Rocky Mountain Spotted Fever
In Arizona

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Rocky Mountain Spotted Fever (RMSF)

- *Rickettsia rickettsii*, tick-borne pathogen
- Acute presentation: Fever, headache, rash (humans)
- Rapidly progressive disease with respiratory, gastrointestinal, and neurologic manifestations
- Multisystem organ failure, death (in 1-10%)

Traditional RMSF Vectors

Dermacentor variabilis
American dog tick

Dermacentor andersoni
Rocky Mountain wood tick

Index Case, 2003

- 14 month old child died of suspected sepsis following a febrile rash illness
- From a tribal community in eastern Arizona
- Astute IHS clinician sent samples to CDC for testing
- Tested negative for hantavirus, Neisseria meningitidis
- PCR positive for R. rickettsii

Index Case, 2003

- No history of travel
- From same community as the only other AZ RMSF case in the past several years
- Environmental investigation:
  - No Dermacentor spp. of ticks
  - Heavy household infestation of Rhipicephalus sanguineus (the brown dog tick)
Environmental Investigation
Reservation #1

• Ticks abundant on dogs and in yards of patients’ homes
• > 1,000 ticks collected, all identified as *R. sanguineus*
• *R. sanguineus* ticks found attached to 1 confirmed case-patient

Prevalence of *R. rickettsii* in ticks

<table>
<thead>
<tr>
<th>Sample origin</th>
<th>Total</th>
<th><em>R. rickettsii</em> PCR+</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dogs from case homes</td>
<td>30</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>Stray dogs</td>
<td>46</td>
<td>5</td>
<td>10.9</td>
</tr>
<tr>
<td>Case houses (environmental ticks)</td>
<td>275</td>
<td>13</td>
<td>4.7</td>
</tr>
<tr>
<td>Non-case houses</td>
<td>273</td>
<td>14</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Overall prevalence of *R. rickettsii* in *R. sanguineus* ticks: 5.6%

Emerging Vector of RMSF in the United States

*Rhipicephalus sanguineus*
Brown dog tick
Reservation #1, 2003

- Medical chart review with IHS hospital
- Enhanced surveillance and testing
- More human cases identified
- Pediatric serosurvey
  - Antibodies to spotted fever group rickettsiae detected in 10% of children
  - Antibodies detected in 16% of children from a neighboring reservation

Reservation #1, 2004

- 13 patients with RMSF were identified from May-September 2004
  - 8 confirmed, 5 probable
  - 10 children ≤12 years of age
  - 11 hospitalized
  - 1 death
- All patients had contact with tick-infested dogs
- 4 patients had a history of tick bite preceding illness

RMSF Cases in Eastern AZ, 2003-2011
RMSF in AZ

- 194 cases 2003-2011
- American Indian populations
- Expanded to include 4 different reservations
- During 2010-2011, > 200X the national RMSF average incidence
- 15 deaths (case fatality rate 7.7%)
  - National rate < 0.5%
- Pediatric populations significantly impacted
  - 60% children <18 years of age

Proportion of RMSF Cases by Age Group, 2002-2009

Month of RMSF Onset
The Role of Dogs in AZ RMSF

- *R. sanguineus* preferentially feeds on dogs
- Numerous dogs in the affected area
- No local animal control or veterinary care
- Numerous free-roaming dogs
- Loose definition of ownership
- Owned dogs introduce ticks into the home environment, risk for children
- Role for dogs as a reservoir for *R. rickettsii*?
  - New susceptible puppies born each year
  - Amplification among co-feeding ticks
- Translocation and potential to expand to neighboring communities?
Dogs as Sentinels for Human RMSF Risk

- Dogs have heavier exposure to ticks
- Dogs develop illness and robust serologic response to *R. rickettsii*
- Dogs can be systematically sampled more easily than people
- Good indicator of environmental risks
- Evidence in dogs precedes first human case reports – key to action?

