

Assessment of spatial, environmental, and management effects on lameness prevalence in UK sheep flocks

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1. UK Sheep Industry

- Approx. 33 million sheep (16 million ewes)
 - 25% EU population
 - 3% Global population
- Predominantly meat production
 - 64% consumed, 36% exported
 - One third EU supply
 - Sixth largest global producer
- Worth £2.2 billion

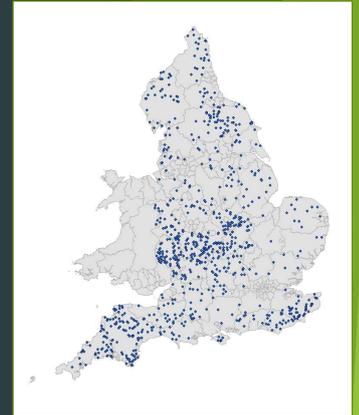


2. Footrot

- Bacterial infection
 - Dichelobacter nodosus*
 - Aerotolerant anaerobe
- 70% of all lameness in UK sheep
- Seasonal variation
 - Rainfall? Temperature? Soil?
- Cost ≈ £80 million/year

3. Data

- Questionnaires – 802 English sheep flocks
 - 2013 and 2014
 - Annual lameness prevalence
 - Lameness management practices
- Soil composition – Cranfield University
- Altitude – ArcGIS World Topography map
- Agricultural Land Classification (ALC) – Natural England

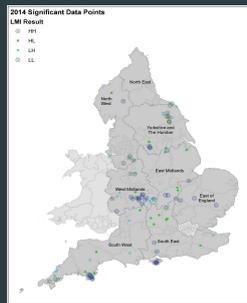
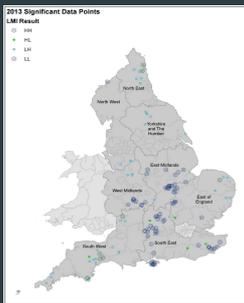


4. Local Moran's I Statistic

$$I_i = \frac{x_i - \bar{x}}{S_i^2} \sum_{j=1, j \neq i}^N w_{ij} (x_j - \bar{x})$$

$$S_i^2 = \frac{\sum_{j=1, j \neq i}^N (x_j - \bar{x})^2}{N - 1}$$

- Accommodates data with clustered distribution
- Spatially weighted matrix (S_i^2)
 - Individual years – 8 nearest neighbours
 - Combined years – 17 nearest neighbours
- Possible outcomes:
 - High-high (HH) clusters
 - Low-low (LL) clusters
 - High-low (HL) outliers
 - Low-high (LH) outliers



5. Multi-level Modelling

$$\text{Number of lame sheep}_{ij} \sim \text{OFFSET} + \beta_{0j} + \beta_{x_{ij}} + u_{0j} + \pi_{ij}$$

- Negative binomial with 2-level clustering
 - Farm - 802
 - Year - 2
- Static environmental factors
- Lameness management practices

Variable	RR	95% CI
Longitude	0.95098	0.91880-0.98429
% Coarse sand - max ^1	1.30879	1.03965-1.64761
% Coarse sand - max ^2	0.95812	0.92608-0.99127
% Coarse sand - max ^3	1.00244	1.00052-1.00437
% Coarse sand - max ^4	0.99996	0.99992-0.99999
% Clay - mean ^1	1.03488	1.00835-1.06210
% Clay - mean ^2	0.99936	0.99890-0.99982
Organic content - mean ^1	0.80511	0.66761-0.97093
Organic content - mean ^2	1.03066	1.00630-1.05562
Organic content - mean ^3	0.99857	0.99747-0.99967
Organic content - mean ^4	1.00002	1.00001-1.00004

Variable	Response	RR	95% CI
Able to recognise lame sheep at locomotion score 1	Yes	-	---
	No	1.14921	1.07444-1.22918
	No answer	1.08664	0.74557-1.58375
Gathered sheep if only 1 in the group was lame	Yes	-	---
	No	1.19254	1.07692-1.32056
	No answer	1.22923	0.92255-1.63785
Caught and treated lame sheep the same day they were identified	Yes	-	---
	No	1.22928	1.05801-1.42828
	No answer	1.18435	0.84407-1.66180
Footrot is present in the flock	Yes	-	---
	No	0.89161	0.80440-0.98827
	Don't know	0.86876	0.63714-1.18456
	No answer	0.94984	0.76127-1.18511
Contagious ovine digital dermatitis (CODD) is present in the flock	Yes	-	---
	No	0.80495	0.74832-0.86585
	Don't know	0.77340	0.58408-1.02160
	No answer	0.99580	0.83049-1.19403
Never routinely foot trimmed the flock	Yes	-	---
	No	1.08963	1.01234-1.17282
	No answer	1.03159	0.79029-1.34656
Trimmed less than 25% of the flock during a routine foot trim	Yes	-	---
	No	1.14354	1.06124-1.23223
Percent of sheep that bled during a routine foot trim		1.01594	1.01031-1.02160
Footbathed ewes at any point during the year	Yes	-	---
	No	0.88189	0.81880-0.94985
Culled sheep after being lame once	Yes	-	---
	No	1.29400	1.04230-1.60647
Kept ewes at a stocking rate of 8 ewes per acre or less	Yes	-	---
	No	1.30782	1.11336-1.53626
	No answer	1.09760	0.89678-1.34340
Average lameness prevalence in lambs		1.06053	1.05504-1.06606

6. Getis Ord Gi* Statistic

$$G_i^* = \frac{\sum_{j=1}^N w_{ij} x_j - \bar{x} \sum_{j=1}^N w_{ij}}{S \sqrt{\frac{N \sum_{j=1}^N w_{ij}^2 - (\sum_{j=1}^N w_{ij})^2}{N - 1}}}$$

$$S = \sqrt{\frac{\sum_{j=1}^N x_j^2}{N} - (\bar{x})^2}$$

- Identify hotspots and coldspots for performing significant lameness management practices
- 8 regions (above maps)
 - Neighbours = shared edges and corners
- Outcomes based on confidence intervals
 - 90%
 - 95%
 - 99%

Variable	North East	North West	Yorkshire and the Humber	East Midlands	West Midlands	East of England	South East	South West
Able to recognise lame sheep at locomotion score 1	-	-	-	-	-	-	-	-
Gathered sheep if only 1 in the group was lame	-	-	-	-	-	95% Hotspot	-	-
Caught and treated lame sheep the same day they were identified	-	-	-	-	-	-	-	-
Footrot is not present in the flock	-	-	-	90% Hotspot	-	90% Hotspot	-	-
Contagious ovine digital dermatitis (CODD) is not present in the flock	-	-	-	-	-	95% Hotspot	-	-
Never routinely foot trimmed the flock	-	-	-	-	90% Hotspot	-	-	-
Trimmed less than 25% of the flock during a routine foot trim	-	-	-	-	-	-	-	-
Percent of sheep that bled during a routine foot trim	90% Hotspot	-	-	-	-	95% Coldspot	90% Coldspot	-
Footbathed ewes at any point during the year	95% Hotspot	-	-	-	-	-	95% Coldspot	-
Culled sheep after being lame once	-	90% Coldspot	-	-	-	90% Hotspot	-	-
Kept ewes at a stocking rate of 8 ewes per acre or less	-	-	-	-	-	-	-	-