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Herd-level risk factors for bovine tuberculosis and adoption of related biosecurity measures in Northern Ireland: A case-control study

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ABSTRACT

Bovine tuberculosis (bTB) is a zoonotic disease which is endemic in Northern Ireland. As it has proven difficult to eradicate this disease, partly due to a wildlife reservoir being present in the European badger (*Meles meles*), a case-control study was conducted in a high incidence area in 2010–2011. The aim was to identify risk factors for bTB breakdown relating to cattle and badgers, and to assess the adoption of bTB related biosecurity measures on farms. Face-to-face questionnaires with farmers and surveys of badger setts and farm boundaries were conducted on 117 farms with a recent bTB breakdown (cases) and 75 farms without a recent breakdown (controls). On logistic regression at univariable and multivariable levels, significant risk factors associated with being a case herd included having an accessible badger sett within the farm boundaries in a field grazed in the last year (odds ratio, OR, 4.14; 95% confidence interval, CI, 1.79, 9.55), observation of live badgers (OR 4.14; 95% CI 1.79, 9.55), purchase of beef cattle (OR 4.60; 95% CI 1.61, 13.13), use of contractors to spread slurry (OR 2.83; 95% CI 1.24, 6.49), feeding meal on top of silage (OR 3.55; 95% CI 1.53, 8.23) and feeding magnesium supplement (OR = 3.77; 95% CI 1.39, 10.17). The majority of setts within the farm boundary were stated to be accessible by cattle (77.1%; 95% CI 71.2, 83.0%) and 66.8% (95% CI 63.8, 69.7%) of farm boundaries provided opportunities for nose-to-nose contact between cattle. Adoption of bTB related biosecurity measures, especially with regards to purchasing cattle and badger-related measures, was lower than measures related to disinfection and washing.

Introduction

Bovine tuberculosis (bTB), caused by *Mycobacterium bovis,* is a zoonotic disease which is endemic in many species worldwide (Pollock and Neill, 2002). In Northern Ireland, the disease has consequences for animal and human health, alongside being a financial burden for the government. A control programme based on test-and-slaughter (Council Directive 64/432/EEC) has been in place since the 1950s, but has not lead to eradication, possibly due to fragmented farms, dependence on rented pasture, frequent inter-herd cattle movement and the presence of a wildlife reservoir, the European badger (*Meles meles*) (Abernethy et al., 2006).

Many studies have been conducted to assess risk factors for bTB breakdown (Skuce et al., 2012), with cattle movement, bTB outbreaks on neighbouring farms, bTB history and herd size being commonly described herd-level risk factors. Comparisons of studies such as these are complicated by differing outcomes due to variation in farm management, farm structure, regional bTB incidence and wildlife density in the study areas. Although previous studies have focused on biosecurity measures mitigating potential risk factors for bTB transmission (Phillips et al., 2003; Ward et al., 2010; Johnston et al., 2011; Judge et al., 2011; Wilson et al., 2011), there is as yet no empirical evidence linking improved biosecurity with reduced risk of bTB breakdown. Furthermore, great variation in uptake of biosecurity measures has been reported previously in Great Britain (Brennan and Christley, 2012; Cresswell et al., 2014), Ireland (Sayers et al., 2013) and further afield (Brandt et al., 2008; Nöremark et al., 2010). No such assessment had ever been conducted in Northern Ireland. Biosecurity measures examined in our work are based on previously suggested management ideas relating to prevention of bTB introduction into the herd by badgers, neighbouring cattle, cattle purchases and indirect transmission (Phillips et al., 2003; Ward et al., 2010).

The current study had the following objectives: (1) to assess the level of adoption of biosecurity measures in Northern Ireland; and (2) to assess the impact of potential bTB biosecurity measures on the risk of bTB breakdown. The results in relation to a third objective (assessing farmers' attitudes toward bTB control) have been reported previously (O'Hagan et al., 2016).

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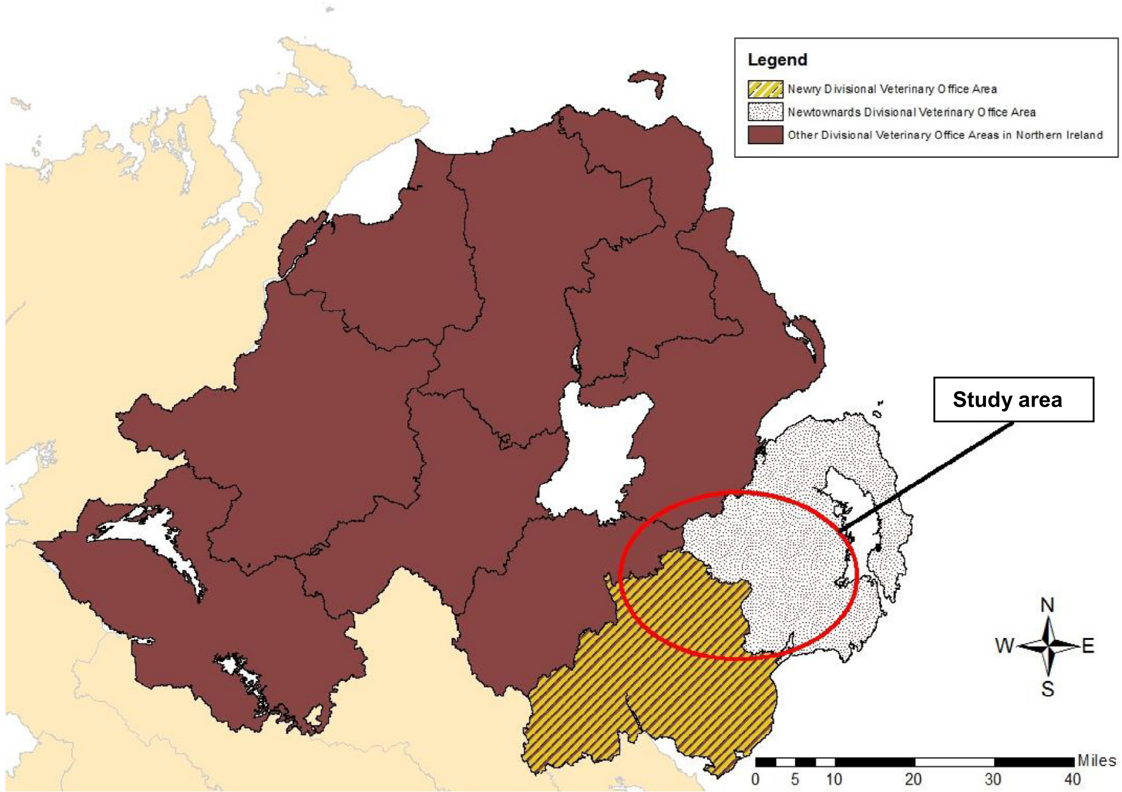

