Prevalence and distribution of lice on sheep and cattle farms in Great Britain

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ABSTRACT

Lice are common production-limiting ectoparasites affecting livestock. Up-to-date data on their prevalence and spatial distribution on farms in Great Britain is important given that prevalence is believed to be increasing as a result of insecticide resistance. Here the prevalence of farms reporting lice, and factors associated with louse presence, were assessed using a retrospective questionnaire. For sheep and cattle farms, 16.1% and 15.8% reported lice on their livestock, respectively. Beef farms were more likely to report lice than dairy farms, with a prevalence of 18.0% and 7.8%, respectively. For sheep farms, prevalence was highest in Wales (27.7%) and Scotland (22.4%). For cattle farms, prevalence was highest in Scotland (27.6%), Wales (18.5%) and SW England (18.5%). For sheep farms, statistical hotspot clusters were identified in Wales, NW England and SW Scotland, with prevalence in these areas ranging from 30.7 – 40.0%. For cattle farms clustering of cases was less evident. Multivariable analysis showed that significant factors associated with lice on sheep farms were larger flock sizes and geographic location (Scotland or Wales). For beef cattle farms, significant associated factors were larger herd sizes and upland grazing. More than 90% of farms that reported lice, also reported treating for lice.

Key words: livestock, ectoparasite, Phthiraptera, questionnaire, prevalence, spatial clustering

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1. Introduction

Lice (Phthiraptera) are obligate parasites of economic and welfare concern in livestock husbandry. The entire louse lifecycle takes place on the host, survival time in the environment is short and they are transmitted mainly by direct contact (Durden, 2019). They are most prevalent during winter housing when stocking density is high and physical contact facilitates transmission, the coat is at its longest and climatic conditions of low temperatures, high humidity and relatively low light intensities allow high rates of survival (James et al., 1998). The introduction of lice into a flock or herd usually occurs via bought-in stock or contact with neighbouring animals (Horton et al., 2009). In low numbers, lice often go undetected, causing only minor, chronic dermatitis (Milnes and Green, 1999; Foster et al., 2015).

Heavy burdens are more likely on susceptible individuals, such as young (Milnes and Green, 1999; Milnes et al., 2003), malnourished or immunocompromised animals (James, 1999; Foster et al., 2015). Economic losses are also incurred due to light spot damage to leather hides, downgrading of fleece value and production losses caused by interference with host thermoregulation due to hair loss (Coles et al., 2003; Sargison, 2008). High intensity infestations can cause inflammation, pruritis and excoriation as a result of the host immune response, which can reduce time spent feeding (Weeks et al., 1995), resulting in reduced weight gains (James et al., 1998).

Both chewing and sucking lice are present in the UK, but chewing louse infestations are more prevalent (Titchener, 1983; Milnes and Green, 1999). In cattle the chewing louse, *Bovicola bovis*, and three species of sucking louse: *Lingonathus vituli*, the long-nosed cattle louse, *Haematopinus eurysternus*, the short-nosed cattle louse and *Solenopotes capillatus*, the little blue cattle louse may be present (Milnes and Green, 1999; Foster et al., 2015). The only species of veterinary importance infesting sheep in the UK is the chewing louse, *Bovicola ovis* (Sargison, 2008). The prevalence of farms infected with lice, based on farm sampling and questionnaire
surveys in regions of the UK, has been found to range from 59 – 80% for cattle farms (Titchener, 1983; Milnes and Green, 1999; Barton et al., 2006), and 11 – 21% for sheep farms (Bisdorff, Milnes & Wall, 2006; Armstrong and Davies, 2007; APHA, 2018).

