Emerging and Endemic Vector-Borne Diseases in Michigan

Ned Walker
With thanks to:

• Dr. Kim Signs, MDCH
• Dr. Mary Grace Stobierski, MDCH
• Dr. Gabe Hamer, MSU
• Erik Foster, MDCH
• Mike Kaufman, MSU
• Betsy Brouhard, MSU
• Bill Stanuszek, SCMAC
• Randy Knepper, SCMAC
Purpose of this Presentation

• Briefly discuss concepts of emerging, vector-borne diseases

• Tick-borne infectious diseases of Michigan: emergence of Lyme disease

• Mosquito-borne diseases relevant to Michigan conditions
Concepts in Emerging Diseases

- New pathogens emerge and are discovered
- Known pathogens expand geographic or host range, increasing in incidence
- Environmental receptivity: physical and living landscape is receptive to invasion and establishment of pathogens whose range expands
- Most are zoonotic, many vector borne
- Endemic diseases show cyclical activity, suggesting occasional “re-emergence”
- Importance of international travel, trade
If the St. Lawrence seaway is the front door, Michigan is the foyer for introduction of invasive species into North America.

Human-assisted pathways of introduction of alien species into North America
Once introduced, is habitat suitable for establishment? (introduction > invasion/spread > establishment)
What is Lyme Disease?

- Tick-borne disease transmitted by the Blacklegged tick, *Ixodes scapularis*
- Bacterial, spirochete, *Borrelia burgdorferi*
- Transmission from tick to host takes 24-48 hours
- No person-to-person spread
- Range of potential symptoms and difficulties interpreting laboratory results makes reported Lyme difficult to characterize for public health surveillance purposes

**Lyme disease ~~**
Lyme disease is a nationally notifiable disease. The Centers for Disease Control and Prevention collect and analyze data from all states. The graph at right illustrates percent of clinical findings among 119,965 patients for whom at least one symptom was reported.
Lyme disease has emerged over time in the United States:
....and over space
Current distribution of the blacklegged tick, *Ixodes scapularis*
Emergence and spread of *Ixodes scapularis* and Lyme disease in Michigan

Prior to 2002, no local populations of blacklegged ticks had been identified in the Lower Peninsula. Over the past decade, extensive field surveys have documented a northward progression of tick invasion along Michigan’s western shoreline.
Factors that influence tick habitat suitability include:
- Forest Type
- Soil Type
- Humidity
- Host Availability
Northward spread of *I. scapularis* detected continuously on coastal mice, but not on inland mice.
Northward spread of *I. scapularis* nymphs detected along coastal sites, but not inland.
Northward spread of *I. scapularis* detected: *B. burgdorferi* prevalence (%) in host-seeking nymphs.
Phenology in Southern Michigan

- Larvae
- Nymphs
- Adults

Relative activity

Month

1 2 3 4 5 6 7 8 9 10 11 12
Lyme disease prevalence in Michigan, 2000 - 2010

- Unknown Exposure
- Out-of-State Exposure
- In-State Exposure
**2010: Case Summary**

- 95 cases reported
- Age range: 2 — 76 years
- Median age: 37 years
- Males: (57) 60%  Females: (38) 40%
- Onset dates of illness:
  - March 10 — December 1
- Exposure:
  - In-State: 63
  - Travel Associated: 32
  - Unknown: 0
Case Onsets for Michigan Exposures

2010 Lyme Disease Case Onset

- All Cases w/Reported Onset
- MI UP Exposures
- MI West Exposures

No. Cases

May → Jun → Jul → Aug → Sept

MMWR Week
Conclusions and Considerations

• Tick populations and Lyme disease risk continue to expand geographically in Michigan, now encompassing the entire western shoreline of the Lower Peninsula, but at a relatively slow rate (decadal scale).

• The endemicity of Lyme disease in Michigan is increasing and the situation is worsening:
  – Tick surveys do not support widespread establishment of *I. scapularis* across Michigan’s Lower Peninsula but show range expansion.
  – The Lower Peninsula has large land area with suitable tick habitat, based on a predictive and verified landscape model.

• Studies are on-going to estimate the entomologic risk index (density *B. burgdorferi* infected nymphs/1000m²) at Sleeping Bear Dunes & National Lakeshore, and the Manitou Islands (data not shown).

• Several other tick surveys are ongoing and several citizens groups show strong interest in this disease system from various points of view.

• Other tick borne disease agents are of real concern: *Anaplasma*, *Babesia*, Deer Tick virus, etc.

• Physician and veterinarian education and networking is key at this relatively early point in the process.
Michigan Mosquitoes

• About 60 species in the state, 250 in the US, and 3,000 in the world
• Only the females bite, and not all of our species need blood, or bite people, or transmit pathogens
• The overwintering stage is species specific; eggs, larvae, or adult females may overwinter
• Mosquitoes are classified by their shape and anatomy
• An invasive species, *Aedes japonicus*:
Two major groupings:

Culiciniae

Culex

Aedes

Anophelinae

Aedes

Anopheles
Mosquitoes in Michigan, 2011: “It was a very good year … “
2011 was a wet year.
More rain = more mosquitoes.
Mosquito-Borne Diseases

• Malaria: once common in Michigan, now eradicated but imported regularly
• Bird malaria: common
• Dog heartworm: common
• Mosquito-borne viruses:
  – Eastern Equine Encephalitis virus
  – La Crosse encephalitis virus
  – St. Louis encephalitis virus
  – West Nile virus
  – Dengue
Bird malaria is endemic to Michigan.

