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Risk factors for visible lesions or positive laboratory tests in bovine tuberculosis reactor cattle in Northern Ireland

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ABSTRACT

An observational case–control study was conducted to investigate risk factors for confirmed bovine tuberculosis (bTB) infection in cattle reacting positively to the single intradermal comparative cervical test (SICCT) in Northern Ireland in the years 1998, 2002 and 2006.

Macroscopic lesions were detected at slaughter (positive visible lesion (VL) status) in 43.0% of reactor cattle, whilst 45.3% of those sampled were confirmed as bTB positive due to the presence of lesions or positive histopathology/mycobacterial culture (positive bTB status). In 97.5% of the reactors, the VL status and bTB status were either both negative or both positive. Generalized linear mixed model analyses were conducted on data of 24,923 reactor cattle with the variables herd identifier, local veterinary office (DVO) and abattoir being used as random effects within all the models generated at univariable and multivariable level. The other variables within the dataset were used as fixed effects. Significant risk factors associated with VL status and bTB status at multivariable level ($p < 0.05$) included age at death, breed, sex, test year, net increase in skin thickness at bovine tuberculin injection site, epidemiological status of skin test, total number of reactors at the disclosure test, mean herd size and prior response to the skin test.

These risk factors are likely related to the time since infection, the strength of the challenge of infection and the susceptibility of the animal. These findings are important as the detection of visible lesions and the confirmation of bTB are an integral part of the overall bTB control programme in Northern Ireland and the veterinary meat inspection and hygiene programme. The visible lesion status and bTB status of an animal can affect the way in which bTB breakdowns are managed, since failure to detect visible lesions and recovery of *Mycobacterium bovis* can lead to a less stringent follow-up after other risk factors have been taken into account.

1. Introduction

Bovine tuberculosis (bTB) is a chronic, infectious and zoonotic disease of domestic and wild animals caused by *Mycobacterium bovis*. Transmission of infection to cattle occurs from the environment (e.g. faeces), wildlife (e.g. badger), humans and cattle (Good and Duignan, 2011). The airborne route is the most important route of transmission in cattle (Morris et al., 1994) with 90–95% of the primary foci being located in the respiratory tract (Palmer et al., 1999; Quinn et al., 2004). Following aerosol exposure and phagocytosis, infected macrophages enter the lymphatic system and are carried to the lymph nodes. This engulfment with macrophages in turn will activate other macrophages and draw helper T-cells to the area. Activated T-cells then proceed to kill macrophages infected with mycobacteria leading to destruction of the surrounding tissue, which in combination with the dead or dying macrophages creates caseous necrosis forming a granuloma or lesion. Not only does this lesion or granuloma create a micro-environment in which infection can be controlled, it also provides the mycobacterium with a niche in which it can survive (Miranda et al., 2012). The evolution of lesions is dynamic and different between individuals (Grosset, 2003).

Clinical signs of bTB (i.e. coughing and weight loss) are now rarely seen in the United Kingdom due to the slow progression of

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disease and the Government's compulsory testing and slaughter programme. However, despite this compulsory scheme to control bTB being in place since 1959, bTB is still endemic and of high financial importance in Northern Ireland (Anonymous, 2011). The cattle density is high, most cattle trade takes place at livestock sales, winter housing is common and sixty percent of farms in Northern Ireland have multiple premises. All these factors promote movement and cattle-to-cattle contact (Abernethy et al., 2006). In addition, Northern Ireland has a wildlife reservoir for bTB in Eurasian badgers (*Meles meles*) (Denny and Wilesmith, 1999; Abernethy et al., 2011).

The single intradermal comparative cervical test (SICCT) is the primary ante-mortem diagnostic tool for bTB in cattle. Estimates of the sensitivity of the SICCT range from 68 to 95% depending on the potency and dose of tuberculin administered, the post-infection interval, desensitisation, deliberate interference, post-partum immunosuppression and observer variation (Monaghan et al., 2004; De la Rua-Domenech et al., 2006).

In Northern Ireland, all cattle over 6 weeks of age are tested annually with the SICCT by government veterinarians or private veterinary practitioners. In addition there is computerised tracing of contact herds and cattle, short interval testing of herds contiguous to outbreaks and compulsory slaughter of positive cattle. On disclosure of reactors to the SICCT or tuberculous lesions at routine post mortem inspection, herds are restricted from moving animals, except direct to slaughter, until they have passed several tests at intervals of 42–60 days (Abernethy et al., 2006).