Control of lice on livestock is primarily through the use of neurotoxic insecticides. In the UK, insecticides licensed for treatment of lice on cattle include pour-on and injectable macrocyclic lactones (ML) and pour-on or spot-on synthetic pyrethroids (SPs) (AHDB, 2020). For the treatment of lice on sheep, licensed insecticides include pour-on pyrethroids and organophosphate (OP) dips (AHDB, 2020). Treatment is applied primarily in autumn to protect stock during winter housing, or for sheep, in early summer post-shearing (Bisdorff and Wall, 2008). However not all licensed treatments are effective against louse eggs, so a second treatment may be required (Foster et al., 2015). The compulsory use of OP in immersion dips for the management of sheep scab, caused by *Psoroptes ovis* mites, had the added effect of contributing to louse management. After sheep scab was deregulated in 1992, treatment was no longer mandatory and there was a substantial reduction in the use of OP dips. This was correlated with an increase in scab prevalence (Bisdorff, Milnes, & Wall, 2006) and is also considered likely to have allowed an increase in the louse population (Taylor, 2009). Louse incidence may also be increasing because of growing insecticide resistance (Sargison, 2008), a contributing factor to which may be incomplete topical application (Ellse et al., 2012). Resistance in louse populations to pyrethroid insecticides is a widespread problem in Australia (Taylor, 2012). In the UK, Sands et al. (2015) found reduced susceptibility of *Bovicola bovis* from two UK cattle farms to deltamethrin *in vitro*.

Given the likely impact of resistance on louse management, more targeted risk-based control strategies for louse infestation will be required (Milne et al., 2007). For this, up-to-date empirical data on louse prevalence and distribution will be essential. However, detailed studies of louse distribution across the UK are limited. The aim of the current study, therefore, was to investigate the prevalence and distribution of sheep and cattle farms with lice across Great...
Britain and to use spatial distribution modelling to identify areas with a high prevalence of livestock farms with louse infestation.

2. Methods

2.1 Questionnaire survey

Data were collected using a cross-sectional retrospective questionnaire, as described previously in Lihou et al. (2020). Addresses were selected at random from a commercial database (Map of Agriculture, 2018). A total of 7,200 questionnaires were sent, stratified into 6 regions: Scotland, Wales, north, central, southwest and eastern England. All selected farms met the following criteria: greater than 50 sheep, or greater than 20 beef cattle, or greater than 30 dairy cattle. Minimum numbers of animals were specified to avoid surveying smallholdings and ‘hobby-farms’ which may not be representative of commercial farms. The number of questionnaires sent out in each region was based on the number of cattle or sheep holdings in each (AHDB 2018a,b), an estimated response rate of 30% [based on previous farm-based survey studies (Milnes and Green, 1999; Bisdorff et al., 2006)], an estimated prevalence rate of 15%, a margin of error of 5%, and a confidence level of 95% (Win Episcope v2.0; Thrushfield et al., 2001). The questionnaire was sent out in November of 2018 and asked for general information about the holding and information about livestock numbers, louse presence and louse treatment in the previous 12 months between November 2017 and October 2018 (see Lihou et al. (2020) for the questionnaire).

To ensure the respondents were a representative sample of livestock farms, the distribution of questionnaire respondents was externally validated by qualitative comparison with the distribution of sheep and cattle holdings in Britain (APHA, 2017a,b). Additionally, the holding types of respondents were externally validated by qualitative comparison with the known ratio of dairy to beef farms (AHDB, 2018b) and the known ratio of upland to lowland farms (DEFRA, 2017).
2.2. Prevalence

Differences in louse prevalence (proportion of farms reporting louse presence compared to louse absence) were tested between regions, livestock type (sheep/cattle), farm terrain (upland/lowland), cattle type (beef/dairy) and farm type (conventional/organic), using univariable logistic regression. All prevalence values are reported ± their 95% Wald confidence intervals. When statistics are reported, “n” refers to the number of farms in the relevant sample of the population (the numerator used in calculation of the percentage), whereas “N” refers to the sample size used in any specific analysis (the denominator used in calculation of the percentage).