Fig. 1. Map of the study area used for a case-control study of 117 farms with a bovine tuberculosis breakdown and 75 farms without a breakdown in Northern Ireland in 2008/2009.

Materials and methods

Study area

For logistical reasons and in order to decrease variability, a defined study area was chosen in an area of high bTB incidence. This area consisted of parts (area 27/37/39) of two divisional veterinary office (DVO) areas with an annual bTB herd incidence for 2010 of 4.92% in DVO Newry and 7.86% in DVO Newtownards[1] (Fig. 1).

Study population

There were 2281 active herds in the study area based on the fact that they were subjected to the single intradermal comparative cervical skin test (SICCT) in 2008 and/or 2009. Inclusion of herds into the study by location was based on point map references of the main farm house since, for practical purposes, this is the best geo-referencing method (Durr and Froggatt, 2002). As the SICCT used to disclose bTB infected animals is not 100% specific (Clegg et al., 2011), case herds were selected on the basis of the presence of confirmed or multiple reactors. The case definition was therefore 'herds in the study area that, during 2008 and/or 2009, had multiple reactors to the SICCT, or a confirmed bTB breakdown (based on either one or more confirmed reactors to the SICCT, or one or more confirmed animals that were detected at post-mortem examination during routine slaughter)'. Confirmation was based on having positive histopathology or bacteriology findings (O'Hagan et al., 2015). The control selection definition was 'herds in the study area without restricted herd tests or reactors to the SICCT from 2007 to 2009'.

Herd size is a known risk factor in relation to bTB breakdown (Griffin et al., 1996; Olea-Popelka et al., 2004; Green and Cornell, 2005; Abernethy et al., 2010). Background analysis assessing the distribution of active herds in the study area by herd size and case-control status confirmed that large herds were more likely to be cases. Therefore, cases were selected by stratified random sampling based on herd size category (see Appendix: Supplementary Table S1) and DVO area. Small herds (<10 animals) were excluded from the study. Subsequently, controls were selected on a group-matched basis (1:1 match).

[1] See: https://www.dardni.gov.uk/sites/default/files/publications/dard/tb-stats-december2010.pdf (accessed on 22 March 2016).

Data collection

Data were gathered from face-to-face questionnaires and from surveys of badger setts and farm boundaries, with answers referring to the 12 months prior to the bTB breakdown for case farms and the 12 months prior to the survey taking place for control farms (see Appendix: Supplementary Questionnaire). Staff involved in data collection were trained in completing the questionnaires, conducting badger sett surveys, reading farm maps, use of camera/global positioning system (GPS) and recording of field boundaries. The majority of farms were visited by two members of staff to ensure consistency.

Two surveys of badger setts were conducted per farm; one survey evaluated the existence of badger activity within the farm boundary and a similar survey assessed the area within a 250 m radius around the farm buildings (see Appendix: Supplementary Badger Survey Form). Badger setts were classified according to Thornton (1998) (see Appendix: Supplementary Table S2). Farm boundaries were defined as any place of contact with a contiguous neighbour; they were described by the participating farmers and boundary surveys were conducted for verification purposes. This resulted in an assessment of the possibility of nose-to-nose contact with cattle from the neighbouring farm, taking into account the farmer's statement on whether cattle were grazed on both sides of the boundary over the 12 month period either prior to the bTB breakdown (cases) or over the 12 months prior to the survey taking place (controls) (risk assessment score 1 to 5; Table 3). If more than one boundary type was present between the study farm and a contiguous farm, they were recorded separately. In November 2010, a pilot study was conducted on eight farms, resulting in minor alterations to the questionnaire. The field study commenced in December 2010 and finished in June 2011.

Data handling and statistical analyses

Data were checked and entered on a SQL Server database. Data analyses were conducted using R (2.15.0; The R foundation for Statistical Computing) and SPSS Statistics version 19 (IBM). A comparison between farms that participated and the rest of the study population was conducted by location and herd size in order to assess response bias. There was no significant difference between participating case and control farms in relation to DVO area ($\chi^2 = 5.5703$; $P = 0.061$), but there was a significant difference in relation to herd size (two-sample *t* test; $P = 0.012$). Therefore, a univariable logistic regression model, with herd size added as an a priori confounder, was used to determine whether each variable was significantly associated