The Identification of the Range of Ixodidae Ticks in Kansas and the Epidemiological Evaluation of Lyme Disease and Spotted Fever Rickettsiosis in Kansas from 2008 to 2012

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MPH Field Experience
Objectives

- Collect county level data on the *Ixodes scapularis*, *Dermacentor variabilis*, and *Rhipicephalus sanguineus* tick vector location and to determine the range of these ticks in Kansas
- Determine if counties in Kansas are considered endemic based on the Centers for Disease Control and Prevention (CDC) case definition
- Conduct a descriptive epidemiologic study on Lyme disease cases reported from 2008-2012
- Conduct a descriptive epidemiologic study on Spotted Fever Rickettsiosis cases reported 2008-2012
Surveillance Overview

- Step 1: Lyme or Spotted Fever Rickettsiosis Case is identified
- Step 2: Reported to the KDHE
- Step 3: Alerts local health department
  - Responsible for investigation and follow-up
- Step 4: KDHE reports cases to CDC
Lyme Disease

Background
Bacteria

- *Borrelia burgdorferi*
- Motile spirochete
- Obligate intracellular pathogen
Vector

- Vectors: *Ixodes scapularis* & *Ixodes pacificus*
- *Ixodes pacificus* not found in Kansas
- Habitat: woody, brushy areas with leaf litter
Ixodes scapularis Life Cycle

Infected or Uninfected Adult Female
Ixodes scapularis

Primary Route
Secondary Route

3rd Blood Meal
Adult Mating

2nd Blood Meal
Infected Nymph

1st Blood Meal
Infected Human

Primary Route
Secondary Route

University of South Carolina, School of Medicine
Acute Symptoms

- Occur within 3-30 days post bite
  - Mean 7-10 days
- Erythema Migrans (EM) rash
  - Seen in 60-80% of patients
- Fatigue
- Fever
- Headache
- Neck Pain
- Arthralgia
- Myalgia

Erythema Migrans Rash
Chronic Symptoms

- **Chronic**: Months to years post-bite
  - **Musculoskeletal System**:
    - Recurrent and brief attacks of joint swelling
    - Chronic arthritis
  - **Nervous System**:
    - Lymphocytic meningitis
    - Cranial neuritis
    - Facial palsy / Bell's palsy
    - Radiculoneuropathy
    - Encephalomyelitis
  - **Cardiovascular System**:
    - Acute onset of 2nd/3rd degree atrioventricular conduction defects
Methods

Lyme Disease
Methods

- Conducted literature review and collected retrospective data on *Ixodes scapularis* vector location
  - Primary data from 2000 to 2012 obtained from Dr. Michael Dryden of Kansas State University’s College of Veterinary Medicine (KSU-CVM)
    - Submissions to CVM
    - Tick drags
    - Deer at the Chronic Wasting Disease (CWD) stations
  - Determined counties where *I. scapularis* ticks were reported
- Created maps depicting these counties using ArcMap 10.1 software
Methods- Epidemiologic Study

- Time period for the study: January 1\textsuperscript{st}, 2008 – December 31\textsuperscript{st}, 2012
- Retrospective data
  - Collected from two surveillance systems used by KDHE
    - The Kansas Electronic Disease Surveillance System (KS-EDSS)
      - Data from January 1\textsuperscript{st}, 2008 - December 31\textsuperscript{st}, 2011
    - EpiTrax
      - Data from January 1\textsuperscript{st}, 2012 - December 31\textsuperscript{st}, 2012
Methods- Epidemiologic Study

- Included only confirmed and probable cases
  - Confirmed cases
    - EM rash with an exposure in an endemic* county
    - EM rash with lab
    - One late manifestation with lab
  - Probable cases
    - Physician diagnosis and lab
- Laboratory criteria for diagnosis:
  - Two-tier testing
    - Positive IgM ≤ 30 days from symptom onset
    - Positive IgG at any point during illness
  - Single tier IgG immunoblot seropositivity
  - Positive culture for *B. burgdorferi*
  - Cerebral spinal fluid (CSF) positive for *B. burgdorferi*

*Endemic counties are counties that have two or more confirmed cases of Lyme disease reporting exposure or positive *I. scapularis*
Based on CDC definition
Methods - Epidemiologic Study

- Variables studied:
  - Number of probable and confirmed cases by year
  - Age
  - Gender
  - Race
  - Ethnicity
  - Seasonality
  - Exposure
  - Clinical presentation

- Population data to calculate incidence was obtained from U.S. Census Bureau statistics

- SAS 9.2 was used to calculate frequency for all demographic and clinical symptom variables
Results

Lyme Disease
Map of Counties in Kansas where *Ixodes scapularis* ticks have been reported

- Counties with *I. scapularis*
Endemic Counties in Kansas for CDC Case Classification

