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Phenotypic effects of subclinical paratuberculosis (Johne's disease) in dairy cattle

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ABSTRACT

The effect of subclinical paratuberculosis (or Johne's disease) risk status on performance, health, and fertility was studied in 58,096 UK Holstein-Friesian cows with 156,837 lactations across lactations 1 to 3. Low-, medium-, and high-risk group categories were allocated to cows determined by a minimum of 4 ELISA milk tests taken at any time during their lactating life. Lactation curves of daily milk, protein, and fat yields and protein and fat percentage, together with $\log_e$-transformed somatic cell count, were estimated using a random regression model to quantify differences between risk groups. The effect of subclinical paratuberculosis risk groups on fertility, lactation-average somatic cell count, and mastitis were analyzed using linear regression fitting risk group as a fixed effect. Milk yield losses associated with high-risk cows compared with low-risk cows in lactations 1, 2, and 3 for mean daily yield were 0.34, 1.05, and 1.61 kg; likewise, accumulated 305-d yields were 103, 316, and 485 kg, respectively. The total loss was 904 kg over the first 3 lactations. Protein and fat yield losses associated with high-risk cows were significant, but primarily a feature of decreasing milk yield. Similar trends were observed for both test-day and lactation-average somatic cell count measures with higher somatic cell counts from medium- and high-risk cows compared with low-risk cows, and differences were in almost all cases significant. Likewise, mastitis incidence was significantly higher in high-risk cows compared with low-risk cows in lactations 2 and 3. Whereas the few significant differences between risk groups among fertility traits were inconsistent with no clear trend. These results are expected to be conservative, as some animals that were considered negative may become positive after the timeframe of this study, particularly if the animal was tested when relatively young. However, the magnitude of milk yield losses together with higher somatic cell counts and an increase in mastitis incidence should motivate farmers to implement the appropriate control measures to reduce the spread of the disease.
Key words: paratuberculosis, Johne's disease, dairy cattle, prevalence

INTRODUCTION

Paratuberculosis (or Johne's disease), caused by *Mycobacterium avium* ssp. *paratuberculosis* (**MAP**), is a fatal chronic enteritis to which ruminants are particularly susceptible and is responsible for significant efficiency losses in livestock (Raizman et al., 2009) and compromises animal welfare (CHAWG, 2012). Its unproven association with type 1 diabetes (Rani et al., 2010; Naser et al., 2013) and, in particular, Crohn's (Sartor, 2005; Uzoigwe et al., 2007), an incurable disease in humans, could potentially risk the reputation of the agri-food sector (Sartor, 2005; Groenendaal and Zagmutt, 2008). Additionally, MAP can persist in the environment for many months (Whittington et al., 2004) and in a small proportion of cases the organism has been found to survive anaerobic digestion (Slana et al., 2011), water treatment (Aboagye and Rowe, 2011), and pasteurization of milk (Grant et al., 2002), with it being found in retailed milk (C. E. D. Rees, Nottingham University, Nottingham, UK, personal communication) including powdered infant formula (Botsaris et al., 2016). In different regions around the world, increased incidence of Crohn's disease has recently been reported (Molodecky et al., 2012), and although insufficient evidence of a causal link between MAP and Crohn's disease exists, the UK Food Standards Agency has appealed for strategies to further minimize human exposure to MAP (Rubery, 2001).

Paratuberculosis is reported worldwide among cattle populations and is commonly found where significant dairy industry exists. It is considered endemic in Europe and North America, with herd prevalence estimates expected to be higher than 50% (Nielsen and Toft, 2009; Lombard et al., 2013). Paratuberculosis is considered endemic in the United Kingdom (Carslake et al., 2011)