2.3. Spatial analysis and associated factors

Farm postcodes were used for spatial analysis of cases (reported louse presence) and controls (reported louse absence). Spatial statistical analyses were used to assess the relative risk of louse prevalence, and identify ‘hotspot’ clusters of significantly higher risk-areas where case farms deviated from complete spatial randomness (CSR) significantly more than control farms. Relative risk was assessed using the ratio of kernel density estimates between case and control farms. As the study used a cross-sectional design, the data cannot be used to give an assessment of true risk of infestation, rather relative risk was used to assess the spatial patterns of louse infestation as a proxy for prevalence ratio. Envelopes of the G and L function assessed CSR of farm data points, and CSR of case and control farms at different spatial scales, respectively, to detect whether case points were more clustered than control points, which represent clustering caused by the underlying point distribution. Clustering significance was assessed using MonteCarlo discrete spatial scan statistics in SaTScan™, which adjusts for the underlying spatial distribution of the data points (Kulldorff, 1997). Associated factors for louse presence were assessed using multivariable logistic regression models. As well as data from the questionnaire
survey, published data on sheep and cattle density (head per km$^2$), at a spatial resolution $\sim 0.5 \times 1$ km, were obtained (Robinson et al., 2014). Analyses were conducted in R (version 3.6.1; R Core Team, 2019). For full details of data analysis, see Lihou et al. (2020).

3 Results

3.1 Respondents

In total, 964 farms responded to the questionnaire survey, a response rate of 13.4% (Fig. 1). Of these farms, 926 provided valid postcodes (906 full postcodes, with the remaining 20 valid to at least district level). Respondent numbers were highest in the southwest of England and Wales, and this was consistent with the known density of sheep and cattle farms (APHA, 2017a,b). Of the total respondents, 17% (C.I.$\pm 2$; $n=159$) farmed only sheep, 33% ($\pm 3$; $n=316$) farmed only cattle, and 51% ($\pm 3$; $n=489$) farmed both. 63% of respondents ($\pm 3$; $n=605$) described their farms as being lowland, 31% ($\pm 3$; $n=294$) as upland, 3% ($\pm 1$; $n=25$) as both, and 4% ($\pm 1$; $n=40$) did not specify. The majority of farms, 84% ($\pm 2$; $n=810$), were conventional and 5% ($\pm 1$; $n=50$) were organic, with 11% ($\pm 2$; $n=104$) unspecified. Of the farms with cattle, 72% ($\pm 3$; $n=580$) farmed beef, 13% ($\pm 2$; $n=104$) farmed dairy, and 15% ($\pm 3$; $n=121$) farmed both. The data were generally representative of the underlying holding population of England, Wales and Scotland, in terms of holding density (APHA, 2017a,b), ratio of upland to lowland farms (DEFRA, 2017), and ratio of beef to dairy farms (AHDB, 2018b). After internal validation, 3 sheep farm respondents and 5 cattle farm respondents were removed from analysis due to uncertainty interpreting farmer response.

3.2 Louse prevalence

The proportion of farms reporting lice in each month was highest in the winter months (November – February) for both sheep and cattle (Fig. 2). Overall, 16.1% of sheep farms and
15.8% of cattle farms reported lice on their animals, but prevalence differed significantly with region for both sheep (\(\chi^2 = 31.9, N=619, df = 5, P<0.001\)) and cattle (\(\chi^2 = 20.2, N=769, df = 5, P<0.01;\) Fig. 3). Reported prevalence on sheep was highest on farms in Wales and Scotland where the reported prevalence was 27.7% (±8.0; n=33) and 22.4% (±8.3; n=22), respectively (Fig. 3). The lowest reported prevalence of lice on sheep was from east England, with only 2% (±4.0; n=1) of farms reporting lice. Reported prevalence of lice on cattle was highest from farms in Scotland, Wales and southwest England where reported prevalence was 27.6% (±8.1; n=32), 18.5% (±6.7; n=24), and 18.5% (±6.3; n=27), respectively (Fig. 3). The lowest reported prevalence on cattle was from northern England, with 10.0% (±4.2; n=20) of farms reporting lice.