- **2 or more confirmed cases**
- **Positive I. scapularis tick**

[Map of endemic counties in Kansas]
Results

- Total number of cases from 2008 to 2012
  - 103 cases
- Highest number of total cases in 2009
  - 34 cases
- Over the 5 year period, from 2008 to 2012:
  - 59 (57%) confirmed cases and 44 (43%) probable cases
Number of Confirmed and Probable Cases of Lyme Disease Reported in Kansas, 2008-2012
United States and Kansas Incidence of Lyme Disease, 2008–2012

Incidence Rate (Per 100,000)

Year

KS Incidence
US Incidence
Results

- More males (59%) than females (41%) were reported to have Lyme disease
- Ethnicity
  - A majority of cases (97%) were Non-Hispanic/Latino
- Race
  - A majority of cases were white (71%)

<table>
<thead>
<tr>
<th>Race</th>
<th>Number of Cases</th>
<th>Percentage of Cases</th>
<th>Percentage in Kansas</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>73</td>
<td>70.87</td>
<td>84.7</td>
</tr>
<tr>
<td>Black/African American</td>
<td>3</td>
<td>2.91</td>
<td>6.10</td>
</tr>
<tr>
<td>Native Hawaiian/Pacific Islander</td>
<td>1</td>
<td>0.97</td>
<td>0.10</td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>0.97</td>
<td>1.20</td>
</tr>
<tr>
<td>Unknown</td>
<td>25</td>
<td>24.27</td>
<td>----</td>
</tr>
</tbody>
</table>
Number of Cases of Lyme Disease Reported in Kansas by Age, 2008-2012 (n=89)
## Clinical Manifestations of Lyme Disease

### Acute Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythema Migrans</td>
<td>36</td>
</tr>
<tr>
<td>Fatigue</td>
<td>34</td>
</tr>
<tr>
<td>Headache</td>
<td>24</td>
</tr>
<tr>
<td>Fever</td>
<td>23</td>
</tr>
<tr>
<td>Arthralgia</td>
<td>20</td>
</tr>
<tr>
<td>Myalgia</td>
<td>18</td>
</tr>
<tr>
<td>Neck Pain</td>
<td>6</td>
</tr>
</tbody>
</table>

### Chronic Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Musculoskeletal System</td>
<td>38</td>
</tr>
<tr>
<td>Nervous System</td>
<td>26</td>
</tr>
<tr>
<td>Cardiovascular System</td>
<td>2</td>
</tr>
</tbody>
</table>
Number of Cases of Lyme Disease by Month, 2008-2012
Percentages of Exposures for Lyme Disease Cases in Woody/Grassy/Brushy Areas, 2008-2012

- Yes: 36.0%
- No: 62.0%
- Unknown/Unavailable: 0.02%
Results

- For the 103 total cases
  - 59 cases reported exposure in Kansas
  - 22 cases reported out of state exposure
  - 22 cases either did not report place of exposure or their place of exposure is unknown
Counties in Kansas where reported exposures occurred for individuals with confirmed or probable cases of Lyme disease, 2008-2012
Discussion

Lyme Disease
Discussion

- Prior to 1988 – *I. scapularis* only identified in Cherokee County
- Currently – *I. scapularis* identified in 23 counties all in the Eastern half of the state
- 13 counties have cases reporting both exposure and identified tick vector
  - 9 counties – cases reported exposure but no tick vector identified
    - Recall
    - Vague definition
    - Passive surveillance for ticks
- Endemic counties
  - Reno & Sedgwick County ➔ no tick vector
  - Data importance
Discussion

- Increase in Lyme disease reports in 2009
  - Moisture conditions in 2007

- Increased nymph survival

- PHDI July of 2006 is -2.40
  - Low moisture

- PHDI from July of 2007 is 3.47
  - Increase in moisture

(Subak et al, 2003)

(American Lyme Disease Foundation)
Discussion

- Adults most commonly reported with Lyme disease
  - Rural occupations
  - Increased outdoor exposures

- Seasonality
  - Spring to early Fall
  - Similar to United States

- Kansas’ incidence lower than US
  - Suitable habitat
  - Most US reports in 13 Eastern states

- Exposure
  - Definition of exposure
  - Recall ability
  - Investigation by local health department
Public Health Implications

- Greater awareness of the tick vector location
- Targeting Lyme disease education to susceptible populations
- Further development of Lyme disease surveillance activities
Background

Spotted Fever Rickettsiosis
Bacteria

- *Rickettsia* spp.
- Gram negative
- Cocobacillus
- Obligate intracellular pathogen
- Tropism for endothelial cells

*Rickettsia rickettsia* Bacteria (CDC)
Vectors

- *Dermacentor variabilis*
- *Rhipicephalus sanguineus*
- Habitats: woody, brushy areas
Dermacentor variabilis Life Cycle

Note: The life cycle of a 3-host tick may take 1-2 years depending on whether or not the tick can find a suitable host between life stages.

