Purpose of this Presentation

- Review epidemic of West Nile virus in Michigan and the United States
- Discuss features of mosquito biology and mosquito-borne viral encephalitis transmission relevant to Michigan conditions
- Review strategies to reduction in mosquito transmitted disease
Mosquito Life Cycle

Emergence
Eggs
Pupa
Larva
Adult female
Michigan Mosquitoes

• About 60 species in the state
• Only the females bite, and not all of our species need blood, or bite people
• The overwintering stage is species specific; eggs, larvae, or adult females may overwinter
• Mosquitoes are classified by their shape and anatomy
Two major groupings:

Culicinae

- Culex

- Aedes

Anophelinae

- Ochlerotatus

- Anopheles
Generalized Classification Scheme for Michigan Mosquitoes

- Spring woodland pool mosquitoes
- Summer floodwater mosquitoes
- Open water mosquitoes
- Container mosquitoes
- There are important exceptions to this classification

- One generation per year; eggs overwinter
- >1 generations in summer; eggs overwinter
- *Anopheles, Culex*: females overwinter, >1 generation per summer
- Adapted to small bodies of water held in plants or made by people; overwinter as eggs or larvae
- Examples: waste water and underground mosquitoes
Spring woodland pool

Summer floodwater in ditch

Cattail marsh

Extensively flooded freshwater marsh extending into swamp
Larval habitat of Culiseta beneath tree hummock

Urban street catchbasin

Treehole

Tires

Pitcher
Arbovirus Transmission Cycles are Complex

- Food, Space, Breeding sites
- Predators and Pathogens
- Weather and Climate

Vertebrate Host

Virus

Vector

Adults

Terrestrial
Pupae

Aquatic
Larvae

Eggs

Dead-end hosts
Vertebrate Host

Virus

Vector

Dead-end hosts

Eggs

Terrestrial

Aquatic

Larvae

Pupae

Adults

Mosquito population growth

Virus amplification in birds and mosquitoes

A     M     J     J     A     S
Arbovirus

[Contraction]

Arthropod-borne virus

Mosquito and tick transmitted viruses that cause disease in humans and animals
Vector

An arthropod (such as a species of mosquito or tick that is capable of transmitting viruses that cause disease in humans and animals.)
Mosquito-borne Arboviruses

Arboviruses: Not a taxonomic term. Refers to viruses transmitted biologically by blood-feeding arthropods “Arthropod-Borne viruses”

Major groupings of arboviruses:
Flaviviruses (Flaviviridae): yellow fever, dengue; [Japanese encephalitis complex (incl. WNV)]
Alphaviruses (Togaviridae): EEE, WEE, VEE; chikungunya, o’nyong nyong, Ross River
Bunyaviruses (Bunyaviridae): California serogroup (e.g., LaCrosse virus)
Phleboviruses (Bunyaviridae): Rift Valley fever
Principal Arboviral Diseases, United States

LaCrosse (LAC) encephalitis
St. Louis encephalitis (SLE)
Eastern equine encephalomyelitis (EEE)
Western equine encephalomyelitis (WEE)
West Nile encephalitis
Dengue
Common Arboviruses in the United States

California Serogroup
(Primarily LaCrosse)

St. Louis

Eastern equine

Western equine
Urban Flavor of SLE and WNV Transmission Cycles

- Culex mosquito vectors: larvae associated with waste- and storm-water retention and channeling systems (street catchbasins and stormwater retention catchments are key)
- Culex mosquitoes quest for urban bird (crow, other) hosts in the urban green space tree canopy: setting for urban amplification
- Crows have become urbanized
- Culex spp. rarely but stealthly feed on humans (late at night; indoors and outdoors; at low densities of exposure)
- Urban virus overwintering in hibernating female Culex in refugia (under streets etc)
Cryptic habitats of larval and adult Culex in urban environments

Urban trees provide roost for crows

Manholes leading to utility workspaces

Catchbasin
Progression of WNV in US
Any WNV Activity Reported - 2002

West Nile Virus in the United States, 2002

- Orange states indicate verified avian, animal, and mosquito infections during 2002, as of October 8, 2002.
- Brown states indicate a pattern that indicates human case(s).
Michigan Department of Community Health Announces
Probable Human Cases of West Nile Virus

August 16, 2002

Michigan Department of Community Health Chief Medical Executive, David R. Johnson M.D., today announced two probable human cases of West Nile virus. Laboratory samples have been sent to the Centers for Disease Control and Prevention for confirmatory testing.

The first case involves an 82 year-old male from Southeast Michigan who was hospitalized and has been released in good condition. The second involves a 63 year-old male from Southeast Michigan who is currently hospitalized and appears to be improving.