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and is highly prevalent affecting about three-quarters of dairy cattle herds (Woodbine et al., 2009), which results in significant efficiency losses to the farm business and the dairy industry as a whole, particularly due to reduced milk production as well as reduced slaughter value and premature culling (Raizman et al., 2009; Richardson and More, 2009). Furthermore, the clinical cases are sometimes referred merely as the tip of the iceberg, as it is estimated that at least 25 other animals may be infected with each clinical case born on the farm (Whitlock and Buergelt, 1996). The main source of MAP infection is the fecal-oral route, as it is mostly excreted in feces (although it can also be shed in colostrum, milk, and semen) and can be transmitted through contaminated teats, bedding, pasture, soil, or water. Spread of MAP mostly occurs from infected adults to newborns, who are most susceptible to infection (Windsor and Whittington, 2010). However, due to a long incubation period, the disease is largely subclinical in domesticated livestock, with clinical disease manifesting not until 2 or more years after infection, with it taking place earliest via vertical transmission (i.e., transplacental) where dams were advanced in the disease (Windsor and Whittington, 2010). Nevertheless, economic losses are also expected before clinical signs taking place (Benedictus et al., 1987; Nielsen et al., 2009).

At present, no cure exists for MAP; therefore, control strategies are based upon timely detection through testing and culling of infected animals together with good hygiene practices to reduce transmission. In some countries, voluntary Johne's control programs have been established (Benedictus et al., 2000; Nielsen, 2007; Bartlett and Pearse, 2012); however, due to the latency and slow progression of the infection together with the lack of accurate diagnostic tests, diagnosis of MAP infection can prove challenging, being particularly difficult to identify infected cattle in the early stages. Thus, herd prevalence is expected to be underestimated, particularly when animals are tested or culled at a relatively young age; consequently, clinical cases may not be seen within the lifespan of the animal. Several diagnostic tests exist, but they differ in their sensitivity, specificity, cost, and practicality. Repeated testing over time is valuable for the detection of paratuberculosis due to the progression of the disease in infected animals, and testing tends to be more effective in the later stages of disease.

Since the introduction of various diagnostic tests for MAP, many studies have reported efficiency losses associated with the disease. However, the magnitude of losses reported in the literature are wide ranging and sometimes conflicting. For instance, milk production losses range from 2 (Tiwari et al., 2007) to 18% (Spangler et al., 1992), which results in large variation in estimates of the costs of the disease. Previous studies on UK cattle diseases have indicated paratuberculosis to be of less importance in terms of costs when compared with other major endemic diseases (Bennett and Ijpelaar, 2005; Stott et al., 2005).

Until recently, reliable national disease data in the UK have been scarce (Bennett and Ijpelaar, 2005), and studies on the effect of paratuberculosis that require prevalence estimates or the magnitude of efficiency losses have been confined to small geographical regions (Woodbine et al., 2009; Beasley et al., 2011) or based their assumptions on estimates from other countries. To a certain degree, losses associated with paratuberculosis are related to the production system; therefore, results obtained in one country may not necessarily be applied to another. However, with the recent introduction of a voluntary control program for paratuberculosis in the UK, the volume of data has increased year by year and is now sufficient for analysis. It is probable that these tests would be used to identify animals with subclinical paratuberculosis rather than clinically affected animals that would be displaying signs of the disease. The objective of the current study was to estimate the effect of a subclinical paratuberculosis risk group based upon milk ELISA measurements in terms of efficiency losses related to production, fertility, and udder health.

MATERIALS AND METHODS

Testing milk samples for paratuberculosis (Johne's disease) is a service available to farmers in the United Kingdom through National Milk Records (**NMR**) via the commercial milk ELISA IDEXX Pourquier *Mycobacterium paratuberculosis* Screening Antibody Test (Idexx Laboratories Inc., Westbrook, ME; Bartlett and Pearse, 2012). Herds enrolled in the paratuberculosis-control program have their milking cows tested quarterly during routine herd recording. Test results of milk ELISA from a 5-yr period, 2007 to 2012, were obtained from NMR for 2,197 UK herds. Routinely recorded production and SCC, fertility, and health records were also obtained from NMR.

Most infected cows produce antibodies, and it is reported that repeated ELISA testing before 350 DIM is the best method to capture infected animals (Nielsen and Ersbøll, 2006). The use of single tests per animal can lead to higher false-negative results, which could misclassify an infected animal, as an animal may change infection status during a period of testing. Therefore, cows were classified into low- (**LR**), medium- (**MR**), and high-risk (**HR**) groups based upon combined test results from a minimum of 4 samples, as defined in Table 1 and derived upon simplified categories of