Vector-borne Diseases in Minnesota

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Mosquito-Transmitted Disease in Minnesota
Diseases Transmitted by Mosquitoes in Minnesota

• LaCrosse encephalitis
• Western equine encephalitis
• Eastern equine encephalitis
• West Nile virus disease
West Nile Virus (WNV)
West Nile Virus: Epizootology

Mosquito vector

West Nile virus

Bird reservoir hosts

Incidental infections

Incidental infections
Culex tarsalis, the mosquito primarily responsible for transmitting WNV and WEE in Minnesota

Image provided by Dale Parker
**Culex tarsalis**

- Wide range of hosts
  - preference for birds, but does feed on cows, horses and humans
- Crepuscular feeders
- Lifespan of a few weeks during warm summer months
- Late emerging females overwinter until spring
WNV Human Infection “Iceberg”

1 CNS disease case = ~150 total infections

~80% Asymptomatic

~20% “West Nile Fever”

<1% CNS disease

~10% fatal (<0.1% of total infections)

Very crude estimates
U.S. Counties Reporting Human WNV Illness or Non-Human WNV Activity in 1999

- **Non-Human WNV Activity**
- **Human Disease Cases**
U.S. Counties Reporting Human WNV Illness or Non-Human WNV Activity in 2002

Non-Human WNV Activity

Human Disease Cases

[Map showing U.S. counties with different colors indicating the presence of WNV activity and human disease cases.]
U.S. Counties Reporting Human WNV Illness or Non-Human WNV Activity in 2003*

* Reported as of 1/20/2004
## Human Cases of WNV in Minnesota

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Cases</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>148</td>
<td>4</td>
</tr>
<tr>
<td>2004</td>
<td>34</td>
<td>2</td>
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<tr>
<td>2005</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>2006</td>
<td>65</td>
<td>3</td>
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<tr>
<td>2007</td>
<td>101</td>
<td>2</td>
</tr>
<tr>
<td>2008</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>2009</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>463</td>
<td>14</td>
</tr>
</tbody>
</table>
Human WNV Cases by Median Date of Illness Onset, Minnesota, 2002-2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Cases</th>
<th>Onset Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>(n=48)</td>
<td>July</td>
</tr>
<tr>
<td>2003</td>
<td>(n=148)</td>
<td>August</td>
</tr>
<tr>
<td>2004</td>
<td>(n=34)</td>
<td>August</td>
</tr>
<tr>
<td>2005</td>
<td>(n=45)</td>
<td>August</td>
</tr>
<tr>
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<td>(n=65)</td>
<td>August</td>
</tr>
<tr>
<td>2007</td>
<td>(n=101)</td>
<td>August</td>
</tr>
</tbody>
</table>
Tick-borne Diseases of Concern in Minnesota

• **Endemic**
  – Lyme disease
  – Human anaplasmosis
  – Babesiosis

• **Rare or Not Endemic**
  – Rocky Mountain spotted fever
  – Human monocytic ehrlichiosis
  – Powassan encephalitis
On the left are adult male and female blacklegged ticks. On the right is an adult female American dog tick (wood tick)
Blacklegged Tick
(“Deer Tick”)
Ixodes scapularis

Nymph
Adult (female)
Larva

Tim Leonard and Russell Johnson
University of Minnesota
Blacklegged Tick Larvae

- Size of period at end of sentence
- Initially does not have Lyme disease bacteria
- May get the bacteria from a host who has the bacteria
White-Footed Mouse: Main Reservoir Host for Several Blacklegged Tick (Deer Tick) - Transmitted Pathogens (including POWV)
Blacklegged Tick
(Deer Tick)
Nymph
Blacklegged Tick Nymph

- Size of a poppy seed
- Transmits most disease because they are so difficult to detect
Male and Female Adult Blacklegged Tick

- Feed and mate on large animals in the fall or early spring
- After feeding, female lays eggs, then dies
- Ticks that did not feed go dormant
Adult Blacklegged Ticks Mating
Blacklegged Tick (Deer Tick) Habitat
Blacklegged ticks search for a host from the tips of grasses and shrubs, generally climbing onto a person or animal near ground level.
“Dragging for Ticks”
Lyme Disease