Lice were significantly more likely to be reported from upland farms than lowland farm for both sheep (\(\chi^2 = 24.8, N=624, df = 2, P<0.001\)) and cattle (\(\chi^2 = 10.8 , N=769, df = 2, P<0.01\)). Prevalence on upland farms was 25.6% (±2.8, n=64) and 21.6% (±2.7, n=52) for sheep and cattle, respectively. There was no significant difference in louse prevalence between conventional and organic farms for either sheep (\(\chi^2 = 2.8, N=574, df = NA, P<0.5\)) or cattle farms (\(\chi^2 = 0.03, N=712, df = 1, P<1.0\)).

18.0% (±3.1; n=104) of farms reporting lice were beef only, 7.8% (±5.5; n=8) reporting lice were dairy only and 11.6% (±6.6; n=14) of farms reporting lice had both beef and dairy. Beef only farms were significantly more likely to report lice on their cattle than dairy only farms (\(\chi^2 = 8.3, N=769, df = 2, P<0.05\)). The regional prevalence of beef only farms reporting lice was very similar to prevalence across all cattle farms, as the majority of cattle farm respondents were beef only farms (71.9%; n=553).

3.3 Spatial distribution and associated factors for lice
G function analysis showed that respondent density differed significantly from complete spatial randomness (CSR), as would be expected due to the heterogeneous nature of underlying farm density. Qualitative assessment of the kernel density estimation of farms reporting lice (case farms) and farms not reporting lice (control farms) showed that the kernel density of control farms was similar to the kernel density of respondents, whereas the kernel density of louse case farms appeared to be more spatially clustered for both sheep and cattle farms. Comparison of the case/control L functions confirmed that case farms were more clustered than control farms at radii of more than ~2 km for sheep. For cattle, both case and control farms were clustered at radii above ~10 km.

The relative risk of farms reporting lice was not homogenously distributed across Great Britain (Fig. 4). For sheep farms, risk was significantly elevated in Wales, northwest England and southwest Scotland. For cattle farms, southwest England, north Wales and Scotland all contained areas of elevated risk, but these were not found to be significant.

SaTScan identified significant clusters of sheep farms with lice in south Wales and in north England and southwest Scotland (Table 1). The prevalence of farms reporting lice in these clusters was 40.0% (N=60) in South Wales and 30.7% (N=127) in north England and southwest Scotland. SaTScan only identified one small cluster of cases of cattle farms in southwest England (Table 1), which had a prevalence of 100.0% (N=6).

For sheep, variables included in the initial multivariable logistic regression model, based on a significance of $P<0.25$ in univariable analysis, were: terrain type (upland/lowland), flock size, farm type (organic/conventional), region, and sheep density. Terrain type and sheep density were eliminated during stepwise selection. After farms with missing data were removed, 493 remained in the final model. The variance inflation factor (VIF) was <4 for all variables in the final model. Significant associated factors for reported louse presence on sheep were larger flock sizes and being located in Wales and Scotland [Table 2; Area under receiver operator curve (AUC) = 0.67, N = 493, residual deviance = 387.0 ($df = 485$), null deviance = 430.6 ($df = 492$)].
Only beef farms were included in the cattle multivariable model, to avoid issues with differing average herd sizes between beef and dairy farms, and because beef only farms made up the majority of the respondents (71.9%; n=553). Beef farms containing dairy cattle were not included because the questionnaire did not allow specification of the cattle type infested with lice. Variables included in the initial model, based on a significance of $P<0.25$ in univariable analysis, were: Terrain type (upland/lowland), herd size, livestock type (cattle only/sheep and cattle) and Region. Region and livestock type were eliminated during stepwise selection. After farms with missing data were removed, 489 remained in the final model. The VIF was <4 for all variables in the final model. Significant associated factors for reported louse presence on beef cattle were upland terrain and larger herd sizes [Table 2; AUC = 0.61, $N = 489$, residual deviance $= 435.1$ ($df = 486$), null deviance $= 457.9$, ($df = 488$)].

