

Table S1. Experimental challenge study of lambs with parainfluenza 3 (PI3) virus and *Mannheimia haemolytica* - clinical scoring system for respiratory disease.

Respiration:

- 0 Normal
- 1 Slightly increased
- 2 Increased
- 3 Respiratory distress (mouth breathing)

Depression:

- 0 Bright, alert
- 1 Slow to eat
- 2 Reluctant to eat, moves slowly
- 3 Anorexic, moves when stimulated

Body weight change:

- 0 no weight loss
- 1 weight loss < 15%
- 2 Weight loss \geq 15%

Rectal temperature:

- 0 Normal 37 - 39.4°C
- 1 Elevated temperature 39.5 - 40.5°C
- 2 High temperature > 40.5°C
- 3 Subnormal temperature < 37°C

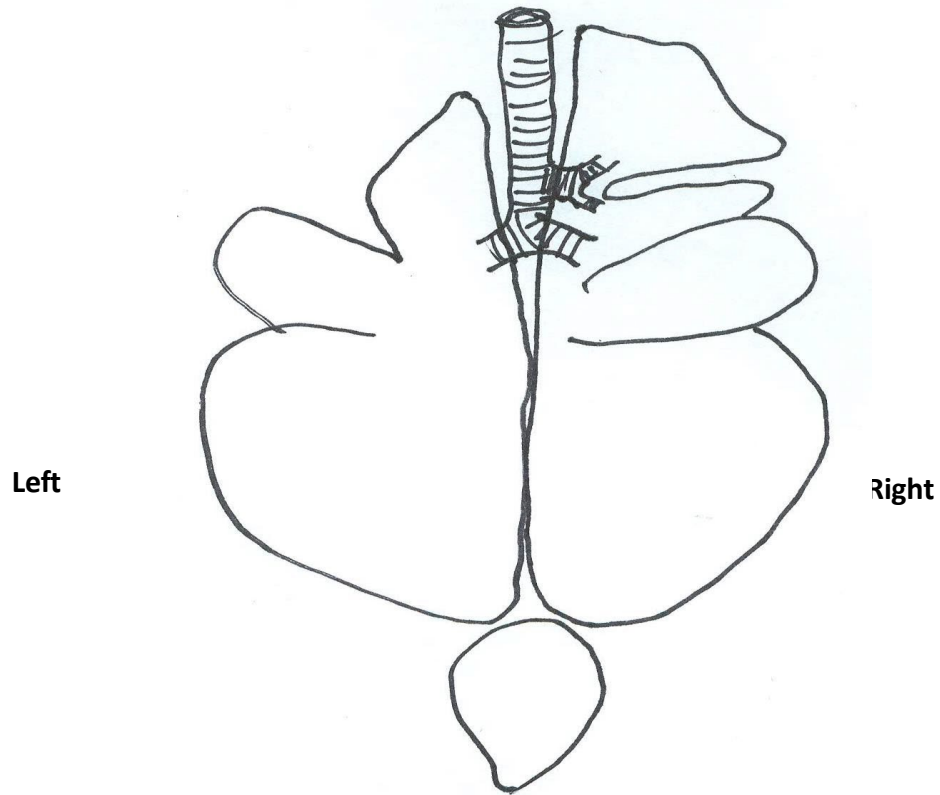
Table S2. Experimental challenge study – ovine lung scoring record.

AS#: _____

Animal ID#: _____

Date: _____

Observations: _____



Lung Lobe	A: % of lobe with lesion	B: Lobe Area (% of total)	A X B ÷ 100
Right cranial-anterior		6	
Right cranial-posterior		5	
Right middle		7	
Right caudal		35	
Accessory		4	
Left cranial-anterior		5	
Left cranial-caudal		6	
Left caudal		32	
Lung Score			

Signed _____

Table S3. Causes and number of deaths in lambs vaccinated with an experimental subunit ovine leukotoxin A (LtxA) and transferrin binding protein B (TbpB) *Mannheimia haemolytica* vaccine at a commercial sheep flock.

Cause of death	Pre-weaning phase*		Growing phase		Finishing phase	
	Unvaccinated	Vaccinated	Unvaccinated	Vaccinated	Unvaccinated	Vaccinated
No. lambs	2453	2421	2146	2069	2068	1984
Pneumonia	43	59	36	39	19	26
Enteritis	52	54	3	2	0	3
Starved	50	54	3	3	0	0
No necropsy	28	22	13	10	8	9
Other	13	15	7	3	5	3
Unknown	4	6	8	1	7	7
Digestive disease	8	7	2	5	5	4
Injury/trauma/crushed	9	11	3	3	0	0
Kidney disease	4	1	2	3	6	8
Waterbelly	0	0	4	1	10	9
Septicemia	5	11	5	0	1	0
Liver disease	1	3	1	0	0	0
Navel infection	2	3	0	0	0	0
Peritonitis	0	5	0	0	0	0
Arthritis	1	0	1	1	1	0
Rectal prolapse	0	0	0	0	2	1
Abscess	0	1	0	1	0	0
Lungworm	0	0	0	0	0	2
Orchitis	0	0	0	0	2	0
Pleuritis	0	0	0	0	1	1
Watery mouth	1	1	0	0	0	0
Congestive heart failure	0	0	0	0	1	0
Heat stroke	0	0	1	0	0	0
Conjunctivitis	0	0	0	0	0	1
Total	221	253	89	72	68	74

*Lambs in the vaccinated group were born to ewes vaccinated twice with the LMB-010 vaccine pre-lambing to boost colostral immunity.

Table S4. Bacterial culture results in lambs vaccinated with an experimental subunit leukotoxin A (LtxA) and transferrin binding protein B (TbpB) ovine *Mannheimia haemolytica* vaccine.

Culture results	Unvaccinated n (%)	Vaccinated n (%)	P-value
<i>Pre-weaning phase</i>			
No. samples	19	24	
<i>Mannheimia haemolytica</i> (type I or II)	12 (63%)	16 (67%)	1.00
<i>Bibersteinia trehalosi</i>	4 (21%)	3 (12%)	0.68
<i>Pasteurella multocida</i>	6 (32%)	6 (25%)	0.89
<i>Trueperella pyogenes</i>	9 (47%)	6 (25%)	0.23
<i>Moraxella bovoculi</i>	0 (0%)	1 (4%)	1.00
No. samples	10	12	
<i>Mycoplasma ovipneumoniae</i>	5 (50%)	8 (67%)	0.67
<i>Mycoplasma arginini</i>	7 (70%)	11 (92%)	0.29
<i>Post-weaning phase</i>			
No. samples	17	19	
<i>Mannheimia haemolytica</i> (type I or II)	12 (71%)	12 (63%)	0.73
<i>Bibersteinia trehalosi</i>	0 (0%)	4 (21%)	0.11
<i>Pasteurella multocida</i>	6 (35%)	7 (37%)	1.00
<i>Trueperella pyogenes</i>	7 (41%)	5 (26%)	0.56
<i>Moraxella bovoculi</i>	1 (6%)	0 (0%)	0.47
No. samples	12	11	
<i>Mycoplasma ovipneumoniae</i>	7 (58%)	9 (82%)	0.37
<i>Mycoplasma arginini</i>	10 (83%)	8 (73%)	0.64