravid females; important from transmission
  - Inexpensive, easily deployed – not invasive
  - Can provide population and epidemiologic information; relationship between eggs/ovitrap and number of mosquitoes/trap, human cases, and other factors
  - May be influenced by availability of other aquatic habitats – particularly after source reduction efforts
  - Requires some effort/training to count eggs or hatch eggs to identify the larvae

Electro-Mechanical Aspirators

- Involves aspirating indoor/outdoor areas for a given limit of time
- Provides absolute density data (mosquitoes per house; per city area)
- More effective for *Ae. aegypti* (indoor mosquito compared with *Ae. albopictus*)
- Requires approx. 200 houses for reliable estimates
- Highly invasive; resident permission may not always be granted
- Labor intensive

Passive, Sticky Gravid Traps

- Target gravid females – potential vectors (must have had blood meals to produce eggs)
- Inexpensive, easy to deploy
- Mosquitoes are counted in the field; data is obtained instantly
- Data from sticky traps correlate well with data from BG Sentinel Traps
- Provide a more representative estimate of mosquito abundance than ovitraps
- CDC Autocidal Gravid Ovitrap (AGO trap) requires servicing only every 2 months

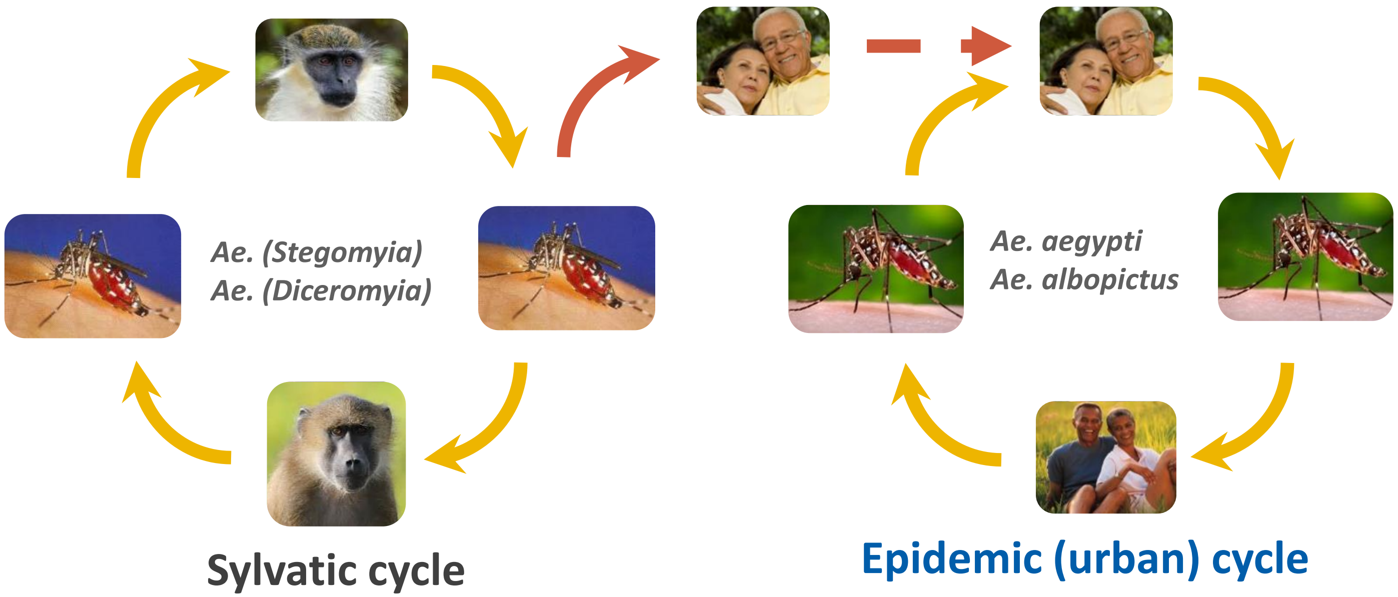
BG Sentinel Traps

- Highly specific for DENV/ZIKV/CHIKV/YFV vectors
- Track different physiological stages of adult *Ae. aegypti* and *Ae. albopictus*
- Can be deployed in sufficient numbers for reliable adult mosquito abundance estimates (20-30 traps)
- Can be used to track spatial and seasonal variations
- Black BG traps capture more mosquitoes than white BG traps in Puerto Rico
- Very expensive (trap, batteries, lure)

Aedes aegypti: A Particularly Dangerous Vector

- Also the primary vector of:
  - Dengue
  - Yellow fever
  - Chikungunya
- "Urban" mosquito; lives in close proximity to humans and prefers to bite humans
- Day biting
- Short flight range (typically 200m)
- Feeds on multiple hosts in a single egg cycle
- Skip oviposition
- Difficult to control
  - No magic bullet

Zika Virus Transmission Cycles



Virus Surveillance in Mosquitoes

- Surveillance is conducted to
  - Obtain evidence of local transmission
  - Estimate infection rates
  - Estimate local transmission thresholds
  - Evaluate the effectiveness of control measures
- Not an efficient method to conduct Zika virus surveillance (very low infection rates – low mosquito densities) – human/disease case surveillance is more efficient

Specimen Processing

- All efforts should be made to transport mosquitoes alive or in a cool container to maximize the chances of keeping the virus viable.
- Field collected mosquitoes must be sorted and identified on a cold surface (chill table) to maximize the chances of detecting virus.
- The identified mosquitoes are pooled into groups of 50 or fewer mosquitoes for arboviruses.
- The different species, sexes, and trap locations are pooled separately to keep track of arboviral infections in different species and arboviral infestation at different locations.
- If screening is not done right after mosquito identification, the pooled samples should be stored at -70°C.

