Bacterial Pneumonia in Sheep, The Domestic – Bighorn Sheep Interface, and Research at ADRU

USAHA Committee on Sheep and Goats
Providence, RI
October 27, 2015

M. A. Highland, DVM, DACVP, PhD candidate
PhD Veterinary Training Program
USDA-ARS ADRU
Veterinary Microbiology and Pathology
Washington State University
Pullman, WA
DS – BHS Interface Issue

Captive/penned commingling studies & anecdotal field reports → associate BHS and DS contact with BHS pneumonia

Removal of DS public land grazing allotments
- profound economic impacts

Pneumonia continues to afflict BHS herds
- despite decades of research and intense management practices

Anecdotal field reports also associate DG with BHS pneumonia
- pack goat restrictions on public lands
DS and BHS Pneumonia

- **DS**
  - Lambs > Adults
  - Etiology
    - Polymicrobial (bacteria +/- viruses) or Unimicrobial
    - Multifactorial (colostrum, air quality, environmental stressors)

- **BHS (wild)**
  - Reports of respiratory disease date back to the 1920’s
  - All age outbreaks +/- subsequent years of disease in lambs
    → population-limiting disease
  - Etiology
    - Long been debated
    - Evidence for **polymicrobial** (bacterial) and **multifactorial**
    - Viruses occasionally reported (no current indication for primary role)
What do we know about BHS (and DS) pneumonia?

Polymicrobial

and

Multifactorial

(the presence of the bacteria in BHS alone does NOT = disease/death)

Incompletely understood disease phenomenon
DS and BHS pneumonia-associated bacteria

Mycoplasma ovipneumoniae (M ovi)

Pasteurellaceae ("Pasteurellas")

- **Mannheimia haemolytica** (Mh)
  - *Pasteurella haemolytica* biotype A (prior to 1999)
- **Bibersteinia trehalosi** (Bt)
  - *P. haemolytica* biotype T and 3 (prior to 1990)
  - *P. trehalosi* (1990-2007)
- **Pasteurella multocida**

Anaerobic bacteria – *Fusobacterium necrophorum* (Fn)

Other aerobic bacteria
**Mannheimia haemolytica**

Pasteurellaceae (“Pasteurella”) family member
- Easily cultured by standard laboratory methods
- Historically most commonly reported bacteria in BHS pneumonia
  (along with *Bibersteinia trehalosi*......
  remember both use to be called “Pasteurella”)

Acute bronchopneumonia in compromised ruminants
- Infection with a 1° pathogen (such as *Mycoplasma ovipneumoniae*)
- Environmental stressors (air quality, crowding, shipping, other?)
- “Shipping fever” in domestic ruminants

No epidemiologic evidence to support this as the primary agent of epizootic pneumonia in wild bighorn sheep (or captive)
Bug Chasing...on the wrong trail
(evidence against “Pasteurella” as a 1⁰ cause of BHS pneumonia)

Wild and domestic ruminants (cattle, sheep, goats, elk, deer, etc) known to carry “virulent” forms of the Pasteurellas

BHS captive penning with animals carrying virulent forms of Pasteurellas (in the absence of *M. ovipneumoniae*) do not experience high mortality

No evidence supporting these organisms as 1⁰ cause of BHS epizootic pneumonia in the wild

- often culture multiple types/strains from lung tissue = secondary opportunistic pathogens that invade given the right circumstance (in addition to other bacteria, ie. anaerobes)

Experiments to prove *Mh* as BHS killer require high dose inoculations in BHS, resulting in death within days (not like the subacute/chronic disease seen in wild BHS)
**Mycoplasma ovipneumoniae**

**Mycoplasmataceae family member**

- Smallest of all free-living organisms, no cell wall
- Fastidious organisms (difficult to culture) → enrichment broth and/or PCR

Species specific (subfamily: Caprinae)