3.4 Louse treatment

In total, 26.6% (±3.4, n=170) of sheep farms reported treating for lice (Fig. 5). SPs were the most common drug class used, reported by 16.5% (±2.9, n=107) of sheep farms. Of the sheep farms reporting lice, 97.1% (±3.2, n=101) reported treating for lice. SPs were more likely to be used by farms reporting lice, whereas OPs were more likely to be reported by farms not reporting lice. In total, 24.4% (±3.0, n=196) of cattle farms reported treating for lice (Fig. 5). MLs were the most common drug class used, reported by 12.9% (±2.3, n=104) of cattle farms, followed by SPs, reported by 8.7% (±2.0, n=70) of cattle farms. Of the cattle farms reporting lice, 92.9% (±4.5, n=117) reported treating for lice. SPs were more likely to be used by cattle farms reporting lice, compared with those not reporting lice.

4. Discussion
The overall reported prevalence of lice was 16% for both sheep and cattle farms, but this differed significantly with region. For lice on sheep, Wales had the highest prevalence, at 28%. This is higher than previous studies have reported in Wales, with the prevalence of infested farms ranging from 15-21%. A prevalence of 19% of welsh sheep farms (N=89) with lice was reported from a retrospective questionnaire survey (Bisdorff et al., 2006). A survey of wool samples in Wales, found a similar prevalence, with 21% of flocks infested (APHA, 2018), and a farmer survey in Wales found 15% (N=2070) of farmers reporting lice on sheep (Armstrong and Davies, 2007). The relative distribution of regional prevalences reported here was similar to the 2003/4 country-wide questionnaire survey of sheep farms conducted by Bisdorff et al. (2006), but regional prevalences in this study were either similar or higher. The most notable difference was Scotland, which Bisdorff et al. (2006) found to have a prevalence of <10%, compared to 23% reported here. Due to the range of unquantified differences in the study population demographics, these studies are not directly comparable, but assuming farmer awareness has remained broadly the same, this suggests a potential increase in sheep louse infestation over recent years. This may be a long-term product of the deregulation of sheep scab and end of compulsory sheep dipping in 1992 (Taylor, 2009) and the withdrawal of cypermethrin-based dips (Natural England, 2009). Alternatively it could indicate a growing problem with the efficacy of the treatments used for louse control due to resistance (Sargison, 2008; Ellse et al., 2012).

Conversely, the prevalence of both beef (18%) and dairy (8%) farms reporting lice in this study is considerably lower than prevalences of 59-80% previously reported. A farm prevalence of 80% (N=100) in calves in Ayrshire, Scotland was reported by Titchener (1983). A questionnaire survey by Milnes and Green (1999) found that 75% (N=24) of dairy farms at the England Wales border were infested and 59% (N=72) of beef farms surveyed in southwest England reported problems with lice (Barton et al. 2006). The relatively low prevalence reported here may reflect a real decrease in the prevalence of louse infestations on cattle farms due to increased farmer
awareness and a subsequent improvement in control measures, or it may reflect a general lack of
ability of cattle farmers to diagnose sub-clinical louse infestations.

The regional variation in louse prevalence seen for both cattle and sheep farms is likely to
be largely associated with extensive upland farming husbandry practices (Bisdorff et al., 2006;
Morgan-Davies et al., 2006) and also the presence of associated common grazing in these areas,
where the mixing of flocks and herds with no, or uncoordinated, ectoparasite treatments can
prevent local eradication of louse infestations (Fraser et al., 2006). The prevalence in significant
hotspots for sheep louse infestation ranged between 31-40%. However, the reasons for the
spatial clustering observed were not well explained by the multivariable model, the statistical
effect of upland farming on sheep louse prevalence was probably weakened by the regional
significance in the multivariable model presented here. Farms with cattle lice were not
significantly clustered however, apart from one small cluster of 6 farms, suggesting that
associated factors for louse presence are associated with individual farm management.