1. Female tick lays eggs on ground.

2. Six-legged larva feeds on a small mammal, then drops off to the ground and molts.

3. Eight-legged nymph feeds on a small mammal, then drops off to the ground and molts.

4. Eight-legged adults feed and mate on a larger mammal, including livestock and pets, then drop off to the ground. Males die soon thereafter and females begin to develop eggs.

(Dept. of Medical Entomology, Purdue University)
Rhipicephalus sanguineus Life Cycle

Florida Medical Entomology Laboratory
©2001 University of Florida (University of Florida)
Signs & Symptoms

- Fever
- Headache
- Nausea
- Vomiting
- Abdominal pain
- Muscle pain
- Lack of appetite
- Conjunctivitis
- Rash
  - Some type of rash occurs in 90% of individuals diagnosed
  - Classically occurs 2-5 days after fever onset
  - Petechial rash - severe disease
Methods

Spotted Fever Rickettsiosis
Methods

- Conducted literature review and collected retrospective data on *Dermacentor variabilis* and *Rhipicephalus sanguineus* vector locations
  - Primary data for 2000-2012 obtained from Dr. Michael Dryden of KSU-CVM
  - Determined counties where *D. variabilis* & *R. sanguineus* ticks were reported
- Created maps depicting these counties using ArcMap 10.1 software
Methods- Epidemiologic Study

- Time period for the study: January 1\textsuperscript{st}, 2008 - December 31\textsuperscript{st}, 2012
- Retrospective data
  - Collected from two surveillance systems used by KDHE
    - The Kansas Electronic Disease Surveillance System (KS-EDSS)
      - Data from January 1\textsuperscript{st}, 2008 - December 31\textsuperscript{st}, 2011
    - EpiTrax
      - Data from January 1\textsuperscript{st}, 2012 - December 31\textsuperscript{st}, 2012
Methods - Epidemiologic Study

- Included only confirmed and probable cases

- Confirmed case:
  - Clinically compatible case that is laboratory confirmed
    - Laboratory confirmed:
      - Fourfold change in IgG titers
      - Detection of bacteria by PCR assay
      - Spotted fever group antigen in biopsy
      - Isolation of bacteria in cell culture

- Probable case:
  - Clinically compatible case and supportive laboratory results
    - Laboratory supportive:
      - Serologic evidence of elevated IgG or IgM antibody to \textit{Rickettsia} bacteria
Methods- Epidemiologic Study

- Variables studied:
  - Number of probable and confirmed cases
  - Age
  - Gender
  - Race
  - Ethnicity
  - Seasonality
  - Exposure
  - Clinical presentation

- Population data to calculate incidence was obtained from U.S. Census Bureau statistics

- SAS 9.2 was used to calculate frequency for all demographic and clinical symptom variables
Results

Spotted Fever Rickettsiosis
Map of Counties in Kansas where *Dermacentor variabilis* ticks were found
Map of Counties in Kansas where *Rhipicephalus sanguineus* ticks were found

Counts with *R. sanguineus*
Results

- Total number of cases, 2008-2012
  - 235 cases
- Largest number of cases in 2012
  - 136 cases
- Probable and Confirmed cases
  - 6 (2.55%) confirmed
  - 229 (97.45%) probable
Number of Confirmed and Probable Cases of Spotted Fever Rickettsiosis Reported in Kansas, 2008-2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Confirmed</th>
<th>Probable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>40</td>
<td>39</td>
</tr>
<tr>
<td>2009</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>2010</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>2011</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>2012</td>
<td>140</td>
<td>140</td>
</tr>
</tbody>
</table>
United States and Kansas Incidence of Spotted Fever Rickettsiosis, 2008-2012

Incidence Rate (Per 100,000)

Year

KS Incidence
US Incidence
Results

- More male (63%) than female (37%) cases

Ethnicity

- Non-Hispanic/Latino (74%)

Race

- Majority are white

<table>
<thead>
<tr>
<th>Race</th>
<th>Number of Cases</th>
<th>Percentage of Cases</th>
<th>Percentage in Kansas</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>189</td>
<td>80.43</td>
<td>87.40</td>
</tr>
<tr>
<td>Black/African American</td>
<td>1</td>
<td>0.43</td>
<td>6.10</td>
</tr>
<tr>
<td>American Indian/Alaskan Native</td>
<td>1</td>
<td>0.43</td>
<td>1.20</td>
</tr>
<tr>
<td>White; American Indian/Alaskan Native</td>
<td>1</td>
<td>0.43</td>
<td>----</td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>0.43</td>
<td>2.50</td>
</tr>
<tr>
<td>Unknown</td>
<td>42</td>
<td>17.87</td>
<td>----</td>
</tr>
</tbody>
</table>
Number of Cases of Spotted Fever Rickettsiosis Reported in Kansas by Age, 2008-2012 (n=165)
## Clinical Manifestations of Spotted Fever Rickettsiosis