- Currently known to cause disease only in and/or be carried by sheep and goats

1° respiratory pathogen → 2° pulmonary bacterial infections

- Colonizes respiratory epithelium → impede mucociliary clearance

**Subacute** to **chronic** pneumonia in young DS, can cause otitis media

- Atypical pneumonia, “coughing syndrome”
**Mycoplasma ovipneumoniae in BHS pneumonia**

Historic infrequent/sporadic detection (fastidious nature)
- *Mycoplasma* spp. in 1970; *Mycoplasma ovipneumoniae* in 1980 and 1996

High association with pneumonia in wild BHS
- Canadian Cooperative Wildlife Health Centre, 2011-12 report (BC, Canada)

**BHS pneumonia:**
**Subacute** to **chronic** pneumonia, otitis media
- Time course likely dependent on host factors and 2° bacteria

Captive commingling studies: no disease “outbreak” in the absence of *Mo*
Evidence for association of DS to BHS pneumonia & for *Mycoplasma ovipneumoniae* as a 1⁰ pathogen (captive pen experiments)

<table>
<thead>
<tr>
<th>Species commingled</th>
<th>Bighorn sheep (died/total)</th>
<th>% death</th>
<th># of studies</th>
<th>Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS (39)</td>
<td>41/43</td>
<td>95%</td>
<td>7</td>
<td><em>Mh, Bt, Mo, A. pyogenes, Corynebacterium</em></td>
</tr>
<tr>
<td><em>Movi</em>-free DS (4)</td>
<td>1/4</td>
<td>25%</td>
<td>1</td>
<td><em>Mh, Bt (@day 90)</em></td>
</tr>
<tr>
<td>Goat (7)</td>
<td>2/10</td>
<td>20%</td>
<td>2</td>
<td><em>Mh</em></td>
</tr>
<tr>
<td>Horse (3)</td>
<td>1/6</td>
<td>17%</td>
<td>1</td>
<td><em>Pm, Strep zoo</em></td>
</tr>
<tr>
<td>Cattle</td>
<td>1/9</td>
<td>11%</td>
<td>2</td>
<td><em>Mh</em></td>
</tr>
</tbody>
</table>


Death in BHS between 8 days and 3-4 months
Confounding the matter....

DS and BHS pneumonic agents as “commensals”

*M. ovipneumoniae*

- Upper/lower respiratory tract of subfamily *Caprinae* (sheep and goats)

- Healthy DS herds: 87% positive (453 tested)
  (National Animal Health Monitoring System-Sheep2011)

- Healthy BHS herds: 4 of 32 positive

- Pneumonic BHS herds: healthy carriers present (disease w/in last 10 yrs)

“*Pasteurella*” (including pathogenic forms)

- Upper respiratory/oropharynx in both DS and BHS

  - Multiple publications support this statement

Outbreaks of BHS pneumonia have occurred in which no know or “possible” contact with DS or DG is documented/known (see slide 14)
Research at ADRU-ARS-USDA (current and proposed)

**Objective 1:** Identification of host factors in domestic and bighorn sheep associated with shedding of respiratory pathogens and respiratory disease

**Objective 2:** Identification of innate and humoral immune factors that are associated with the differential susceptibility to pneumonic pathogens between and amongst domestic sheep and bighorn sheep

---

*Mycoplasma ovipneumoniae*

- Hosts (are sheep and goats the only carriers?)
- Impact of subclinical infections on DS production
- Virulence differences between strains of *M. ovipneumoniae*?