Reservation #1 (Eastern AZ)
First Human Cases: 2003

Reservation #2 (Eastern AZ)
First Human Cases: 2005
Reservations #1 and #2
Canine Seroprevalence

- 1996: 5% of dogs were seropositive (n=17/329)
- 2003-2004, 78% of dogs were seropositive (n=86/111)
- Suggests recent emergence in the affected area since 1996

Reservation #3 (Central AZ)
First Human Cases: 2009

- Canine Serosurvey conducted in 2010: 14/276 (5.1%) of dogs were positive
- Index Community: 13 dogs positive
- Results helped tribe focus limited resources on prevention efforts in the affected community
- No new human cases since 2009
Reservation #3 (Central AZ)
Canine Seroprevalence

Reservation #3: Index Community and Positive Dogs

Reservation #4 (Southern AZ)
First Human Cases: 2011
Seroprevalence in Dogs from Reservation #4 (Southern AZ)

<table>
<thead>
<tr>
<th>District</th>
<th>Number of RMSF Positive Dogs</th>
<th>Number of Dogs Tested</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>District A</td>
<td>11</td>
<td>21</td>
<td>53</td>
</tr>
<tr>
<td>District B</td>
<td>3</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>District C</td>
<td>3</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>District D</td>
<td>0</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>District E</td>
<td>0</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>District F</td>
<td>2</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>District G</td>
<td>1</td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td>District H</td>
<td>4</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>District I</td>
<td>57</td>
<td>109</td>
<td>52</td>
</tr>
<tr>
<td>District J</td>
<td>2</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>District K</td>
<td>2</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>297</td>
<td>29</td>
</tr>
</tbody>
</table>

Reservation #4 (Southern AZ)

- Canine Serosurvey conducted in 2011: 85/297 dogs positive (28.6%) of dogs were positive
- Numerous Communities positive, some > 50% seropositivity in dogs
- Results informed tribe that focused efforts unlikely to be successful, efforts needed reservation-wide

Seroprevalence in Dogs from Non-Reservation Communities, 2005-2006

- 5.7% of dogs (n=14/247) were seropositive
- Dogs in counties directly bordering the affected area had higher rates
Correlation between Canine Seropositivity and Human Risk

- Seropositivity Rate and Human Risk
  - In general, no human cases in communities where the canine seropositivity rate is ~ 5%
  - Human cases observed in communities where canine seropositivity is > 50%
  - Threshold for human risk somewhere in between
- Canine seropositivity has been observed prior to the first reports of human cases on some reservations
  - Seropositive dogs (>60%) reported in northern reservations, but no confirmed human cases
  - Is human surveillance adequate?
  - First human case identified/reported does not equal the first human case

RMSF in Mexico

- 2009 urban outbreak in Mexicali, Mexico, near the U.S. border
  - > 1,000 suspected cases
  - Children disproportionately affected
- *Rhipicephalus sanguineus* the associated vector
- Stray and free-roaming dogs an amplifying factor
- RMSF cases have continued to be identified throughout much of Mexico, likely endemic

Origins of *R. rickettsii* in *Rhipicephalus sanguineus* Ticks

- Strains of *R. rickettsii* circulating in AZ are distinct from strains circulating in Mexicali, Mexico
  - *Rhipicephalus* ticks in eastern AZ are genetically different than ticks from Mexicali
  - No evidence ticks were “imported” from Mexico
- *R. rickettsii* strains in AZ distinct from strains associated with *Dermacentor* ticks in the western U.S. and eastern U.S.
- Likely present at low enzootic levels in many areas
- May emerge as an outbreak or epidemic under the right environmental conditions
**Climate and RMSF Risk**

- Bimodal seasonal peak (dip in early summer and peak in late summer/fall) suggests a correlation between human risk and moisture levels
  - Monsoon season June 15-September 30
  - Additional climactic analyses are needed to assess this observation
- May provide advance recognition of higher risk tick years (heavy monsoon rains) and a point of intervention
- Effects of climate change difficult to predict
- Vectorborne diseases in general likely sensitive to climate change

**Discussion**

- Since its emergence in Arizona almost a decade ago, RMSF has become established as an enzootic focus and spread to new areas.
- Dogs play an important role in the ecology of RMSF in this region. Dogs may serve as sentinels for human risk, and help direct prevention efforts in affected communities.
- Control of dogs and ticks the key to control, but prevention is difficult due to limited resources, regional isolation, and huge tick/dog populations. Early detection and aggressive interventions are key to success.

