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

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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 1^{o} 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 1^{o} 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 (Woolf, et al. 1970; Bunch, et al. 1980; Rudolph, et al. 2007)

High association with pneumonia in wild BHS

- Besser, Cassirer, **Highland** et al. *Prev. Vet. Med*. 2013 (WSU)
- Besser, **Highland**, et al. *Emerg. Infect. Dis*. 2012 (WSU)
- Canadian Cooperative Wildlife Health Centre , 2011-12 report (BC, Canada)
- Wolfe, et al. *J. Wildl. Dis.* 2010 (Colorado)

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 1^{o} pathogen (captive pen experiments)

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

(Foreyt: 1982, 1989, 1990, 1994, 1996, 1998, 2009; Onderka1988; Besser2012)

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)
(Besser, et al. *Prev. Vet. Med*. 2012)

"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

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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*)

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

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

Environment
- Weather
- Feeding stations
- Natural disasters (ie. fire)
- Non-human predators

Table 1. Bighorn sheep pneumonia die-offs, winter 2009-2010, in 5 states (MT, NV, WA, UT, WY), as of 6/21/2010.

BHS Die-off Location	Pre die-off Estimated BHS Population Size	# BHS Culled	# Known Add'l Mortalities	Estimated % BHS Mortality	Estimated # BHS Mortalities	Known, Likely or Possible Association with Domestic Sheep or Goats, Prior to BHS Die-off
East Fork Bitterroot, MT	200-220	80	N/A	50%	~100	Known
Bonner/W Riverside, MT	160-180	99	4	68%	~110	Known
Lower Rock Creek, MT	200	18	N/A	43%	87	Possible
Upper Rock Creek, MT	~340	39	N/A	60%	~200	Possible
East Humboldt Range, NV	160-180	1	113	80%	140	Likely
Ruby Mountains, NV	160	1	36	65%	100	Possible
Yakima River Canyon, WA	280	69	42	33%	99	Possible
N slope Uinta Mountains, UT	50-70	51	0	95%	50	Unknown
Gros Ventre River, WY	50-60	2	0	5%	2	Unknown
Totals	1600-1680	360	195		888	

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

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Questions?

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