Review of *M. ovi* management strategies

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Contracted to
BC Ministry of Agriculture and FLNRO

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Review/Sythesize 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.

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

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 of drugs tested against *M. ovi*

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Drug group	Active ingredient (drug)	Delivery/ schedule	Efficacy in domestic sheep	Licensed for administration in lambs?	Other considerations
fluoroquinolone	Enrofloxacin (Baytril)	Politis notes 3-5 administrations of 5-10 mg/kg body weight (consecutive days)	Note: Goncalves et al. 2010 also suggests enrofloxacin should be effective in goats. Besser (2018) trial showed little effect of injectable Baytril alone.	Yes.	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).
fluoroquinolone	Difloxacin (Dicural)	Subcutaneous injection 4.0 mg/kg body weight one daily for 3 consecutive days (in lambs in Mavrogianni)	Good -- Mavrogianni. No Movi detected after treatment (at this dosage)		
fluoroquinolone	Marbofloxacin	Subcutaneous injection of 2-3 mg/kg bw (depending on treatment schedule) (Skoufos et al. 2007 Small Rum Res).	“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)		“no local reactions were recorded in any lamb injected with marbofloxacin.” (Skoufos et al. 2007)
macrolide	Tilmicosin (Micotil)	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	Looked pretty good to me in terms of weight gain, but Mavrogianni prefers difloxacin. No Movi detected after treatment.	Yes.	“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)

Table of test-remove or test-treat efforts in domestics

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Species (date)	Operation size	Rounds of testing	# Tested/ Positive/ Negative	Age/sex classes included	Who paid	Method for removal	Follow-up testing/ Status
Goats (Jan 2018)	17 (+ 3 kids = 20)	3 (2 for 3 new kids) @ months 1, 2, 3; all qPCR	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	Adults & kids	Alaska Wild Sheep Foundation	Quarantined and evenutally culled	5 remaining goats tested July and were PCR-negative. 6 replacement animals were also tested, and were all negative
Goats (Jan 2019)	14	3 @ months, 1, 3, 4 (qPCR & cELISA)	14/2/12	Bucks, does, kids	Alaska Wild Sheep Foundation	Both bucks positive and were culled; 3 others died from other causes	9 remaining + 11 kids tested 6 months later (October); all qPCR negative
Sheep (June 2020)				Ewes, lambs	USFWS/ WSU/ USU	Culled five chronically infected ewes	
Sheep (~2017?)	~50	3 initially,		all	IDFG, Rocky Crate	Culled 1 lamb initially, more culls required by subsequent reintroduction	3 negative whole herd, then owner purchased infected rams to reintroduce

Data from

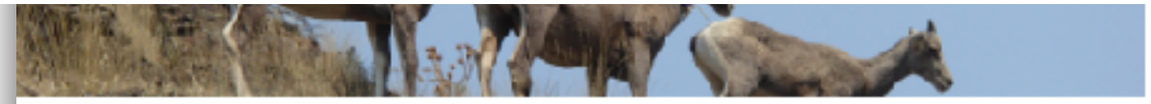
- Becky Schwanke
- Helen Schwantje
- Tom Besser (with IDFG)
- USWFS (with Tom Besser)

Table of fencing cost-benefits

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

Distance from core herd home range	Probability a foraying animal goes this far	Ratio adjustment (assume 1km of operation boundary, and 100 km circumference of round bighorn core area)	Annual proportion of herd expected to foray this far	# animals expected to become infected (assuming bighorn herd has 25 males, with infection probabilities described below)	Waiting time to infection from this operation (years)	Expected proportion of years with disease (= persistence time/ waiting time)	Expected cost (= pers to waiting * annual disease cost)	Annual benefit from fencing (assuming fencing reduces risk by 90%)
1 km	1	0.0048	0.0048 x 0.179 = 0.00087	0.00087 x 25 x 0.876 = 0.0190	52.62	0.21	$40,510.38	$36,459.34
5 km	0.80	0.0043	0.0043 x 0.179 = 0.00077	0.00077 x 25 x 0.876 = 0.0169	59.03	0.19	$36,110.78	$32,499.71
10 km	0.55	0.0038	0.0038 x 0.179 = 0.00068	0.00068 x 25 x 0.876 = 0.0149	67.05	0.16	$31,794.51	$28,615.06
20 km	0.23	0.0030	0.0030 x 0.179 = 0.00055	0.00055 x 25 x 0.876 = 0.0120	83.08	0.13	$25,660.24	$23,094.22
30 km	0.04	0.0026	0.0026 x 0.179 = 0.00046	0.00007 x 25 x 0.876 = 0.0101	99.10	0.11	$21,510.18	$19,359.16

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



How do you test for *M. ovi* in bighorn and domestic sheep and goats?