<table>
<thead>
<tr>
<th>Symptoms</th>
<th># Cases</th>
<th>Total Known</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>225</td>
<td>228</td>
<td>98.7</td>
</tr>
<tr>
<td>Myalgia</td>
<td>172</td>
<td>214</td>
<td>80.4</td>
</tr>
<tr>
<td>Headache</td>
<td>162</td>
<td>211</td>
<td>76.8</td>
</tr>
<tr>
<td>Rash</td>
<td>97</td>
<td>209</td>
<td>46.4</td>
</tr>
<tr>
<td>Elevated Hepatic Transaminases</td>
<td>31</td>
<td>133</td>
<td>23.3</td>
</tr>
<tr>
<td>Anemia</td>
<td>28</td>
<td>160</td>
<td>17.5</td>
</tr>
<tr>
<td>Leukopenia</td>
<td>25</td>
<td>150</td>
<td>16.7</td>
</tr>
<tr>
<td>Thrombocytopenia</td>
<td>24</td>
<td>145</td>
<td>16.6</td>
</tr>
<tr>
<td>Eschar</td>
<td>4</td>
<td>205</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Results

- For the 235 total cases
  - 140 cases reported exposure in Kansas
  - 22 cases reported out of state exposure
  - 73 cases either did not report place of exposure or their place of exposure is unknown
Percentages of Exposures for Spotted Fever Rickettsiosis Cases, 2008-2012

- Yes: 41
- No: 7
- Unknown/Unavailable: 52
Percentages of Tick Bite History for Spotted Fever Rickettsiosis Cases, 2008-2012

- Reported Bite: 46
- No Reported Bite: 41
- Unknown/Unavailable: 13
Counties in Kansas where reported exposures occurred for individuals with probable or confirmed cases of Spotted Fever Rickettsiosis, 2008-2012
Discussion

Spotted Fever Rickettsiosis
Discussion

- Significant increase in probable cases in 2012
  - 134 cases
  - 464% increase from previous 4 year average of probable cases
- Increase due to:
  - Change in surveillance procedures
    - Increase in monitoring local health departments investigation
  - Change in surveillance systems
    - KS-EDSS $\rightarrow$ EpiTrax
      - Easier to review cases based on specific variables
      - Better report functionality
  - Testing
Discussion

- 2008 to 2012 majority of cases are probable, not confirmed
  - Lack of laboratory testing needed for a confirmatory classification
  - Acute and convalescent serology
Discussion

- Higher the incidence in Kansas than the United States
- *R. sanguineus* is not the primary tick vector in Kansas
- *D. variabilis* most likely is primary vector
- Compared to the U.S.
  - CDC cites increase in incidence in U.S. from 2000 to 2010
  - Attributed to *R. sanguineus*
Discussion

- More adult cases reported than young and elderly cases
  - Rural occupations
  - Increased exposures

- Seasonality:
  - Most cases are seen between April and October
    - Ticks are more active and seeking a blood meal
    - Greater outdoor activity
Discussion

- Exposures
  - More than half reported tick habitat exposure (52%)
  - 41% unknown
    - Recall ability
    - Vague definition of exposure
    - Unable to be interviewed

- Tick bite
  - Less than half reported a tick bite (46%)
    - More likely to visit health care provider if bitten/ill
    - More likely to be tested
  - 13% unknown
    - Clear answer (Y/N)
    - Greater recall
  - 41% reported no bite
    - Nymphs are small and easily overlooked
Public Health Implications

- Increase in cases
  - Improved surveillance due to reviewed cases
- Greater awareness of tick vector location
- Prevention efforts targeted to specific groups
Overall Study Limitations

- Passive Surveillance
  - Tick data

- Under-reporting
  - KDHE relies on clinicians, local health departments, laboratories, and hospitals for disease reporting

- Incomplete Data
  - Ability of local health department to follow up
  - Patients recall ability
Recommendations

- Extension agents
  - Maintain more accurate and comprehensive records on tick species distribution in Kansas

- KDHE
  - Provide training and assistance to local health department during an investigation of tick-borne diseases

- Health Departments
  - Provide more information to health care providers on the appropriate confirmatory tests to order for tick-borne disease

- Education
  - Preventative measures
Acknowledgements

- Mrs. Sheri Tubach
- Dr. Cates, Dr. Wilkerson, Dr. Hollis
- Barta Stevenson
- Wayne and Alice Coleman
- Josh Oden
Thank You!

Questions?