Prevalence and risk factors for *Coxiella burnetii* infection in sheep, goats & farm workers in Ontario, Canada

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Introduction:

- Q fever: zoonotic disease caused by *Coxiella burnetii*, commonly associated with sheep, goats and cattle
- In small ruminants, *C. burnetii* causes abortion, stillbirth and neonatal mortality
- In humans, most infections (60%) are asymptomatic, but flu-like illness, pneumonia, hepatitis, endocarditis, and miscarriages also occur commonly
- An outbreak in the Netherlands (2007-2010)[1] demonstrated the public health and economic significance of *C. burnetii* - it resulted in ~4000 human cases, mass animal culling, and estimated control costs of 50 million Euros[2]
- Due to the public health and economic consequences of infection, it is important to determine the prevalence and risk factors for exposure to *C. burnetii* in small ruminants and their farm workers in Ontario

Objectives:

1. To determine the seroprevalence of *C. burnetii* exposure in sheep, goats and their farm workers in Ontario, Canada
2. To examine specific risk factors for *C. burnetii* exposure in sheep, goats and their farm workers
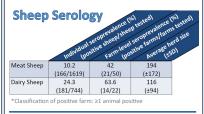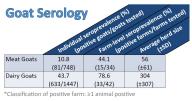
Materials and Methods:

- Cross-sectional serological survey
- Farms sampled: 42 dairy goat, 34 meat goat, 50 meat sheep, 22 dairy sheep (148 farms total)
- Randomly blood sampled ~35 females that kidded / lambed in the previous 12 months, per farm
- Farm workers were invited to provide a blood sample
- Animal serum testing: CHEKIT ELISA (IDEXX)
- Human serum testing: IFA (Focus Diagnostics)
- Separate questionnaires completed on each farm to collect data on human and farm management factors possibly associated with *C. burnetii* exposure
- Multivariable logistic regression models, with random effects for farm to account for clustering, separately built for sheep, goats, and farm workers (Stata 10.1)

References:

1. Roest *et al* (2011). Epidemiology & Infection 139; 1-12.
2. Bruschke & Emeka (2012). Proceedings of 15th International Congress on Infectious Disease, Bangkok, Thailand.

Results:

Sheep Serology

	Individual seroprevalence (%) (positive sheep/sheep tested)	Farm-level seroprevalence (%) (positive farms/farms tested)	Average herd size (±SD)
Meat Sheep	10.2 (166/1619)	42 (21/50)	194 (±172)
Dairy Sheep	24.3 (181/744)	63.6 (14/22)	116 (±94)

*Classification of positive farm: ≥1 animal positive

Goat Serology

	Individual seroprevalence (%) (positive goats/goats tested)	Farm-level seroprevalence (%) (positive farms/farms tested)	Average herd size (±SD)
Meat Goats	10.8 (81/748)	44.1 (15/34)	56 (±61)
Dairy Goats	43.7 (633/1447)	78.6 (33/42)	304 (±307)

*Classification of positive farm: ≥1 animal positive

Human Serology

- Farm-level human seroprevalence = **78.7%** (59/75)
- Individual human seroprevalence = **67.4%** (116/172)

Table 1. Distribution of human serology titres

	Phase I Antibody Titres						
Phase II Antibody Titres	< 1:16	1:16	1:32	1:64	1:128	≥1:256	TOTAL
< 1:16	56	8	3	1	0	0	68
1:16	5	7	4	1	0	0	17
1:32	1	11	10	7	2	1	32
1:64	0	1	3	11	5	1	21
1:128	0	0	0	1	12	6	19
≥ 1:256	0	0	0	4	0	11	15
TOTAL	62	27	20	25	19	19	172

Negative: 34.4% (56/172)
(Phase II > Phase I): 15.1% Acute (26/172)
(Phase I ≥ Phase II): 52.3% Chronic (90/172)

Farm Worker Risk Factors

Table 2. Multivariable mixed logistic model for sheep and goat farm worker sero-status, with random effect for farm (n=172)

Variable	OR	p
Fixed effect parameters		
Small ruminant sector (LRT χ²=11.48, p=0.022)		
- Dairy goats	Referent	-
- Dairy sheep	0.04	0.015
- Meat goats	0.09	0.018
- Meat sheep	0.30	0.180
- Multiple [b]	0.29	0.540
% of sheep and/or goats seropositive	1.044	0.003
Ever smoked tobacco [a]	4.03	0.07
Random effect parameters	**Estimate**	**p**
Farm Standard deviation	1.456	0.004

Random effect explains 42.7% of variation in the model
LRT=Likelihood ratio test, OR= Odds ratio
[a] Included as a confounder
[b] Farms had animals in more than 1 category

Sheep Risk Factors

Table 3. Multivariable mixed logistic model for sheep sero-status, with random effect for farm (n=2363)

Variable	OR	p
Fixed Effect Parameters		
Lambing pen hygiene practice: (LRT χ² = 11.71, p = 0.0084)		
- Add bedding, remove birthing materials, disinfect	Referent	-
- Add bedding & remove birth materials	8.96	0.002
- Add bedding only	5.94	0.038
- Do nothing	0.97	0.986
Lambing ewes in separate airspace from flock (LRT χ² = 11.77, p = 0.0082)		
- Always	2.08	0.362
- Sometimes	11.26	<0.0001
- Not applicable (do not lamb indoors)	0.44	0.614
- Never	Referent	
Loaning sheep that returned to farm	8.14	0.006
Female flock size (log₁₀ scale)	3.24	<0.0001
Random effect parameters	**Estimate**	**p**
Farm Standard deviation	1.59	<0.0001
Random effect explains 43.3% of the variation in the sheep model		

LRT=Likelihood ratio test, OR= Odds ratio

Goat Risk Factors

Table 4. Multivariable mixed logistic model for goat sero-status, with random effect for farm (n=2195)

Variable	OR	p
Fixed effect parameters		
Kidding pen hygiene practice: (LRT χ²=11.50, P-value =0.0093)		
- Add bedding, remove birthing materials, disinfect	Referent	-
- Add bedding & remove birth materials	19.30	0.041
- Add bedding only	4.65	0.298
- Do nothing	160.97	0.018
Kidding in airspace separate from rest of herd	14.33	0.011
Female herd size (log₁₀ scale)	13.66	<0.0001
Male herd size (log₁₀ scale)	0.16	0.001
Kidding outdoors	0.01	0.001
Pigs on farm	3.42	0.181
Interaction: kidding outdoors * pigs on farm	29.41	0.035
Other sheep or goat farms within 5km	5.59	0.048
Quarantining new animals [a]	0.23	0.062
Kidding in summer season [a]	0.96	0.963
Purchasing animals from sales barn [a]	1.62	0.625
Disposing of placenta in manure pile [a]	0.22	0.165
Random effect parameters	**Estimate**	**p**
Farm Standard deviation	1.13	<0.0001
Random effect explains 27.9% of the variation in the goat model		

[a] Included as confounder, LRT=Likelihood ratio test, OR= Odds ratio

Discussion and Conclusions:

- Exposure to *C. burnetii* among Ontario sheep, goats and their farm workers was common
- Better understanding of the risk factors and protective measures associated with *C. burnetii* exposure
- Provides support for the development and validation of control protocols, particularly disinfection
- Results used to provide better access of the animal *Coxiella* vaccine to sheep and goat producers in Ontario
- Results will be used to direct knowledge translation and transfer to producers, veterinarians and physicians