Mosquitoes and Mosquito-borne Pathogens

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Mosquitoes

- Mosquitoes need water
- Four life stages: egg, larva, pupa, and adult
- Larval and pupal stages are aquatic
- Two-winged Diptera (flies): Family Culicidae: most species females have a long proboscis for sucking blood
Eggs

- Singly on surface or edge of water
- Eggs in rafts on surface of water
- Some sp. hatch 24-36 h
- Some hatch after 1-3 y
- Overwintering stage for some species
Eggs
Larvae

- “Wrigglers”, very active, most come to surface for air
- 1\(^{st}\), 2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\) instars
- 4-12 d, some species weeks
Pupae

- Stage that changes from larva to adult
- “Tumblers” very active, come to surface for air
- 3-6 d
- Non-feeding stage
Adult mosquitoes emerge from aquatic stages
• Emerges first
• Feeds on nectar sources for energy
• Mates within 2–7 d and dies
Adult (Females)

- Emerge and feed on nectar
- Mate usually once
- Need blood meal to develop eggs
- 1-5 blood meals over life of 7 - 28 d
Winter Survival Is Important:

Most overwinter in the egg stage (*Aedes*, *Ochlerotatus*, and *Psorophora*)

Some as larvae (*Anopheles* and *Ochlerotatus*)

Some as adults (*Culex* and *Anopheles*)

Mated females rest in protected, cool locations, such as cellars, sewers, crawl spaces, and well pits

Warm spring days allow females to seek a blood meal
Mosquitoes are classified based on larval habitat

- Floodwater mosquitoes - Eggs laid in damp areas
- Permanent water mosquitoes
- Container mosquitoes
Flood Water Mosquitoes

- *Aedes* and *Psorophora*
- Some genera are important pest species
- Bite humans, livestock, pets
- Can have very large populations in spring and early summer
Floodwater (cont.)

- Can survive in egg stage for several years until flooded
- Can have different hatches within several days if increased water levels hatch new eggs
• Adult populations peak in late April, May, and June, some species hatch with late summer fall rains
• Adults die quickly during hot weather
• Flood water usually dries up too fast to support larvae in hot weather
• Females most active around sunset or in shady areas when disturbed
• Some are active during the day
Aedes vexans & Psorophora

Green space (parks, soccer fields, lawns, etc.)
Vector Roles

- *Aedes vexans* (Inland floodwater mosquito)
  - Known vectors of dog heartworm

- *Psorophora columbiae* (Dark ricefield mosquito)
  - Vector of West Nile Virus in humans (CDC)
Permanent Water Mosquitoes

- *Anopheles*, some *Culex* spp.
- Found in quiet bodies of freshwater with sunlight, surface vegetation and little wave action
- Shallow edges of ponds, some lakes backwaters of rivers slow moving streams
- Never in lakes with wave action
Permanent Water Group (cont.)

- *Anopheles* vectors malaria
- 1,500-2,000 cases of malaria
- Most travel related

Mismanaged ponds:
- Excessive vegetation
- Stagnant water
- Lack of predators
Permanent Water Group (cont.)

- Populations low in spring
- Build through the summer
- Peak July-October (varies by location)
- Many prefer birds as hosts, feed on mammals
- Vectors of viruses
- Bite more readily at night
Mosquitoes of Great Concern

- *Culex tarsalis*, (western encephalitis mosquito)
  *C. quinquefasciatus* (southern house mosquito)

- Note: all are permanent water mosquitoes, populations peak in summer through fall at same time virus activity peaks

- Feed on birds and mammals
Roadside ditches

Wastewater treatment

*Culex* spp. prefer nasty, smelly water
Vector role of *Culex* Mosquitoes

- West Nile virus
- St. Louis encephalitis
- Western and Eastern Equine Encephalitis
- Brazilian scientists are investigating if *Culex* is transmitting Zika virus
Container Mosquitoes
(you breed ‘em, you feed ‘em)

• 99% = *Culex* or *Aedes*

• In nature larvae live in tree holes, rock pools even leaf axils

• Many species associated with man made containers or materials that hold water
  • Tires, cans, buckets, birdbaths, gutters, pet water dishes, plant container bottoms that catch water, even cans, paper cups etc.
Typical Container Mosquito Habitat
Asian Tiger Mosquito

- *Aedes albopictus*
  - Larvae in containers of any size
  - Adults active during the day

*vector dengue, ChikV*
Aedes albopictus
Eggs in Container

- Container breeder
- Eggs laid on surface of water, on sides of container, and on stick
- Immediate egg hatch of some eggs, delayed hatch for others
Yellow Fever Mosquito
Aedes aegypti

- Container breeder
- Prefer more sunlight
- Dengue and ChikV
Ae. aegypti and Ae. albopictus: Species Competition Factors

• Ae. aegypti - correlated with urbanization

• Ae. albopictus - rural, suburban & vegetated urban habitats (parks)

• Ae. aegypti eggs are more desiccation-resistant.
  • Favored in hot, dry environments

• Ae. albopictus better larval competitor
  • Low-nutrient, natural resource environments.

