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Review

Farm husbandry and badger behaviour: Opportunities to manage badger to cattle transmission of *Mycobacterium bovis*?

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ABSTRACT

Bovine tuberculosis (bTB) is a serious disease of cattle in the UK in terms of the economic impact on the farming industry. The disease has proven difficult to control in the cattle population and the Eurasian badger (*Meles meles*) is a source of infection. In recent years, there has been growing interest in the potential to employ farm husbandry and biosecurity practices to reduce bTB transmission risks. Here we review the potential routes of bTB transmission between badgers and cattle and explore the options for managing cattle and badger behaviour with a view to reducing the risks of inter-species transmission at pasture and within farm buildings. We discuss the relative merits of different cattle grazing regimes, habitat manipulations and badger latrine management in reducing the potential for badger–cattle contact at pasture. The physical exclusion of badgers from farm buildings is suggested as the simplest, and potentially most effective, method of reducing contact and opportunities for disease transmission between badgers and cattle. However, more research is required on the effectiveness, practicalities and costs of implementing such measures before specific guidance can be developed.

Contents

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1. Introduction

Bovine tuberculosis (bTB) caused by *Mycobacterium bovis* is a serious disease of cattle globally in terms of its economic impact. Progression of the disease in cattle can cause reduced productivity and premature death (Krebs, 1997) and has proven difficult to control. Control of the disease in cattle can be particularly challenging when wildlife becomes part of the epidemiological system. Internationally, the most significant wildlife reservoirs of bTB for cattle are considered to be the white-tailed deer (*Odocoileus virginianus*) in northern USA, the Cape buffalo (*Syncerus caffer*) in South Africa and the introduced brushtail possum (*Trichosurus vulpecula*) in New Zealand. However, there are many other potential mammalian hosts (Delahay et al., 2002; de Lisle et al., 2002), some of which may be capable of onward transmission.

In the UK a national programme involving the slaughter of skin-test positive cattle, which started in 1950, was initially successful in reducing herd breakdown rates (Krebs, 1997), infection continued to persist in some parts of the country, with the southwest of England particularly badly affected. This led to the suspicion that there was another source of infection to cattle.

In the early 1970s infected badgers (*Meles meles*) were discovered on farms with persistent breakdowns (Muirhead et al., 1974) and were implicated in the maintenance and transmission of infection. Several other species of wild mammals were also found to be infected with bTB, although prevalence was low compared to badgers (MAFF, 1973). From the mid 1970s to 1997 badgers were culled under a sequence of different strategies in an attempt to reduce the risks of infection for local cattle. However, despite this, the national incidence of herd breakdowns continued to rise during this period (Krebs, 1997). There are several possible explanations for this. Firstly, badger culling, or any other measure to reduce the risk of transmission of bTB from badgers to cattle, would not be expected to reduce herd breakdown rates if their contribution to infection in cattle was small, particularly if there was an undetected reservoir of infection in the cattle themselves. Secondly, even if badgers were the most important source of infection for cattle, culling may be relatively ineffective for ecological and behavioural reasons (Delahay et al., 2003a; Woodroffe et al., 2006). The results of several field studies (reviewed by Carter et al., 2007) suggested that the social perturbation of badger populations subjected to culling may increase the likelihood of disease transmission by enhancing movements within and between social groups. In 1997 badger culling was suspended pending an independent scientific enquiry (Krebs, 1997) and shortly after, a randomised badger culling trial (RBCT) was initiated to experimentally determine the effect of culling badgers on the incidence of cattle herd breakdowns (ISG, 1999). Results showed that infection in cattle could be reduced within areas subjected to proactive badger culling, but that on their periphery and in areas subjected to smaller-scale reactive culling the number of cattle herd breakdowns increased (Donnelly et al., 2003, 2006). The counter-productive effects of culling were ascribed to the social perturbation of badger populations (Woodroffe et al., 2006). More recent analysis of both the RBCT and the Four Area Badger Removal Project in Ireland have indicated that the detrimental effects of culling may diminish over time, however it may still result in an overall increase of bTB in cattle in some areas (Jenkins et al., 2008; Kelly et al., 2008).

As the above research highlights there are complex relationships between badgers, cattle and *M. bovis* and therefore culling of badgers may have both beneficial and detrimental effects on the incidence of bTB in cattle (Woodroffe et al., 2006; ISG, 2007; Donnelly et al., 2006; Jenkins et al., 2008; Kelly et al., 2008). Current scientific evidence therefore suggests that badger culling is unlikely to be a sustainable method of reducing bTB in cattle in the UK (ISG, 2007). Furthermore, the culling of badgers is an emotive subject with response to a public consultation showing that the majority of the British public (95.6%) were opposed to a cull (Defra, 2006). In July 2008 the UK Government announced that badger culling would not form part of its bTB control policy. Potential alternative options for the management of bTB transmission to cattle include vaccination of badgers (Delahay et al., 2003b; ISG, 2004), manipulation of badger behaviour (Phillips et al., 2000, 2003) and changes to cattle husbandry practices (Benham, 1985a; Phillips et al., 2000; Garnett et al., 2002, 2003; Phillips et al., 2003; Tolhurst, 2006).

The relative importance of potential transmission routes of *M. bovis* from badgers to cattle has yet to be identified. Consequently, there is a very limited body of evidence-based advice on how to reduce the risks of transmission. The purpose of the present paper is to review current knowledge relating to situations in which risks of *M. bovis* transmission may be posed from badgers to cattle, and to identify and discuss the areas of data shortfall and the potential options for reducing risks by manipulation of farm management practices. We followed a traditional, systematic, descriptive approach since the data in many of the reports reviewed were not quantitative, and where they were, they were often not independent of each other, i.e. they frequently arose from the same geographical regions and over the same timescale, preventing meta-analysis.

2. Routes of transmission

Whilst the precise processes by which cattle become infected with *M. bovis* have yet to be fully characterised, it is generally accepted that inhalation is the primary route, but also consumption of contaminated material may be important (Pollock and Neill, 2002). Intratracheal inoculation with as few as one colony forming unit may be sufficient to result in infection (Dean et al., 2005). Consequently, and conscious of the fairly low sensitivity of culture as a diagnostic tool, we assume that isolation of viable *M. bovis* from any part of an animal equates to a potential, yet unquantified, transmission risk via that route, regardless of dose. Evidence from *post-mortem* examinations (Clifton-Hadley et al., 1993; Gavier-Widen et al., 2001) and live-sampling (Cheeseman et al., 1985; Clifton-Hadley et al., 1993; Delahay et al., 2001) of badgers suggests that the principal sites of infection are within the