“We are encouraged that both of these gentlemen appear to be recovering and we will continue to work with health care providers throughout Michigan to quickly identify any other potential human cases,” said Dr. Johnson. “The most important thing a person can do to protect themselves from West Nile virus is to follow the common-sense precautions to minimize exposure to mosquitoes.”
Phone Reports of Dead Birds versus Human Cases in Michigan for 2002

Data from 614 out of 644 human cases
Onset Date of Symptoms Among Human West Nile Virus Cases in Michigan for 2002

Data from 614 of the 644 Total Cases
WNV
Human cases
Michigan 2002*

(Includes probable and confirmed cases, all clinical syndromes)

644 cases
51 deaths
*(Total Cases/Deaths)
West Nile Virus Case Summary

Total Laboratory Positive Cases: 644

West Nile Meningo-encephalitis cases: 559 (87%)
   Age range: .75-95 yrs
   Average age: 57.8 yrs

West Nile Fever cases: 57 (9%)
   Age range: 3-80 yrs
   Average Age: 47.7 yrs

Unknown cases: 28 (4%)

Deaths: 51 (9%)
   Age range: 24-95 yrs
   Average age: 74.5 yrs
Additional Arboviruses in 2002

- St. Louis Encephalitis: 3 cases
- Eastern Equine Encephalitis: 6 cases
- LaCrosse Encephalitis: 11 cases
- Powassan virus: 1 case (Emmet Co.)
  (tick borne encephalitis)
  First time ever documented case in Michigan!
### Additional Arbovirus Cases Michigan, 2002

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<th>LAC</th>
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WNV horse cases - 329
WNV human cases - 644
Dead Corvid Density vs. Human Cases for Kent County in 2002

First positive human case confirmed

Week of the Year-(Week 20 began May 12th)
Metro Grand Rapids
WNV human and bird cases

Golf courses and parks

Sites of dead bird reports
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<tr>
<th>Species</th>
<th>No. tested</th>
<th>No. pools</th>
<th>No. positives</th>
<th>estim. MFIR*</th>
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<td>12824</td>
<td>1265</td>
<td>58</td>
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Positive Mosquito Pools by Week of Year, Michigan, 2002

- **June**: 0 pools
- **July**: 2 pools
- **August**: 12 pools
- **September**: 6 pools
In the provided graph, the number of mosquitoes captured in traps over time is depicted for two species: *Aedes vexans* and *Culex pipiens*. The graph shows data collected from 7/16 to 9/17.

- **Aedes vexans**: The line for elevated traps shows a peak on 8/6 with over 500 mosquitoes. The ground-level traps show a more steady increase, reaching over 500 mosquitoes on 9/3.
- **Culex pipiens**: The elevated traps show a steady increase throughout the collection period, reaching over 500 mosquitoes on 8/20. The ground-level traps show a slight increase, reaching over 500 mosquitoes on 8/27.

The graph indicates that both species show an increase in mosquito numbers during the collection period, with *Aedes vexans* showing a sharper peak and *Culex pipiens* showing a more gradual increase.
Prevention of Mosquito Borne Disease

• Prevent mosquito bites
  - Personal protection
  - Physical barriers
  - Personal behavior

• Reduce mosquito populations
  - Suppress larval production
  - Reduce adult mosquito population density

• Reduce virus infection rates in mosquito populations
  - Reduce adult mosquito population density
    (effect kills older mosquitoes by chance)
Virus infection and transmission processes in mosquitoes

- Virus ingestion with the blood meal
- Virus movement to midgut
- Virus infection in midgut
- Virus release without cytopathic effect from midgut cells; virus circulates and infects salivary glands, and ovaries. Virus transmitted to next generation by transovarial transmission

Virus transmission during salivation

Prior to blood feeding
Mosquito population growth

Virus amplification in birds and mosquitoes

Disease risk

Vertebrate Host

Vector

Dead-end hosts

Terrestrial Aquatic

Adults Eggs Pupae Larvae

Mosquito population growth

Control

A M J J A S
Efficacy of aerial ultralow volume application of insecticides to control transmission of SLE virus during an epidemic in Dallas, Texas 1966

Virus infection rate before spray: 1/167 mosquitoes

Virus infection rate after spray: 1/28,639 mosquitoes
West Nile Virus Infection Rates and Mosquito Control, Michigan, 2002

- Vector Control Districts (4 + 2)
  - 6,844 Culex in 579 pools tested
  - 25 pools positive
  - Minimum field infection rate = 3.65/1,000

- No vector control
  - 1,052 Culex in 106 pools
  - 30 pools positive
  - Minimum field infection rate = 28.5/1,000