Tick Vector Biology and Lyme Disease Transmission

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Eastern Region Lyme Disease Training
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Objectives

- Relate the biology of the blacklegged tick, *Ixodes scapularis*, to Lyme disease ecology and epidemiology
  - Vertebrate hosts
  - Seasonal activity
  - Habitat
  - Geographic distribution
    - Discuss how tick surveillance in West Virginia addresses Lyme disease ecology and epidemiology
    - Tick management and tick-borne disease prevention measures
Introduction

- Damage caused by ticks
  - Loss of blood
  - Tick toxicoses
  - Disease transmission
Introduction (cont.’d)

- Pathogen for Lyme disease: *Borrelia burgdorferi*
- Distribution: Worldwide
- United States of America: Mainly northeastern U.S. and upper Midwest
• Tick vectors for Lyme disease in continental United States
  - *Ixodes scapularis*: black-legged tick
  - *Ixodes pacificus*: Western black-legged tick

- *Ixodes scapularis* infected with Lyme disease bacteria are found in West Virginia
Ticks of West Virginia

- *Dermacentor variabilis* - “American dog tick”
- *Amblyomma americanum* - “lone star tick”
- *Dermacentor albipictus* - “winter tick”
- *Rhipicephalus sanguineus* - “brown dog tick”
- *Amblyomma maculatum* - “Gulf Coast tick”
- *Haemaphysalis leporispalustris* - “rabbit tick”
- *Ixodes cookei* - ”groundhog tick”
- *Ixodes texanus* - “raccoon tick”
Tick Life Cycle

- Egg
- Larva
- Nymph
- Adult
*Ixodes scapularis* follows the three host life cycle.

Each stage feeds once on a different vertebrate host.

**Note:** The life cycle of a 3-host tick may take 1-3 years depending on how quickly the tick can find a suitable host between life stages.
Vertebrate Hosts

- **Hosts of *Ixodes scapularis***
  - Field mice, chipmunks, birds, lizards: Larvae, nymphs
  - Raccoon, opossum, humans: Nymphs
  - White-tailed deer, humans: Adults
Vertebrate Hosts (cont.’d)

- Different tick life stages feed on different vertebrate hosts
- Younger tick life stages feed on smaller hosts closer to the ground
Lyme Disease Transmission Cycle

- Hosts of *Borrelia burgdorferi*
  - Field mice, chipmunks
  - Raccoon, opossum, rabbits
  - Birds
Lyme Disease Transmission Cycle (cont.’d)

- Uninfected larval ticks (brown) acquire Lyme disease (become green) from infected (green) field mice
- Nymph and adult ticks transmit Lyme disease to humans and other mammals
Lyme Disease Transmission

- Ticks can attach to any part of the human body
  - Often found in hard-to-see areas such as the groin, armpits, and scalp

- In most cases, the tick must be attached for 36 to 48 hours or more before the Lyme disease bacterium can be transmitted.
  - Nymphs are hard to see and are able to stay on host long enough to transmit disease
Ixodes scapularis Seasonal Activity

- Nymphs are active during the late spring through summer
- Nymphs become adults from fall until following spring
I. scapularis Seasonal Activity (cont.’d)

- Peak tick activity occurs in late spring through early summer
- Nymphs are the most common life stage during late spring through early summer

![Active Tick Surveillance of I. scapularis Nymphs - Charleston, WV 2013-2015 (n=192)](chart1)

![Active Tick Surveillance of I. scapularis Adults - Charleston, WV 2013-2015 (n=28)](chart2)
Most human Lyme disease cases occur in early to mid-summer when tick nymphs are most active.
Ixodes scapularis Seasonal Activity

- Nymphs are the primary life stage transmitting Lyme disease to humans
  - Harder to see nymphs than adults
  - Nymphs have shorter attachment time than adults
  - There are more nymphs in late spring – early summer than adults in fall through early spring
  - Humans are more active in tick habitats during late spring – early summer
Adult *Ixodes scapularis* are active during winter

- Lower than average winter temperatures will not necessarily reduce *Ixodes scapularis* populations the following spring

### MMWR Week | *Ixodes scapularis* 2012 | *Ixodes scapularis* 2013 | *Ixodes scapularis* 2014
---|---|---|---
19 | 4 | 3 | 1
20 | 2 | 1 | 5
21 | 6 | 5 | 20
22 | 1 | 6 | 19
Ixodes scapularis & Lyme Disease Habitat

- Habitat conducive to *Ixodes scapularis*
  - Deciduous forest
  - Canopy closure
  - Deciduous leaf litter
  - Mild, moist conditions
  - White-tailed deer (*Odocoileus virginianus*)
  - Japanese barberry (*Berberis thunbergii*)
  - Winterberry holly (*Ilex verticillata*)
  - Eurasian honeysuckle (*Lonicera* spp.)

- Habitat conducive to Lyme disease cases
  - Close proximity to deciduous forest
Lyme Disease Geographic Distribution

Reported Cases of Lyme Disease -- United States, 2014

1 dot placed randomly within county of residence for each confirmed case
Confirmed and Probable Lyme Disease Cases Reported By County (N=1,573) — West Virginia, 2000-2015

- County with no reported cases of Lyme disease
- County with 1-10 reported cases of Lyme disease
- County with 11-100 reported cases of Lyme disease
- County with >100 reported cases of Lyme disease
A Lyme disease endemic county is “one in which at least two confirmed cases have been acquired in the county or in which established populations of a known tick vector are infected with *Borrelia burgdorferi*."