**Prevention Efforts**

- Treat dogs for ticks all year (collars, topspots, dips, sprays)
- Treat environment for ticks (properly timed, successive months)
Prevention Efforts

• Control dog population (spay/neuter)
• Change free-roaming culture (tie/fence)

Prevention Efforts

• Remove tick harborage (old mattresses, etc)
• Education

RMSF Intervention Assessment: 2005

• 218 homes on Reservation #1 assessed for ticks between April 18-May 13, 2005
• Dry ice traps to quantify #’s of ticks (tick density)
• Re-assessed after spraying
<table>
<thead>
<tr>
<th></th>
<th>Community A</th>
<th>Community B</th>
</tr>
</thead>
<tbody>
<tr>
<td># houses assessed</td>
<td>57</td>
<td>161</td>
</tr>
<tr>
<td># positive tick traps</td>
<td>23 (40%)</td>
<td>90 (56%)</td>
</tr>
<tr>
<td>Density (1-10 ticks)</td>
<td>19 (83%)</td>
<td>58 (64.5%)</td>
</tr>
<tr>
<td>Density (11-100 ticks)</td>
<td>3 (13%)</td>
<td>27 (30%)</td>
</tr>
<tr>
<td>Density (&gt;100 ticks)</td>
<td>1 (4%)</td>
<td>5 (5.5%)</td>
</tr>
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</table>

Tick Trapping Results, Pre-Intervention April 2005
Reservation #1
**Tick Trapping Pre-Intervention Assessment**

- All subdivisions assessed
- % of subdivisions yielding positive traps
  - 69% of Community A subdivisions
  - 83% of Community B subdivisions
- Tick activity was generally widespread

**Post-Treatment Tick Assessment**

- April 25-28: Community A homes sprayed with pesticide
- May 9-13: Repeated tick assessments to measure effectiveness
- 45% decrease in ticks

**Summary of 2005 Intervention Assessment**

- Despite early season, tick activity was high
- Pesticide application very effective at reducing #’s of ticks
- Single application not sufficient to control problem
  - New eggs hatch out as season advances
  - Incomplete coverage of pesticide
  - Introduction of new ticks from free-roaming dogs
  - Pesticide active only ~ 3-4 weeks
Why Isn’t it Working?

• Insufficient prevention activities (scale, timing)
  • Once a summer applications not enough to fix the problem
  • Household and dog treatments need to be properly timed and applied to provide sustained acaracidal activity
• Lack of focus on control of free-roaming dogs
  • Stray dogs less a problem than poorly cared for/unrestrained pet dogs
  • Culture of not fencing/tying dogs
• No permanent veterinary services on most reservations
  • Rural Area Veterinary services only comes once a year, people must take their dogs to them

Neighborhood Pilot Project, 2012

• One community on Reservation #2
• Spay/Neuter every dog
• Remove unowned dogs
• Provide a collar, license, leash, and tie-out stake for every dog
• Treat every dog for ticks
• Treat every house for ticks (sustained effort over the summer)
• EDUCATE HOMEOWNER
• Monitor for changes in human RMSF cases

Neighborhood Pilot Project, 2012

• Goal: Prove improvement in human health by improving the health of the pet population
• Partners
  – Petsmart Charities
  – Bayer
  – PetCo Charities
  – CDC, Indian Health Service, AZ Dept. Health
  – Tribal RMSF Task Force
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**Disclaimer:**
The findings and conclusions in this manuscript are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.