Farms aware of the presence of lice seem keen to implement control, as more than 90%
of farms reporting lice also reported treating. However, there were some reports of unlicensed
treatments. No MLs or IGRs are licensed for use against sheep lice (AHDB, 2020), yet 5% and
2% of sheep farms reported using an ML or IGR for louse treatment, respectively. Inappropriate
use of louse treatment has been previously reported (Fraser et al., 2006; Bisdorff and Wall, 2008),
and is concerning as inappropriate treatments are unlikely to be effective; for example MLs have
limited efficacy against chewing lice (Bovicola), and non-lethal doses contribute to the selection
for insecticide resistance in exposed ectoparasites (Taylor, 2001).

Some caution is required with questionnaire surveys. Although they allow the collection
of large data sets, they rely on accurate reporting by farmers. Farmer awareness can influence
response, for example the observed seasonal prevalence results may have been exaggerated by
existing knowledge and expectation. Reporting louse presence requires farmers to be aware of
what lice are and to be in close enough contact with livestock to spot their presence. Mite
infestation can present with superficially similar clinical signs to louse infestation, and as they are also spread by direct contact, are also most prevalent in winter when animals are housed. It is more likely that louse infestation is being under-reported, with low burdens going undetected, as found by Milnes and Green (1999) when comparing questionnaire responses with farm inspections. The relatively low response rate (13.4%) may indicate some self-selection bias, favouring respondents with worse louse problems, as these farms are most likely to spot and report infestation (Milnes and Green, 1999). Despite this possibility, given that farms in all regions are equally likely to spot and report infestation, the presence/absence design in this study gives robust statistical estimates of the relative prevalence of farms with clinical infestation across Great Britain, taking into account the potential spatial bias of respondents.

In conclusion, the prevalence of farms reporting louse infestation was 16% for both sheep and cattle, with louse infestation unevenly distributed across Great Britain. Prevalence of sheep farms with louse infestation was significantly higher in Wales, northwest England and southwest Scotland. Prevalence in these ‘hotspot’ clusters ranged between 31 - 40%. Prevalence of cattle farms with louse infestation was highest in Scotland, Wales, and southwest England, but when considered on a continuous scale, there were no meaningful areas of significantly high prevalence. The work presented here provides the most up-to-date and widespread data on sheep and cattle farm louse prevalence, distribution, and prevalence ratio across Great Britain. These data are important for an assessment of farmer concern regarding louse infestation and for future optimisation of control.

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**Table 1.** The location (latitude and longitude), radius (km), number of respondents, louse prevalence and relative risk for significant clusters of cases of louse infestation in sheep and cattle, as identified by SaTScan™ analysis of data from a retrospective questionnaire survey in Great Britain. Asterix shows statistical significance value (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$).

<table>
<thead>
<tr>
<th>Cluster location (lat/long of cluster centroid)</th>
<th>Cluster radius (km)</th>
<th>Number (N) of respondents in cluster</th>
<th>Louse prevalence</th>
<th>Relative risk</th>
</tr>
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<tbody>
<tr>
<td><strong>Sheep</strong></td>
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<tr>
<td>South Wales*</td>
<td>60.74</td>
<td>60</td>
<td>40.0%</td>
<td>2.85</td>
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<tr>
<td>(51.95, -3.87)</td>
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<tr>
<td>NW England and SW Scotland*</td>
<td>52.79</td>
<td>127</td>
<td>30.7%</td>
<td>2.38</td>
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<tr>
<td>(55.21, -3.13)</td>
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<tr>
<td><strong>Cattle</strong></td>
<td></td>
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<tr>
<td>SW England *</td>
<td>14.87</td>
<td>6</td>
<td>100%</td>
<td>6.24</td>
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<tr>
<td>(51.32, -2.09)</td>
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Table 2. Associated factors for louse infestation, included in logistic regression models, for sheep (N=493) and beef cattle (N=489) based on data from a retrospective questionnaire survey in Great Britain, showing the coefficient estimate (± standard error) and the odds ratio (± 95% confidence interval). Asterix shows statistical significance value ( . \( P < 0.1 \), \( * P < 0.05 \), \( ** P < 0.01 \), \( *** P < 0.001 \)). ‘Upland’ refers to regions classified as Less Favoured Areas and characterized by rough grazing, heathland and moorland [Department for Environment and Rural Affairs (DEFRA), 2010].

