Review of *M. ovi* management strategies

Kezia Manlove

Contracted to
BC Ministry of Agriculture and FLNRO
Thanks to:

BC Ministry of Agriculture, FLNRO, and BC Sheep Working Group

• Tom Besser (retired!)
• Becky Schwanke (AK WSF)
• Maggie Highland (Kansas State)
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• Austin Weiseler (SDSU)
• Blake Lowrey (MTFWP/MSU)
• Kevin White (Alaska Game and Fish)
• Frances Cassirer (IDFG)
• Mandy Kauffman (Western Ecosystems Technology)
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• Mike Cox (NDOW)
• Peri Wolff (NDOW/WDA)
• Kelly McAllister (Washington Dept of Transport.)
• Marcel Huijser (Western Transportation Institute)
• Brandi Felts (IDFG)
Review/Synthesize current knowledge on the following:

- Approaches and best-practices for eradicating *M. ovi* from domestic sheep and goat operations
- History and performance of diagnostic testing for *M. ovi*
- Host range and potential role of non-non-caprine species in epidemiology of *M. Ovi*
- Relative risk of *M. Ovi* transmission for domestic goats as compared to domestic sheep
- Costs and benefits of various fencing strategies to limit risk of *M. Ovi* transmission
- Likely risk and consequences of *M. Ovi* transmission into mountain goats and thinhorns
- Utility of *M. ovi* strain typing and variation in virulence of particular strains
### Table of all documented *M. ovi* events / detections in mountain goats

PRELIMINARY — PLEASE CONTACT K. MANLOVE PRIOR TO CIRCULATION/REPLICATION.

<table>
<thead>
<tr>
<th>Location (state)</th>
<th>Year</th>
<th>Lab</th>
<th>PCR (N/ +/−)</th>
<th>Serology (N/ +/−)</th>
<th>Sympatric with Bighorn / shared strain</th>
<th>Demographic consequences</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast GYA (WY)</td>
<td>2013</td>
<td>WADDL/WGF</td>
<td>14/3/10</td>
<td>Yes/</td>
<td></td>
<td></td>
<td>Lowrey et al. 2018a: demography from Smith and DeCesare</td>
</tr>
<tr>
<td>Northeast GYA</td>
<td>2014</td>
<td>WADDL</td>
<td>7/1/5</td>
<td>7/2/4</td>
<td>Yes/</td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Southwest GYA</td>
<td>2013</td>
<td>WADDL</td>
<td>13/0/13</td>
<td>7/6/1</td>
<td>No/</td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Southwest GYA (ID)</td>
<td>2014</td>
<td>WGF</td>
<td>9/9/0</td>
<td>No/</td>
<td></td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Southwest GYA</td>
<td>2015</td>
<td>WGF</td>
<td>4/2/2</td>
<td>No/</td>
<td></td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Southwest GYA</td>
<td>2017</td>
<td>WGF</td>
<td>4/2/1</td>
<td>No/</td>
<td></td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Grand Teton NP (WY)</td>
<td>2014</td>
<td>WGF</td>
<td>5/0/5</td>
<td>5/0/5</td>
<td>Yes/</td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Grand Teton NP (WY)</td>
<td>2015</td>
<td>WGF</td>
<td>4/0/4</td>
<td>4/0/4</td>
<td>Yes/</td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Grand Teton NP (WY)</td>
<td>2017</td>
<td>WGF</td>
<td>5/0/5</td>
<td>4/0/4</td>
<td>Yes/</td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>2010</td>
<td>WADDL</td>
<td>19/0/19</td>
<td>No/</td>
<td></td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>2014</td>
<td>WADDL</td>
<td>14/0/14</td>
<td>16/0/16</td>
<td>No/</td>
<td></td>
<td>Lowrey et al. 2018a</td>
</tr>
<tr>
<td>East Humboldts (NV)</td>
<td>2010</td>
<td>WADDL</td>
<td>3/1/-</td>
<td>3/3/-</td>
<td>Yes/Yes</td>
<td>Estimated 13% decline in mtn goat pop size (Cox et al. 2017)</td>
<td>Wolff et al. 2019</td>
</tr>
<tr>
<td>East Humboldts (NV)</td>
<td>2012</td>
<td>WADDL</td>
<td>2/0/-</td>
<td>2/2/-</td>
<td>Yes/Yes</td>
<td></td>
<td>Wolff et al. 2019</td>
</tr>
<tr>
<td>East Humboldts (NV)</td>
<td>2013</td>
<td>WADDL</td>
<td>15/1/-</td>
<td>15/14/-</td>
<td>Yes/Yes</td>
<td>Summer kid survival estimated at 0.19 (Blanchong et al. 2018)</td>
<td>Wolff et al. 2019</td>
</tr>
<tr>
<td>East Humboldts (NV)</td>
<td>2014</td>
<td>WADDL</td>
<td>16/2/-</td>
<td>16/14/-</td>
<td>Yes/Yes</td>
<td>Summer kid survival estimated at 0.19 (Blanchong et al. 2018)</td>
<td>Wolff et al. 2019</td>
</tr>
</tbody>
</table>
Mountain Goat / *M. ovi* data