Stress/environmental component in BHS pneumonia (known in domestics)
Data Base for Record and Risk Assessment

**Land use**
- GIS documentation or mapping of BHS herd locations and herd size
- Mapping of all public DS rangelands
- Survey all private lands within and surrounding known BHS herd ranges
  - Map locations of private lands that have DS and goats

**Respiratory bacteria screening results**
- *Mycoplasma ovipneumoniae* strain typing
- Pasteurellaceae (*Mh, Bt, Pm*)

**Disease documentation in DS and BHS**
- Dates
- Number affected
- Symptoms
- Pathogens identified and by whom

**Human interactions with BHS**
- Wildlife agencies
- Other gov’t and private activities
- Hunting
  - Permits issued
  - Herd size
  - # Harvested

**Environment**
- Weather
- Feeding stations
- Natural disasters (ie. fire)
- Non-human predators
<table>
<thead>
<tr>
<th>BHS Die-off Location</th>
<th>Pre die-off Estimated BHS Population Size</th>
<th># BHS Culled</th>
<th># Known Add’l Mortalities</th>
<th>Estimated % BHS Mortality</th>
<th>Estimated # BHS Mortalities</th>
<th>Known, Likely or Possible Association with Domestic Sheep or Goats, Prior to BHS Die-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Fork Bitterroot, MT</td>
<td>200-220</td>
<td>80</td>
<td>N/A</td>
<td>50%</td>
<td>~100</td>
<td>Known</td>
</tr>
<tr>
<td>Bonner/W Riverside, MT</td>
<td>160-180</td>
<td>99</td>
<td>4</td>
<td>68%</td>
<td>~110</td>
<td>Known</td>
</tr>
<tr>
<td>Lower Rock Creek, MT</td>
<td>200</td>
<td>18</td>
<td>N/A</td>
<td>43%</td>
<td>87</td>
<td>Possible</td>
</tr>
<tr>
<td>Upper Rock Creek, MT</td>
<td>~340</td>
<td>39</td>
<td>N/A</td>
<td>60%</td>
<td>~200</td>
<td>Possible</td>
</tr>
<tr>
<td>East Humboldt Range, NV</td>
<td>160-180</td>
<td>1</td>
<td>113</td>
<td>80%</td>
<td>140</td>
<td>Likely</td>
</tr>
<tr>
<td>Ruby Mountains, NV</td>
<td>160</td>
<td>1</td>
<td>36</td>
<td>65%</td>
<td>100</td>
<td>Possible</td>
</tr>
<tr>
<td>Yakima River Canyon, WA</td>
<td>280</td>
<td>69</td>
<td>42</td>
<td>33%</td>
<td>99</td>
<td>Possible</td>
</tr>
<tr>
<td>N slope Uinta Mountains, UT</td>
<td>50-70</td>
<td>51</td>
<td>0</td>
<td>95%</td>
<td>50</td>
<td>Unknown</td>
</tr>
<tr>
<td>Gros Ventre River, WY</td>
<td>50-60</td>
<td>2</td>
<td>0</td>
<td>5%</td>
<td>2</td>
<td>Unknown</td>
</tr>
<tr>
<td>Totals</td>
<td>1600-1680</td>
<td>360</td>
<td>195</td>
<td>888</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WAFWA June 22, 2010 report

Database aim to eliminate this ambiguity
Conclusion

• BHS pneumonia is a polymicrobial and multifactorial disease
  – Infection ≠ clinical disease and/or death
  – For decades focus narrowed to *M. haemolytica* (“Pasteurella”): no data to support this to be primary cause for epizootic pneumonia in BHS
  – Now there is focus on another microbial agent (*M. ovipneumoniae*): stronger evidence for a primary role in BHS pneumonia

• Broaden our view to move forward with understanding the problem
  – Advances in microbial identification: respiratory microbiota of DS and BHS
    • coinfection(s) associated w/ differences in morbidity and mortality?
  – Central database, shared objective information
    • End state-to-state-agency compartmentalization of data
    • Increase information sharing on the status of all BHS herds

Central to infectious disease:
The BEAST – The BUG(s) – The BURDEN
Acknowledgments
(A large number of people to thank from the following)

- Animal Disease Research Unit-ARS-USDA
- WSU Monoclonal Antibody Center and Flow Cytometry Laboratory
- WSU - Veterinary Microbiology and Pathology
- Washington Animal Disease and Diagnostic Laboratory
- United States Sheep Experiment Station-ARS-USDA

Questions?
Contact info: Maggie.Highland@ars.usda.gov