<table>
<thead>
<tr>
<th>Associated factor</th>
<th>Coefficient estimate (±SE)</th>
<th>Odds ratio (±95% CI)</th>
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<tr>
<td><strong>Sheep</strong></td>
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<tr>
<td>Flock size (log10) **</td>
<td>0.88 (0.30)</td>
<td>2.41 (1.37 – 4.40)</td>
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<tr>
<td>Region *</td>
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<tr>
<td>E England</td>
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<tr>
<td>C England</td>
<td>1.41 (1.10)</td>
<td>4.12 (0.66 – 79.35)</td>
</tr>
<tr>
<td>N England .</td>
<td>2.03 (1.04)</td>
<td>7.62 (1.50 – 139.23)</td>
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<tr>
<td>Scotland *</td>
<td>2.27 (1.06)</td>
<td>9.68 (1.83 – 178.92)</td>
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<tr>
<td>SW England</td>
<td>1.05 (1.12)</td>
<td>2.85 (0.43 – 55.76)</td>
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<tr>
<td>Wales *</td>
<td>2.57 (1.04)</td>
<td>12.99 (2.58 – 236.87)</td>
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<tr>
<td>Farm type .</td>
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<td>Conventional</td>
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<td>Organic .</td>
<td>0.84 (0.48)</td>
<td>2.32 (0.87 – 5.84)</td>
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<td><strong>Beef cattle</strong></td>
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<tr>
<td>Herd size (log10)**</td>
<td>1.07 (0.32)</td>
<td>2.92 (1.60 - 5.49)</td>
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<td>Terrain ***</td>
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<td>Lowland</td>
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<tr>
<td>Upland ***</td>
<td>0.88 (0.25)</td>
<td>2.41 (1.49 – 3.92)</td>
</tr>
</tbody>
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Figure Legends

Fig. 1. Farms reporting lice [red (1)] or not reporting lice [black (0)] for (A) sheep farms or (B) cattle farms in a retrospective questionnaire survey in Great Britain.

Fig. 2. Sheep and cattle farms reporting louse infestation in each month in a retrospective questionnaire survey in Great Britain as a proportion of the overall number of sheep or cattle respondents reporting lice (± 95% confidence intervals).

Fig. 3. The percentage of sheep farms and cattle farms in a retrospective questionnaire survey in Great Britain reporting louse infestation relative to the number of respondents in that region (± 95% confidence intervals). N = North, C = Central, E = East, SW = Southwest.

Fig. 4. Relative risk (RR) of reporting louse infestation in (A) sheep and (B) cattle from a retrospective questionnaire survey in Great Britain with tolerance contour lines overlain. Lighter colours indicate higher risk and areas with significantly higher risk (\(P < 0.05\)) shown by the bold contour. The colour scales show natural log and raw relative risk (rounded to nearest whole number if \(\geq 1\), or nearest d.p if <1).

Fig. 5. The proportion of farms in a retrospective questionnaire survey in Great Britain reporting different louse treatments (± 95% confidence intervals). (A) Sheep farms (B) cattle farms. Some farms reported using more than one treatment option.