In developed countries, the main purpose of meat inspection in relation to bTB is to act as an ancillary surveillance system and it is an essential component of the overall control programme (Olea-Popelka et al., 2008). The sensitivity of gross post mortem examination depends on the method employed and the anatomical sites examined. The detection rate of visible lesions varies significantly between abattoirs (Frankena et al., 2007; Olea-Popelka et al., 2012; Shittu et al., 2013; Wright et al., 2013). In Northern Ireland all reactors with visible lesions are subjected to histology examination of which the majority shows tuberculoid granulomata. These samples are subsequently reported as having a positive bTB status. Those samples that do not demonstrate tuberculoid granulomata on histological examination are subjected to bacterial culture. Lymph node tissue samples from reactors without visible lesions are trimmed, serial sliced and examined for lesions. If no lesions are found these samples are subjected to bacteriological culture only. The likelihood of culturing *M. bovis* is greatly increased by sampling from macroscopic lesions ("Visible lesions" or "VL") and/or by thinly slicing lungs of infected cattle (DEFRA, 2007; OIE, 2009). Lack of macroscopic lesions ("Non visible lesions" or NVL) could be due to early infection, the poor sensitivity of the post mortem examination or infection with Mycobacteria other than *M. bovis* (Corner, 1994).

The purpose of this study was to determine the risk factors associated with the presence of visible bTB lesions or positive laboratory tests (i.e. histology and culture) in cattle that reacted positively to the SICCT with the aim of being able to use this information to inform and improve disease control.

2. Materials and methods

2.1. Study population

The units of interest for this study were cattle that were removed from the herd due to a positive reaction to the SICCT. Reactor cattle were selected from 3 years, reflecting differing bTB trends; 1998 (increasing incidence), 2002 (peak incidence) and 2006 (reducing incidence) (Fig. 1). The total cattle population in Northern Ireland was approximately 1.7 million in each of the 3 study years (DARD, 2011) and the total number of reactor animals in those 3 years was 31,883.

2.2. Data source

Data were extracted from the central animal health database (APHIS) of the Department of Agriculture and Rural Development for Northern Ireland (DARD), which contains the details of all individual cattle, cattle holdings, cattle movements and cattle tuberculosis and brucellosis tests in Northern Ireland since 1988 (Houston, 2001). Complete information was available on the animal health data base for reactor animals in relation to their place of slaughter for the years 2002 and 2006. In 2002, 99.9% of reactor animals were slaughtered in one of three abattoirs. These reactors were nearly evenly distributed over these three abattoirs (respectively 27.7%, 33.0% and 39.2%). However, in 2006 one of these three abattoirs became the destination for 91.7% of reactor animals. Post mortem inspection for evidence of bTB lesions in reactor animals includes the examination of the lymphnodes of the head, chest and mesenterium, lungs, pleura, peritoneum, prescapular lymphnodes,

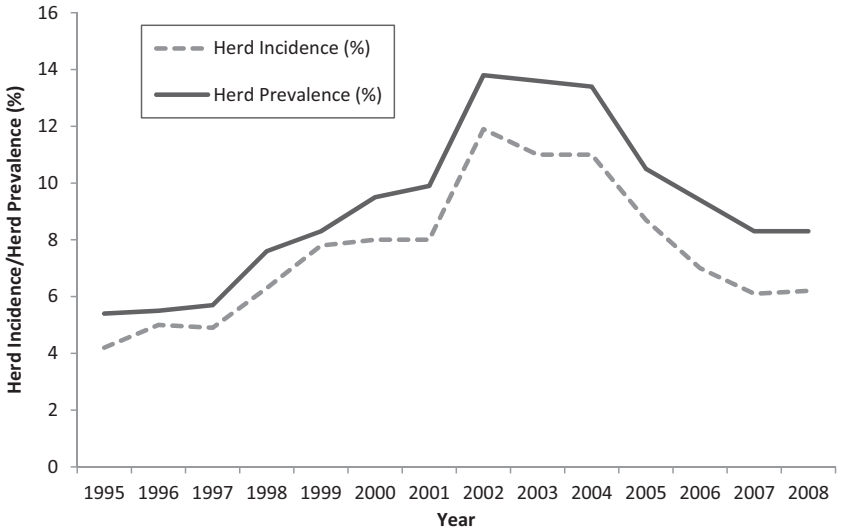

Fig. 1. Bovine tuberculosis herd incidence and herd prevalence in Northern Ireland between 1995 and 2008.