• Larval breeding and adult resting sites typically outdoors in U.S. (screens and use of air conditioning prohibit indoor breeding)
Vector role of *Aedes* Mosquitoes

- Chikungunya
- Dengue
- Zika

Prevent – Detect – Respond
West Nile Virus

- West Nile virus (WNV) is most commonly transmitted to humans by *Culex* mosquitoes.
- There are no medications to treat or vaccines to prevent WNV infection.
- About 1 in 5 people who are infected will develop a fever with other symptoms.
- Less than 1% of infected people develop a serious, sometimes fatal, neurologic illness.
Chikungunya

- Chikungunya (CHIKV) is an arthropod-borne virus (arbovirus) transmitted by *Aedes aegypti* and *Ae. albopictus*

- The CDC and PAHO have developed a preparedness and response plan available at: http://www.cdc.gov/chikungunya
Chikungunya Signs & Clinical Symptoms

Incubation period 2-6 d, symptoms appearing 4–7 d post-infection

Symptoms include:

- Rash
- Nausea
- Pain in the Lower Back
- Vomiting
- Joint Pain
- Fevers
- (with or without swelling)
- Headaches
- Chills
Countries and territories where chikungunya cases have been reported
(as of October 20, 2015)

- Current or previous local transmission of chikungunya virus
524 cases in U.S. in 2015
**Dengue**

- Dengue is caused by any one of four related viruses (DEN 1-4) transmitted by mosquitoes
- ~ 400 million people are infected yearly
- Latin America, Southeast Asia and the Pacific islands
- *Aedes aegypti* mosquito is the most important transmitter or vector of dengue viruses
Areas at Risk of Dengue Outbreaks
Dengue Signs & Clinical Symptoms

Dengue fever (DF) symptoms include:
High fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash and mild bleeding

Dengue hemorrhagic fever (DHF) symptoms include: can be fatal
a fever that lasts from 2 – 7 days. When the fever declines, persistent vomiting, severe abdominal pain, difficulty breathing
Zika

- Alert healthcare providers and the public about Zika

- Zika virus is transmitted to people primarily through the bite of an infected *Aedes* mosquito

  - *Aedes aegypti* and *Ae. Albopictus*

- Same mosquitoes that spread dengue and chikungunya viruses

- Zika virus can also be transmitted from mother to her fetus during pregnancy, through blood transfusions, and through sexual contact
Zika Signs & Clinical Symptoms

- 20% people infected with zika virus become ill
- The most common symptoms are fever, rash, joint pain, and/or conjunctivitis (red eyes)
- Other symptoms include muscle pain and headache
- Incubation period 2-7 d
- Usually mild with symptoms lasting for a few days to a week
- Death is rare
Zika and Microcephaly

- Brazilian communities have experienced a significant number of Zika cases since May 2015
- Officials have also noticed an increase in the number of babies with congenital microcephaly
- Additional studies are needed to determine the degree to which Zika might be linked with microcephaly
- Pregnant women should take steps to prevent mosquito bites

Areas with Zika
<table>
<thead>
<tr>
<th></th>
<th>West Nile</th>
<th>Chikungunya</th>
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<tbody>
<tr>
<td><strong>Virus</strong></td>
<td><em>Flavivirus</em></td>
<td><em>Alphavirus</em></td>
</tr>
<tr>
<td><strong>1&lt;sup&gt;o&lt;/sup&gt; vectors</strong></td>
<td><em>Culex</em></td>
<td><em>Aedes</em></td>
</tr>
<tr>
<td><strong>Human hosts</strong></td>
<td>Incidental</td>
<td>1&lt;sup&gt;o&lt;/sup&gt; host</td>
</tr>
<tr>
<td><strong>% symptomatic</strong></td>
<td>&lt;20%</td>
<td>72-97%</td>
</tr>
<tr>
<td><strong>% chronic</strong></td>
<td>&lt;1%</td>
<td>30-40%</td>
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<tr>
<td><strong>% fatality</strong></td>
<td>&lt;1%</td>
<td>0.03%</td>
</tr>
<tr>
<td><strong>Symptoms</strong></td>
<td>Fever, headache, body aches, skin rash, and swollen lymph nodes</td>
<td>Headache, muscle pain, joint swelling, rash</td>
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<tr>
<td>Dengue</td>
<td>Zika</td>
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<tr>
<td><strong>Virus</strong></td>
<td><em>Flavivirus 1-4</em></td>
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<tr>
<td>1&lt;sup&gt;o&lt;/sup&gt; vectors</td>
<td><em>Aedes</em></td>
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<tr>
<td>Human hosts</td>
<td>1&lt;sup&gt;o&lt;/sup&gt; host</td>
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<tr>
<td>% symptomatic</td>
<td>Can be 50%</td>
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<tr>
<td>% chronic</td>
<td>Variable</td>
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<tr>
<td>% fatality</td>
<td>&lt;1-50% (DF, DHF)</td>
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<tr>
<td>Symptoms</td>
<td>Headache, eye pain, joint pain, muscle and/or bone pain, rash, nausea</td>
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<tr>
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<td>Fever, rash, joint pain, and conjunctivities (?) Microcephaly?</td>
<td></td>
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</tbody>
</table>
Integrated Pest Management (IPM)

- Surveillance
- Source Reduction
- Larvicides
- Adulticides – “when not to spray”
- Biological Control Agents
- Public Education
  - Reduce conducive conditions
  - Eliminate containers holding water
  - Repellents
Mosquito Management

• Stop them at their source – larvicide
• Kill vectoring adults – adulticide
• Erect barriers against the ones you miss
• Advocate personal protection as the final layer of protection – repellents
CDC
http://www.cdc.gov/features/stopmosquitoes

USGS
http://diseasemaps.usgs.gov/dep_ga_human.html

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http://cals.arizona.edu/apmc/public-health-IPM
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