- Kanawha, Roane, Wetzel, Marshall, and Greenbrier counties were new Lyme disease endemic counties in 2015.
Three tick surveillance interns hired

Active surveillance began on May 8, 2015 and covered 16 sites
- Covered 10 counties
- Five northern counties
- Five southern counties
2015 Tick Surveillance Activities

- WVU Core Arboretum (n=1)
- 4-H Camp Muffy (n=1)
- Tygart Lake State Park (n=14)
- Greenbrier Street (Charleston) (n=65)

- County under tick surveillance
- Tick surveillance site
- *Ixodes scapularis* identified
Since 2013, veterinarians have sent ticks collected from animals seen at their practices to the state public health entomologist.

A new interactive map was created to simplify tick identification results to participating veterinary clinics.

## West Virginia Veterinary Tick Submission Project

<table>
<thead>
<tr>
<th>Tick Species</th>
<th># of ticks submitted and identified (2013)</th>
<th># of ticks submitted and identified (2014)</th>
<th># of ticks submitted and identified (2015)</th>
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<tbody>
<tr>
<td><em>Dermacentor variabilis</em>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>472</td>
<td>994</td>
<td>677</td>
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<tr>
<td><em>Amblyomma americanum</em>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>5</td>
<td>16</td>
<td>85</td>
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<tr>
<td><em>Ixodes scapularis</em>&lt;sup&gt;3&lt;/sup&gt;</td>
<td>121</td>
<td>134</td>
<td>410</td>
</tr>
<tr>
<td><em>Ixodes cookei</em>&lt;sup&gt;4&lt;/sup&gt;</td>
<td>7</td>
<td>10</td>
<td>86</td>
</tr>
<tr>
<td><em>Haemaphysalis leporispalustris</em>&lt;sup&gt;5&lt;/sup&gt;</td>
<td>5</td>
<td>8</td>
<td>0</td>
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<tr>
<td><em>Amblyomma maculatum</em>&lt;sup&gt;6&lt;/sup&gt;</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td><em>Rhipicephalus sanguineus</em>&lt;sup&gt;6&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

### Summary of veterinary tick submissions for the three year period from 2013-2015.

1. *Dermacentor variabilis*: Vector of tularemia and Rocky Mountain spotted fever
2. *Amblyomma americanum*: Vector of ehrlichiosis, tularemia, STARI, and spotted fever rickettsioses
3. *Ixodes scapularis*: Vector of Lyme disease, anaplasmosis, babesiosis, and Powassan encephalitis
4. *Ixodes cookei*: Vector of Powassan encephalitis
5. *Haemaphysalis leporispalustris*: Vector of tularemia in rabbits
West Virginia Division of Natural Resources biologists examined 30 white-tailed deer at each of the 20 official game checking stations.

Biologists collected representative sample of all external parasites.

Human pathogen testing conducted by Cornell University’s Animal Health Diagnostic Laboratory.
Deer Ectoparasite Study

Legend
- Game Check Station

2013 WV DNR Deer Ectoparasite Surveillance

2014 WV DNR Deer Ectoparasite Surveillance

- 2014DNREcto Events
- Check Station Map Area
- **282 Ixodes scapularis** from white-tailed deer in 2013
- **120 Ixodes scapularis** from white-tailed deer in 2014
A new interactive map function shows the county-scale distribution of tick species across the state.
Ixodes scapularis reported (blue) or established (red) in county
Ixodes pacificus reported (yellow) or established (green) in county

Lyme Disease Geographic Distribution

Reported Cases of Lyme Disease -- United States, 2001

1 dot placed randomly within county of residence for each reported case
Lyme disease vector distribution 1907-2015

*Ixodes scapularis* reported (blue) or established (red) in county
*Ixodes pacificus* reported (yellow) or established (green) in county

Lyme Disease Spatial Distribution

Reported Cases of Lyme Disease -- United States, 2014

1 dot placed randomly within county of residence for each confirmed case
Lyme Disease Geographic Distribution

Update to Eisen et al. (2016) to include data collected after August 25, 2015

1/234 *Ixodes scapularis* from 2013 West Virginia Veterinary Tick Submission Project and 2013 West Virginia Division of Natural Resources Deer Ectoparasite Study were positive for *Borrelia burgdorferi*
  • Testing done at Cornell University Animal Health Diagnostic Center

0/192 *Ixodes scapularis* from 2014 West Virginia Veterinary Tick Submission Project were positive for *Borrelia burgdorferi*
  • Testing done at West Virginia University

0/154 *Ixodes scapularis* from 2015 West Virginia Veterinary Tick Submission Project were positive for *Borrelia burgdorferi*
  • Testing done at West Virginia University
Future Directions

- Increase *Ixodes scapularis* sampling
- Improved detection and diagnostic techniques for *Borrelia burgdorferi* in *Ixodes scapularis*
- *Borrelia burgdorferi* infection in white-footed mice (*Peromyscus leucopus*) from West Virginia.
- Collect *Ixodes scapularis* from field-collected *Peromyscus leucopus*
- Collect *Ixodes scapularis* from field-collected lizards
Pest Management (Large Scale)

- Pesticide (yard application)
- Tick and flea prevention collars (pets)
- Permethrin impregnated cotton balls
Pest Management (Personal Protection)

- Repellent
  - (DEET, picaridin, oil of lemon eucalyptus, IR3535)
- Long-sleeved shirts and long-trousers; light colored clothing
- Permethrin-impregnated clothing
- Self-examination
- Gentle removal of tick with mouthparts
The blacklegged tick, *Ixodes scapularis*, is a competent vector for *Borrelia burgdorferi*, the causative agent for Lyme disease in West Virginia.

Most human Lyme disease cases occur in early to mid-summer when tick nymphs are most active.

*I. scapularis* live in deciduous forest ecosystems.

Lyme disease is following the westward migration of *Ixodes scapularis* across West Virginia.

Lyme disease can be prevented through personal protection against ticks and tick pest management practices.