Study of house sparrows in 1986 showed 2.6% prevalence in Reed City. Other studies in N. America indicate higher prevalence (up to 40%) in rural areas. Passerine birds in general are thought to have an 11 - 67% infective rate for all types of malaria parasites.
Vignette:

Saginaw zoo penguin mortality - September 2004
Young (< 2 years old) black-footed penguin (*Spheniscus demersus*)
“Flock” suffering from aspergillosis (fungal lung disease)
Autopsy showed parasites in liver, spleen, brain, and lung tissue
Identified as *Plasmodium* spp. (probably *relictum*)
Treatments (Primaquine) given to other birds
All penguin collections in Michigan are put on malaria prophylaxis each summer by zoo vets to prevent deaths

“Sully” (RIP)
Dog Heartworm (affects cats also)
*Dirofilaria immitis*
Vectored by many mosquito species. In Michigan, *Aedes vexans* and *Ae trivittatus* (summer floodwater species) are implicated along with *Ae. canadensis* (spring) and *Anopheles* species (summer, permanent water)

**Heartworm Life Cycle**

- Adult heartworm in heart and pulmonary vessels (1-250 worms)
- 14 days or longer infective 3rd stage larva
- Microfilariae
- 2 to 3 months
- 3 to 4 days
- L3
- L4
- L4 (4th stage larva)
- L4 (4th stage larva)
- 3 to 4 months
- 6 to 7 months post-infection (patency)
- 7 to 8 months post infection (transient patency)

**Wild animal hosts**

- Coyotes, Foxes:
- Cat infection: rare
- Dog infection: common
Distribution of Dog Heartworm in the United States: Positive Dogs by Reporting Veterinary Clinic, 2010

Emerged from southern US northwards from the 1940s

Source: American Heartworm Association
Life Cycle of Human Malaria
Plasmodium vivax infection in a racing fan: local transmission of malaria, 1995

But where did it come from?

Anopheles mosquitoes collected at the camp site.

Old pathogen, re-introduced.
# Arboviruses in the United States

Selected representatives by family

|-------------------------------------------|------------------------|--------------|------------|--------------|------------|------------------------|--------|----------------------|---------|---------------|------------------------|----------|----------------|---------|----------------|----------------|--------|----------------|-----------|----------------|----------|----------------|----------------|----------------|----------------------|----------------|----------------|--------|----------------|----------------|----------------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|

**Virus Family:**

- **Togaviridae**
- **Bunyaviridae**
- **Rhabdoviridae**
- **Flaviviridae**
- **Reoviridae**

*not endemic*
Arboviruses:

_Arthropod – borne viruses_

Not a taxonomic term and nothing to do with trees
PRIMARY ARBOVIRUSES AFFECTING HUMANS IN THE U.S.

- Eastern Equine Encephalitis
- Western Equine Encephalitis
- La Crosse
- Saint Louis Encephalitis
- West Nile
Mosquito-borne viral diseases in people of Michigan, 2010, confirmed infections

- West Nile virus: 29
- Dengue: 9*
- EEE: 3
- SLE: 2
- LaCrosse: 2
- Total: 45

*Only notifiable since 2009
West Nile virus human cases, US, 2011, provisional
Total: 690 including 43 deaths
Michigan: 33 including 2 deaths
Predicting WNV

- Are mosquito infection data any good?
- What about weather?
- What about mosquito/host contact rates?
West Nile virus activity in mosquitoes, metropolitan Chicago

*Culex* spp. mosquito infection rate (2005-2010)

Sequential sampling West Nile virus infected mosquitoes to predict human cases: A test case in metropolitan Chicago

It is possible to predict human cases at the local scale 2 weeks ahead of onset by using mosquito infection curves, with sufficient sampling and testing.
Mosquito Bloodmeal Analysis: A horse at the Potter Park Zoo bitten by a WNV-positive mosquito

(This is mosquito CSI, folks)