- Lowrey et al. 2018 data
  - NE GYA
  - SW GYA
  - Grand Teton NP
  - SE Alaska
- Cox/Wolff/Blanchong with demography
  - NV — East Humboldts
  - NV — Rubys
- Strains in Kamath et al. *M. ovi* phylogeny paper
  - UT — Timpanagos
  - UT — Willard Peak
  - MT — Castle Creek/Tom Miner
  - SD — Battle Creek
<table>
<thead>
<tr>
<th>Drug group</th>
<th>Active ingredient (drug)</th>
<th>Delivery/ schedule</th>
<th>Efficacy in domestic sheep</th>
<th>Licensed for administration in lambs?</th>
<th>Other considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>fluoroquinolone</td>
<td>Enrofloxacin (Baytril)</td>
<td>Politis notes 3-5 administrations of 5-10 mg/kg body weight (consecutive days)</td>
<td>Note: Goncalves et al. 2010 also suggests enrofloxacin should be effective in goats. Besser (2018) trial showed little effect of injectable Baytril alone.</td>
<td>Yes</td>
<td>Disallowed in US meat chain. “Adverse effects of fluoroquinolone administration include excretion of yellow faeces and possible damage to connective tissue (e.g., tendinopathies, arthritis lesions), which preclude their use in lambs to be maintained as replacement animals.” (Politis et al., 2019).</td>
</tr>
<tr>
<td>fluoroquinolone</td>
<td>Difloxacin (Dicural)</td>
<td>Subcutaneous injection 4.0 mg/kg body weight one daily for 3 consecutive days (in lambs in Mavrogianni)</td>
<td>Good -- Mavrogianni. No Movi detected after treatment (at this dosage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fluoroquinolone</td>
<td>Marbofloxacin</td>
<td>Subcutaneous injection of 2-3 mg/kg bw (depending on treatment schedule) (Skoufos et al. 2007 Small Rum Res).</td>
<td>“Two high or three low doses of marbofloxacin, i.e. a total of ≥6.0 mg/kg bodyweight, were needed for effective treatment. Two low doses, i.e. a total of 4.0 mg/kg bodyweight, were not found effective.”(Skoufos 2007 discussion)</td>
<td></td>
<td>“no local reactions were recorded in any lamb injected with marbofloxacin.” (Skoufos et al. 2007)</td>
</tr>
<tr>
<td>macrolide</td>
<td>Tilmicosin (Micotil)</td>
<td>Subcutaneous infection with 15 mg/kg bw twice, four days apart (Mavrogianni). Also used in Skoufos et al. 2007, also effective there, also noted emergence of resistance. Politis notes standard dosing</td>
<td>Looked pretty good to me in terms of weight gain, but Mavrogianni prefers difloxacin. No Movi detected after treatment.</td>
<td>Yes</td>
<td>“It is noteworthy however, that recent papers (Ayling et al., 2000a,b) have reported the finding of tilmicosin-resistant strains of Mycoplasma spp.” (from Mavrogianni pg. 327)</td>
</tr>
<tr>
<td>Species (date)</td>
<td>Operation size</td>
<td>Rounds of testing</td>
<td># Tested/ Positive/ Negative</td>
<td>Age/sex classes included</td>
<td>Who paid</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
<td>-------------------</td>
<td>-----------------------------</td>
<td>--------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Goats (Jan 2018)</td>
<td>17 (+ 3 kids = 20)</td>
<td>3 (2 for 3 new kids) @ months 1, 2, 3; all qPCR</td>
<td>20/3(+3I)/14 on round 1; on re-test, 20/8/12. All in all, 10 tested positive and were removed; 5 others died</td>
<td>Adults &amp; kids</td>
<td>Alaska Wild Sheep Foundation</td>
</tr>
<tr>
<td>Goats (Jan 2019)</td>
<td>14</td>
<td>3 @ months, 1, 3, 4 (qPCR &amp; cELISA)</td>
<td>14/2/12</td>
<td>Bucks, does, kids</td>
<td>Alaska Wild Sheep Foundation</td>
</tr>
<tr>
<td>Sheep (June 2020)</td>
<td></td>
<td></td>
<td>Ewes, lambs</td>
<td>USFWS/ WSU/ USU</td>
<td>Culled five chronically infected ewes</td>
</tr>
<tr>
<td>Sheep (~2017?)</td>
<td>~50</td>
<td>3 initially,</td>
<td>all</td>
<td>IDFG, Rocky Crate</td>
<td>Culled 1 lamb initially, more culs required by subsequent reintroduction</td>
</tr>
</tbody>
</table>

Data from
- Becky Schwanke
- Helen Schwantje
- Tom Besser (with IDFG)
- USWFS (with Tom Besser)
# Table of fencing cost-benefits

PRELIMINARY — PLEASE CONTACT K. MANLOVE PRIOR TO CIRCULATION/REPLICATION.