*Borrelia burgdorferi*
Lyme Disease Signs and Symptoms

3 to 30 days after blacklegged tick bite

- Rash (typically “bulls-eye”)
- Fever
- Chills
- Headache
- Muscle and joint pain
- Fatigue
Erythema Migrans (EM)

Typical “bulls-eye” appearance with central clearing

EM rash without central clearing
Lyme Disease Signs and Symptoms

Days to weeks after illness onset

- Multiple rashes
- Facial paralysis on one side
- Fever, stiff neck, headache
- Weakness, numbness, arm/leg pain
- Irregular heart beat
- Persistent weakness and fatigue
Multiple Rashes

- Dissemination of spirochetes
- Not caused by multiple tick bites
Lyme Arthritis

• Symptoms
  – Joint swelling
  – Joint pain

• Onset:
  – Weeks to months after exposure, if untreated
Human Anaplasmosis

*Anaplasma phagocytophilum* in vacuole of white blood cell

Human Anaplasmosis
Signs and Symptoms

• Acute onset 3-21 days after tick bite
  – Fever (> 102 degrees), chills, shaking
  – Severe headache
  – Muscle aches
  – Leukopenia, thrombocytopenia, elevated aminotransferase levels

• Severe complications: septic/toxic shock-like syndrome, respiratory or renal failure, secondary infections
Babesiosis

*Babesia microti*

in red blood cell
Babesiosis Signs and Symptoms

- High fever, chills
- Headache
- Muscle aches
- Fatigue
- Loss of appetite
- Anemia (hemoglobin < 14.0 g/dL)
- Thrombocytopenia (platelets < 150,000 / mm$^3$)
- Complications include DIC and respiratory, heart, and renal failure
Human Ehrlichiosis due to *E. chaffeensis* in Minnesota?

- Clinical manifestations very similar to HA
- *Ehrlichia* closely related to *Anaplasma*
- Differences from HA:
  - Tick vector: *Amblyomma americanum* (Lone star tick)
  - Endemic to South
- *A. americanum* spreading northward

Modified from CDC: [http://www.cdc.gov/ticks/maps/lone_star_tick.html](http://www.cdc.gov/ticks/maps/lone_star_tick.html)
Human Ehrlichiosis due to *Ehrlichia muris*-Like Agent

- 2009-2010: Mayo Medical Lab detected *Ehrlichia muris*-like agent (EML) in 14 Minnesota and Wisconsin patients
- Patients had illnesses suggestive of anaplasmosis or ehrlichiosis
- EML infection with cross-reactivity to *E. chaffeensis* could explain some Midwestern cases with positive *E. chaffeensis* serology
- EML also identified in *I. scapularis* and *Peromyscus* mice by PCR
Human Ehrlichiosis: *Ehrlicia muris*-like (EML) Agent
Counties of Possible Tick Exposure, 2009-2011*

* Reported as of 11/08/11; n=18 cases
(includes 2 cases with possible exposure in Wisconsin and 3 cases exposed in Minnesota or Wisconsin)
Rare / Not Endemic in Minnesota: Powassan Encephalitis

- Caused by Powassan (POW) virus (flavivirus)
- Distribution: northern North American, eastern Russia
- Vectors: *Ixodes* spp., including the blacklegged tick
- May be a frequent cause of encephalitis of unknown etiology in Minnesota??
POW Cases by Counties of Exposure, 2008-2011 (n=17*)

Lyme Disease Incidence Rate (cases/100,000 person-years), 2006-2010

*Multiple cases exposed in some counties; some cases exposed in multiple counties
Estimated POWV Prevalence* in *I. scapularis*, 2009-2011

* using pooled ticks with maximum likelihood estimate (2009) or individually-tested ticks (2010-11)

5.3% adults (2009); 0.0% adults (2011)