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Species</th>
<th>Fed On</th>
<th>Arboviral Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-071</td>
<td>Ae. triseratus</td>
<td>Opossum</td>
<td>Negative</td>
</tr>
<tr>
<td>65-072</td>
<td>Unknown</td>
<td>Gray Wolf</td>
<td>Negative</td>
</tr>
<tr>
<td>65-093</td>
<td>Ae. other</td>
<td>Goat</td>
<td>Negative</td>
</tr>
<tr>
<td>65-135</td>
<td>Anopheles</td>
<td>Goat</td>
<td>Negative</td>
</tr>
<tr>
<td>65-187</td>
<td>Ae. vexans</td>
<td>Perching/Song Bird</td>
<td>Negative</td>
</tr>
<tr>
<td>65-188</td>
<td>Ae. other</td>
<td>Perching/Song Bird</td>
<td>Negative</td>
</tr>
<tr>
<td>65-189</td>
<td>Culex sp.</td>
<td>Gray Wolf</td>
<td>Negative</td>
</tr>
<tr>
<td>65-294</td>
<td>Ae. other</td>
<td>Human</td>
<td>Negative</td>
</tr>
<tr>
<td>65-323</td>
<td>Culex sp.</td>
<td>Horse</td>
<td>WNV Positive</td>
</tr>
<tr>
<td>65-391</td>
<td>Ae. other</td>
<td>Perching/Song Bird</td>
<td>Negative</td>
</tr>
<tr>
<td>65-510</td>
<td>Culex sp.</td>
<td>Ostrich</td>
<td>Negative</td>
</tr>
<tr>
<td>65-557</td>
<td>Culex sp.</td>
<td>House Sparrow</td>
<td>Negative</td>
</tr>
<tr>
<td>65-598</td>
<td>Ae. other</td>
<td>Oryx</td>
<td>Negative</td>
</tr>
<tr>
<td>65-660</td>
<td>Ae. japonicus</td>
<td>Antelope</td>
<td>Negative</td>
</tr>
</tbody>
</table>
Special Concerns

• Economic downturn, loss of capacity, elimination of surveillance systems, loss of interest …
• Abandoned swimming pools
• Retention and detention catchment systems and NDPES, lack of attention to mosquito production issues
What we find out from passive surveillance: let the cases come to us

What we find out from active surveillance: we go to the cases
Are we dropping our guard – apathy, priorities? Or is our guard dropping us – funding, politics? Does anybody care?
Abandoned swimming pools are a sign of the economic times and are major mosquito factories.
NPDES stormwater management requires retention/detention systems near developments and impervious surfaces: creates mosquito habitat.

Mosquitoes per standard dip

Culex pipiens

Culex territans

Anopheles spp.
California Serogroup Virus Neuroinvasive Disease Cases* Reported by State, 1964-2008

Most reported cases of California serogroup neuroinvasive disease are due to La Crosse virus.

Saginaw Co., Bridgeport township – 2006 human fatality

La Crosse encephalitis virus in Saginaw County
Dengue (DEN’ – gee): an emerging mosquito borne viral disease
Dengue fever in Humans, USA, 2010
A mosquito-borne virus in the same group as WNV

Total: 10,040 human cases
Florida: 53
Puerto Rico: 9,987
Imported dengue fever in Humans, USA, 2010

Total: 436 human cases
Florida: 125
New York: 116
Michigan: 9
“Cases of dengue in returning U.S. travelers have increased steadily during the past 20 years. Dengue is now the leading cause of acute febrile illness in U.S. travelers returning from the Caribbean, South America, and Asia. Many of these travelers are still viremic upon return to the United States and potentially capable of introducing dengue virus into a community with competent mosquito vectors. Because of concerns over the increasing number of travel-associated dengue infections, the risk for local transmission upon introduction of the virus, and the risk for potential transmission of the virus by blood transfusion, the Council of State and Territorial Epidemiologists (CSTE) made dengue a nationally notifiable disease in 2009.”

“On April 9, 2010, a man aged 41 years from Key West was hospitalized with hematuria, leukopenia, and thrombocytopenia. His symptoms had begun April 5 with onset of myalgia, arthralgia, and fever, followed by development of a petechial rash and gingival bleeding on April 7. The patient previously had traveled to dengue-endemic regions but reported no travel outside the United States in 18 months.”

Historic Distribution of EEE United States

- Alphavirus
- First identified in 1930’s
- East coast, Gulf coast, Great Lakes

EEE Human Neuroinvasive disease, 1964-2008
Regional Glacial Geology

Laurentide Ice Sheet just prior to its retreat from Lower Michigan

(c. 17,800 C¹⁴ yrs ago)
Vegetation signatures: Tamarack, Black spruce, Red maple, Poison sumac, sphagnum,
MI EEE Cases, Equine and Human: 1980-2010

Lesson: if we look, we will find cases. Also 10 La Crosse cases.
Eastern Equine Encephalitis - Human

1980 - 2010

- 1 human EEE case
- 2 human EEE cases
- 3 human EEE cases
- Fatality

Total Cases: 17
Human EEE Cases, 2010

Florida 4
Massachusetts 1
Michigan 3
New York 1
Rhode Island 1

Total = 10

USGS Data
Horse cases are the only warning we have (but human cases co-occur)

Reports of ill
Equine
Michigan, 2010

MMWR Wk 28: 7/11
MMWR Wk 29: 7/19
MMWR Wk 30: 7/26
MMWR Wk 31: 8/1
MMWR Wk 32: 8/8
MMWR Wk 33: 8/15
MMWR Wk 34: 8/22
MMWR Wk 35: 8/29
MMWR Wk 36: 9/5
MMWR Wk 37: 9/12
MMWR Wk 38: 9/19
MMWR Wk 39: 9/26
MMWR Wk 40: 10/3

Total Reports: 123 (9 lacked info)
55 Tested Positive for EEE
Thank you for your attention!