<table>
<thead>
<tr>
<th>Distance from core herd home range</th>
<th>Probability a foraying animal goes this far</th>
<th>Ratio adjustment</th>
<th>Annual proportion of herd expected to foray this far</th>
<th># animals expected to become infected (assuming bighorn herd has 25 males, with infection probabilities described below)</th>
<th>Waiting time to infection from this operation (years)</th>
<th>Expected proportion of years with disease (= persistence time/ waiting time)</th>
<th>Expected cost (= pers to waiting * annual disease cost)</th>
<th>Annual benefit from fencing (assuming fencing reduces risk by 90%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 km</td>
<td>1</td>
<td>0.0048</td>
<td>0.0048 x 0.179 = 0.00087</td>
<td>0.00087 x 25 x 0.876 = 0.00087 x 25 x 0.876 = 0.0190</td>
<td>52.62</td>
<td>0.21</td>
<td>$40,510.38</td>
<td>$36,459.34</td>
</tr>
<tr>
<td>5 km</td>
<td>0.80</td>
<td>0.0043</td>
<td>0.0043 x 0.179 = 0.00077</td>
<td>0.00077 x 25 x 0.876 = 0.00077 x 25 x 0.876 = 0.0169</td>
<td>59.03</td>
<td>0.19</td>
<td>$36,110.78</td>
<td>$32,499.71</td>
</tr>
<tr>
<td>10 km</td>
<td>0.55</td>
<td>0.0038</td>
<td>0.0038 x 0.179 = 0.00068</td>
<td>0.00068 x 25 x 0.876 = 0.00068 x 25 x 0.876 = 0.0149</td>
<td>67.05</td>
<td>0.16</td>
<td>$31,794.51</td>
<td>$28,615.06</td>
</tr>
<tr>
<td>20 km</td>
<td>0.23</td>
<td>0.0030</td>
<td>0.0030 x 0.179 = 0.00055</td>
<td>0.00055 x 25 x 0.876 = 0.00055 x 25 x 0.876 = 0.0120</td>
<td>83.08</td>
<td>0.13</td>
<td>$25,660.24</td>
<td>$23,094.22</td>
</tr>
<tr>
<td>30 km</td>
<td>0.04</td>
<td>0.0026</td>
<td>0.0026 x 0.179 = 0.00046</td>
<td>0.00046 x 25 x 0.876 = 0.00046 x 25 x 0.876 = 0.0101</td>
<td>99.10</td>
<td>0.11</td>
<td>$21,510.18</td>
<td>$19,359.16</td>
</tr>
</tbody>
</table>
How do you test for *M. ovis* in bighorn and domestic sheep and goats?

First, you need to know some basic facts about this bacteria, *Mycoplasma ovipneumoniae*. Removing the bacteria, *M. ovipneumoniae* (M. ov) from a group of domestic sheep or goats will benefit producers by improving lamb or kid weight gain, as well as overall herd health.

**Clearing *M. ovipneumoniae* from domestic sheep and goat operations**

*M. ovipneumoniae* and domestic goats

**Mycoplasma ovipneumoniae and domestic goats**

Domestic goats can carry *Mycoplasma ovipneumoniae* (M. ov) strains that can cause disease in wild sheep.

However, goats likely pose a lower risk to wild bighorn sheep. Little is known about *M. ov* in meat. Goats infected with *M. ov* may have a lower risk to wild bighorn sheep. Some *M. ov* strains may cause disease in wild sheep, however, goats likely pose a lower risk to wild bighorn sheep. Little is known about *M. ov* in meat.

**48% median decline in bighorn sheep pneumonia events**

~88% of US domestic sheep and goats infected with *M. ov*.

*Mycoplasma ovipneumoniae and Mountain Goats* **Mycoplasma ovipneumoniae** (*"M. ov"*) can infect and cause disease in mountain goats.

*M. ovipneumoniae* infections in animals other than sheep and goats

In some cases, *M. ovipneumoniae* infections have caused mortality in mountain goats.
Next steps

• Solicit any additional information for WSWG (right this minute!)

• Products will go through BC approval process
  • Distribution & sharing decisions will be made by BC

• Follow-ons
  • Peer review? (maybe as a whole; maybe as smaller chunks)
  • Collaborative manuscript on eradication efforts in domestics
  • Longer-term effort toward manuscript on costs/benefits of various management options
Name
Short-answer text

Email address & phone number (& which method you'd prefer for contact)
Short-answer text

I have information I could contribute about the following

- [ ] An Movi eradication effort in domestic sheep or goats
- [ ] Movi testing information or disease information for MOUNTAIN GOATS
- [ ] Movi testing information for LLAMAS OR ALPACAS
- [ ] Movi testing information for OTHER SPECIES
- [ ] Drug treatment efforts for Movi
- [ ] Cost information for FENCING, TREATMENT, ERADICATION, or DEPOPULATION management of Movi in an...
- [ ] Other...

Description/anecdote/whatever else you want to tell me.