3.8% nymphs (2009) 15.0% adults (2009)

3.6% adults (2009) 0.0% adults (2011)

3.36% adults (2011)
Background – *I. scapularis*-Borne Diseases in Minnesota (MN), 1996-2010
Reported Tick-borne Disease Cases by Age at Onset, Minnesota, 1999-2008
(n = 9,247*)

* Excluding cases with unknown age
Reported Tick-borne Disease Cases by Onset Month, Minnesota, 1999-2008 (n=7,897*)

- Lyme disease
- Human anaplasmosis
- Babesiosis

* Excluding Lyme disease cases without EM and cases with unknown onset
Expanding Geographical Distribution of Lyme Disease by Case County of Residence, MN, 1996-2010

Incidence Rate (cases/100,000 person-years)

- No Cases
- >0.0-10.0
- >10.0-100.0
- >100.0-160.0
High Risk Areas for Tick-borne Diseases in Minnesota

Tick-borne disease risk in Minnesota is highest in forested areas within the shaded zones.

Blacklegged ticks may also be found at lower levels in some forested areas outside this zone.
Blacklegged Tick Populations at Peripheral Study Sites 2005-2008 *

- No specimens identified
- 1-2 life stages identified
- 3 life stages identified

- Highest risk areas for tick-borne diseases

*provisional/unpublished data
## Blacklegged Tick Infection Prevalence, Minnesota* 2009-2010

<table>
<thead>
<tr>
<th></th>
<th>Adults (N = 719)</th>
<th>Nymphs (N = 643)**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td><strong>Borrelia burgdorferi</strong></td>
<td>269 (37.4)</td>
<td>126 (19.6)</td>
</tr>
<tr>
<td><strong>Anaplasma phagocytophilum</strong></td>
<td>54 (7.5)</td>
<td>61 (9.5)</td>
</tr>
<tr>
<td><strong>Babesia microti</strong></td>
<td>60 (8.3)</td>
<td>49 (7.6)</td>
</tr>
<tr>
<td><strong>Ehrlichia muris-like agent</strong></td>
<td>14 (1.9)</td>
<td>14 (2.3)</td>
</tr>
</tbody>
</table>

* 4 long-term monitoring sites in north-central and southeastern Minnesota

** Only 618 of 643 nymphs tested for *E. muris*-like agent
Tick-Borne Diseases: Coinfection

- Coinfected ticks not uncommon
- Coinfection may alter efficiency of transmission, as well as severity and duration of symptoms
- Consider coinfection when pursuing testing or selecting therapy for patients with tick-borne disease
Prevention
Avoid Tick Bites

• Be aware of high-risk times and places
• Walk in the center of trails to avoid picking up ticks from brush
• Wear long pants, light-colored clothing, and repellent
• Perform tick checks
• Control ticks at home
Use Effective Tick Repellents

- **DEET**
  - Use product with up to 30% DEET
  - Apply to skin or clothing
  - Focus below the knees

- **Permethrin**
  - Apply to clothing only
  - Lasts through multiple washings
  - Good choice for people outside frequently
Check for Ticks

- Ticks are easier to spot against light-colored clothing than dark clothing
- Look for ticks while outside and again at home
- Under clothes, ticks tend to attach at points of constriction
- Parents should check young children
Control Blacklegged Ticks at Home

• Modify landscape
  – Remove leaf litter and brush from yard
  – Construct landscape barrier between lawn and woods

• Apply acaricide (pesticide) to low-lying vegetation
Timeline of Autochthonous Vector-borne Diseases of Humans, Minnesota

- **Malaria**
- **Babesiosis**
- **Anaplasmosis**
- **La Crosse encephalitis**
- **West Nile virus**
- **Lyme disease**
- **Western equine encephalitis**
- **EEE equine outbreak**
- **RMSF Fatality**

- **Mosquito-borne**
- **Tick-borne**
For More Information

• Minnesota Department of Health
  – Melissa Kemperman / Dave Neitzel
  – www.health.state.mn.us, 651-201-5414