First, you need to know some basic facts about this bacteria, *Mycoplasma ovipn*

Secon
blood
handl

Thirdl

Antib
•

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

Removing the bacteria *Mycoplasma ovipneumoniae* (*M. ovi*) from a group of domestic sheep or goats will benefit producers by improving lamb or kid weight gain, as well as overall herd health.

Mycoplasma ovipneumoniae and domestic goats

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

However, goats likely pose a lower risk to wild

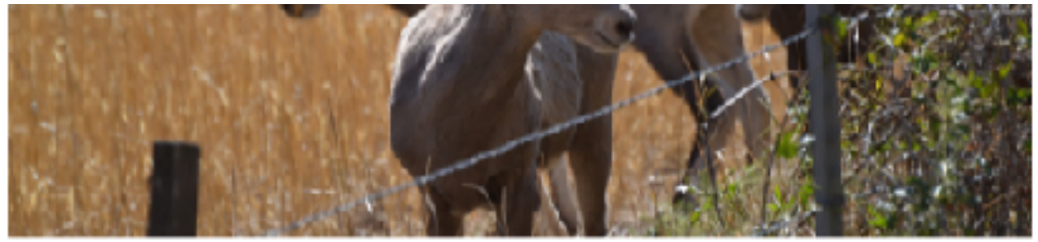
Little is known about *M. ovi* in meat, dairy, a

***M. ovi* prevalence in pack goats is likely much lowe**

- One study of over 500 pack goats from over 80 farms
than 10%, and of these, less than 6% were older than
- For domestic sheep, one study found an average prev
near 50%
- We do not know why this difference exists.

***M. ovi* strains in domestic goats may be**
bighorns than strains in dome

- *M. ovi* bacteria can be classified into different strains.
and different animals can be infected with different str
- Some strains in domestic goats appear to be unique a
- These "goat clade" strains, if transmitted to bighorns,
effects than strains arising from domestic sheep.
- However, "goat clade" strains can and do still produce



Fencing strategies to separate bighorn and domestic sheep

et in height. However, mos
ment, and this seems to al

ns merit consideration.

plain animal movements

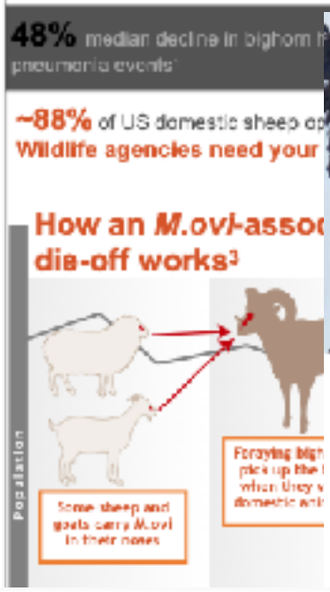
Sheep, wild sheep, and risk of pneumonia

Mycoplasma ovipneumoniae (MLOV) POSES A MAJOR THREAT TO WILD SHEEP IN NORTH AMERICA

48% median decline in bighorn
pneumonia events[1]

~88% of US domestic sheep o
Wildlife agencies need your

**How an *M.ovi*-asso
die-off works[3]**



Mycoplasma ovipneumoniae and Mountain Goats

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

tected in at least eight different free-ranging mountain goat populations.

ked with pneumonia events in mountain goats similar to those observed

ats are sympatric with bighorn sheep populations, they sometimes
ovi strain. However, some sympatric herds do not share strains, and
ds can be infected even when they do not overlap with bighorn herds.

limited information about effects of *M. ovi* on mountain goat population

ll-studied cases, the effect of *M. ovi* on mountain goats
r to its effect on bighorn sheep: all-age die-off events
followed by reduced kid recruitment.

cal factors that may make mountain goats less

M. ovipneumoniae infections in animals other than sheep and 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

https://forms.gle/KHMgcu2kjycfWqbz8

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.

Long answer text