Mosquito Identification

Laboratory Screening

- Real Time RT-PCR
- Cell culture virus isolation

Mosquito-based Surveillance Indicators

Infection rate in vector population

Advantages

- Provides indicator of incidence of virus in the vector population (Minimum Infection Rate, Maximum Likelihood Estimate)
- Provides useful, quantitative basis for comparison (change in infection rate over time/space)
- Permits variable pool number and size

Limitations

- More complex calculations (software available on CDC West Nile virus webpages)
- Sample size dependent (more specimens tested = better estimate of virus incidence)

Mosquito-Based Surveillance Indicators

Vector Index (VI)

Advantages

- Provides indicator of the abundance of infected mosquitoes in an area (VI = proportion infected x number collected per trap night)
- Accommodates multiple vector species from an area
- Permits variable pool number and size

Limitations

- Sample size dependent (more specimens tested = better estimate of infected vector abundance)
- Consistent procedures and effort required for comparability over time and space

*If you are going collect and test mosquitoes, use VI

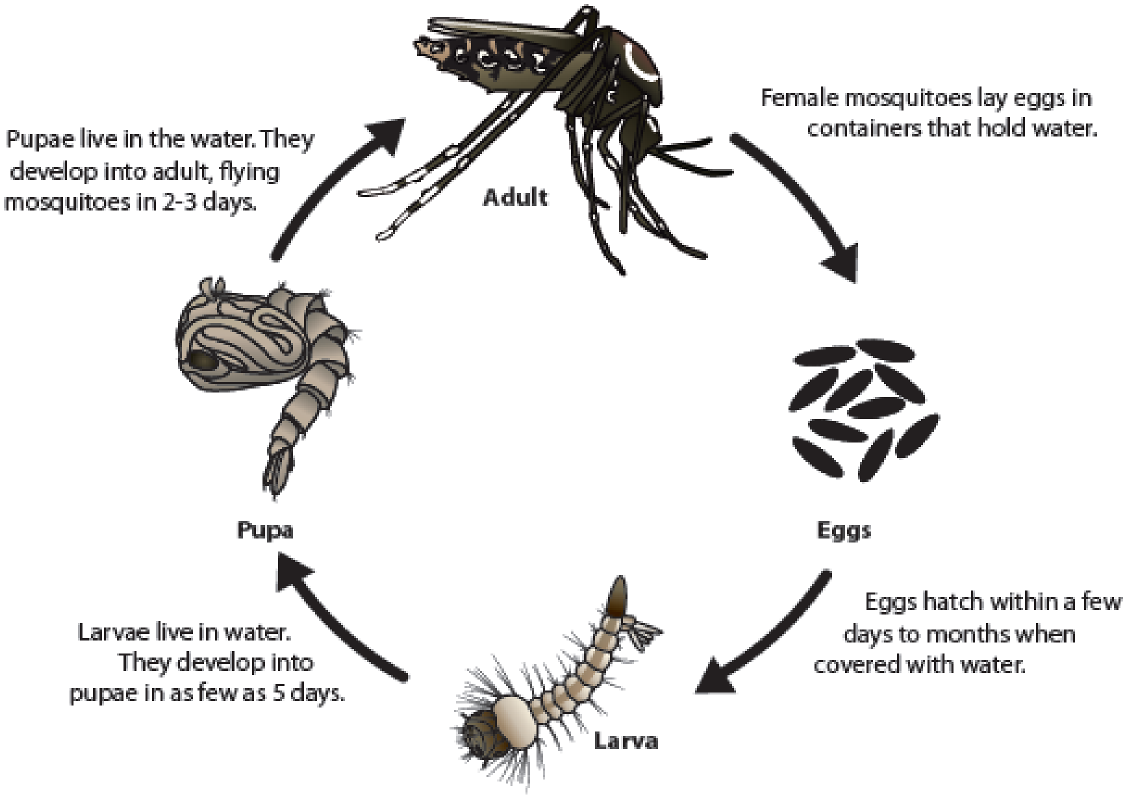
Arbovirus Surveillance Programs

- **S**imple – easy to carry out
- **E**conomical – cost effective
- **E**ffective – predictive
- **S**ustainable – long-term

Arbovirus cycles are complex and components vary regionally:

- Thresholds must be determined regionally
- Thresholds are on basis of historical data

Aedes aegypti Life Cycle



Zika Vector Control Strategies

- **Targeting the immature stages:**
  - Oviposition traps
  - Larvicides
  - Source reduction

- **Targeting adult mosquitoes:**
  - Hand-held or truck-mounted spraying
  - Indoor/outdoor residual spraying
  - Aerial spraying

Important Considerations for Control Programs

- **Insecticide resistance in *Ae. aegypti* populations**
  - May be widespread and highly variable
  - Limited products approved by EPA
- **Socio-cultural factors**
  - Objections to insecticides or application methods
  - Concerns about organophosphate insecticides
- **Legal issues**

Source Materials for the Control of Zika Vectors

- Surveillance and Control http://www.cdc.gov/zika/vector/index.html
- Surveillance and Control of *Aedes aegypti* and *Aedes albopictus* in the United States http://www.cdc.gov/zika/vector/vector-control.html
- Interim CDC Recommendations for Zika Vector Control in the Continental United States http://www.cdc.gov/zika/public-health-partners/vector-control-us.html

Zika Forest, Kisubi Uganda

Thank you!

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov