Transmission of bovine TB between badgers and cattle – a selection of references from a search in CAB Abstracts database

<1>
Accession Number
20173030879
Author
Philipon, S.; Payne, A.; Barbier, E.; Dufour, B.
Title
Evaluation of interactions between wildlife assessed by video surveillance regarding Mycobacterium bovis risk transmission. [French]
Source
Epidemiologie et Sante Animale; 2016. (69):89-104. 18 ref.
Publisher
Association pour l’Etude de l’Epidemiologie des Maladies Animales
Location of Publisher
Maisons-Alfort
Country of Publication
France
Abstract
Interactions among wildlife are likely to play a role in the transmission of diseases caused by multi-host pathogens such as Mycobacterium bovis, the agent of bovine tuberculosis. Although France is officially free from bovine tuberculosis, some areas are still harboring infection in cattle and wildlife. We designed a study to assess how often wild species susceptible to bovine tuberculosis visited artificial feeding places and waterholes, which we considered as prior hotspots for number of individuals and contacts. Then we estimated the number of intra species and interspecies interactions occurring at these places which may lead to transmission of Mycobacterium bovis. Finally, we estimated which interactions were most risky for M. bovis transmission assessing the likelihood of transmission of M. bovis using the ANSES method for risk analysis in animal health. The sites were visited on average 1.41+or-2.07 times per day. Badger visited baited places more frequently than waterholes whereas red deer visited only waterholes. Feeding, watering and foraging, which may lead to infection and excretion, were the most frequent behaviors. The qualitative risk assessment suggested that wild boars may represent the epidemiological link among species within the wild host community. Management measures at such meeting points should be implemented to limit interactions in order to reduce the circulation of M. bovis between animals.
Publication Type
Journal article
Conference paper.

<2>
Accession Number
20173026770
Author
Smith, G. C.; Delahay, R. J.; McDonald, R. A.; Budgey, R.
Title
Model of selective and non-selective management of badgers (Meles meles) to control bovine tuberculosis in badgers and cattle.
Bovine tuberculosis (bTB) causes substantial economic losses to cattle farmers and taxpayers in the British Isles. Disease management in cattle is complicated by the role of the European badger (Meles meles) as a host of the infection. Proactive, non-selective culling of badgers can reduce the incidence of disease in cattle but may also have negative effects in the area surrounding culls that have been associated with social perturbation of badger populations. The selective removal of infected badgers would, in principle, reduce the number culled, but the effects of selective culling on social perturbation and disease outcomes are unclear. We used an established model to simulate non-selective badger culling, non-selective badger vaccination and a selective trap and vaccinate or remove (TVR) approach to badger management in two distinct areas: South West England and Northern Ireland. TVR was simulated with and without social perturbation in effect. The lower badger density in Northern Ireland caused no qualitative change in the effect of management strategies on badgers, although the absolute number of infected badgers was lower in all cases. However, probably due to differing herd density in Northern Ireland, the simulated badger management strategies caused greater variation in subsequent cattle bTB incidence. Selective culling in the model reduced the number of badgers killed by about 83% but this only led to an overall benefit for cattle TB incidence if there was no social perturbation of badgers. We conclude that the likely benefit of selective culling will be dependent on the social responses of badgers to intervention but that other population factors including badger and cattle density had little effect on the relative benefits of selective culling compared to other methods, and that this may also be the case for disease management in other wild host populations.
oral badger TB vaccine is also under development. We investigated the behaviour of badgers and non-target wildlife species towards three candidate baits being considered for delivering BCG to badgers orally. Bait preference was investigated by recording removal rates of baits and through the use of video surveillance at 16 badger setts. We found high variation in rates of bait removal by badgers among setts but no significant differences in removal rates among bait types or in preference behaviour from video footage. Variation in bait removal among setts correlated with the number of nights on which badgers were seen at the sett, with most baits being removed where badgers were seen on >50% of nights during the ten-day study period. Relatively few baits were removed at setts with low levels of recorded badger activity. Monitoring badger activity prior to bait deployment may therefore be useful in increasing bait uptake and vaccine coverage. Bait removal by badgers increased over the ten-day study period, suggesting initial neophobic behaviour at some setts and that a period of 'pre-feeding' may be required prior to vaccine deployment. Our results indicate that all three candidate baits are attractive to badgers. Removal of baits by non-target wildlife species was generally low, but varied among bait types, with smaller baits in packaging less likely to be removed. Enclosing baits in packaging is likely to deter non-target species, although in some cases non-target species did remove up to 13% of packaged baits.

Publication Type
Journal article.
Herd-level bovine tuberculosis risk factors: assessing the role of low-level badger population disturbance.

Bovine TB (bTB) is endemic in Irish cattle and has eluded eradication despite considerable expenditure, amid debate over the relative roles of badgers and cattle in disease transmission. Using a comprehensive dataset from Northern Ireland (>10,000 km²; 29,513 cattle herds), we investigated interactions between host populations in one of the first large-scale risk factor analyses for new herd breakdowns to combine data on both species. Cattle risk factors (movements, international imports, bTB history, neighbours with bTB) were more strongly associated with herd risk than area-level measures of badger social group density, habitat suitability or persecution (sett disturbance). Highest risks were in areas of high badger social group density and high rates of persecution, potentially representing both responsive persecution of badgers in high cattle risk areas and effects of persecution on cattle bTB risk through badger social group disruption. Average badger persecution was associated with reduced cattle bTB risk (compared with high persecution areas), so persecution may contribute towards sustaining bTB hotspots; findings with important implications for existing and planned disease control programmes.

The variability and seasonality of the environmental reservoir of Mycobacterium bovis shed by wild European badgers.

The incidence of Mycobacterium bovis, the causative agent of bovine tuberculosis, has been increasing in UK cattle herds resulting in substantial economic losses. The European badger (Meles meles) is implicated as a wildlife reservoir of infection. One likely route of transmission to cattle is through exposure to infected
badger urine and faeces. The relative importance of the environment in transmission remains unknown, in part due to the lack of information on the distribution and magnitude of environmental reservoirs. Here we identify potential infection hotspots in the badger population and quantify the heterogeneity in bacterial load; with infected badgers shedding between 1x10^3-4x10^5 M. bovis cells g^-1 of faeces, creating a substantial and seasonally variable environmental reservoir. Our findings highlight the potential importance of monitoring environmental reservoirs of M. bovis which may constitute a component of disease spread that is currently overlooked and yet may be responsible for a proportion of transmission amongst badgers and onwards to cattle.

Publication Type
Journal article.

<7>
Accession Number
20163331652
Author
Marsot, M.; Beral, M.; Scoizec, A.; Mathevon, Y.; Durand, B.; Courcoul, A.
Title
Herd-level risk factors for bovine tuberculosis in French cattle herds.
Source
Preventive Veterinary Medicine; 2016. 131:31-40. 33 ref.
Publisher
Elsevier B.V.
Location of Publisher
Amsterdam
Country of Publication
Netherlands
Abstract
Although officially free of bovine tuberculosis (bTB), France has been experiencing a slight increase in the incidence and geographical spread of the infection. Eradication of bTB requires determining the infection risk factors. Although several studies identifying bTB risk factors have been conducted in the United Kingdom and Spain, no information is currently available regarding bTB risk factors in French cattle. The objective of this work was thus to study the factors associated with the risk of bTB in cattle herds in three French administrative divisions (departements of Ardennes, Cote d'Or and Dordogne). A case-control study was conducted to compare herds having experienced a bTB outbreak between 2012 and early 2014 with randomly selected control herds of the three study departements. A questionnaire of farming practices, inter-herd contacts (e.g. at pasture or via vehicles or materials), and the presence of other domestic species was carried out in the selected herds. Data on other variables of interest included animal movements between farms and potential contacts between cattle and wildlife (e.g. badger and wild boar abundances) were also collected. Multivariable logistic regression and multimodel inference methods were used to assess risk factors related to bTB. A total of 216 herds (72 cases and 144 controls) were analyzed. The two main risk factors were the presence of a recent neighboring outbreak, being defined as a neighboring herd at pasture reported as infected in the past two years (odds ratio (OR)=3.6; population attributable fraction (PAF)=30.7%) and the presence of a farm building for cattle housing or for feed storage located at more than 300-m from inhabited areas (OR=2.3; PAF=27.6%). Another risk factor was related to sharing water points at pasture with a recent neighboring outbreak. Results illustrated the multifactorial nature of bTB dynamics. The risk factors related to recently infected neighboring herds could be attributable to between-herd contacts at pasture and/or to exposure to a common source of infection (environment or wildlife). Moreover, the use of remote farm buildings by wildlife may also play a role in the bTB spread in the French departements studied. The identification of the main risk factors help better understand bTB dynamics and are useful for implementing appropriate and targeted surveillance, biosecurity and control measures in France.

Publication Type
Journal article.
Badgers prefer cattle pasture but avoid cattle: implications for bovine tuberculosis control.

Effective management of infectious disease relies upon understanding mechanisms of pathogen transmission. In particular, while models of disease dynamics usually assume transmission through direct contact, transmission through environmental contamination can cause different dynamics. We used Global Positioning System (GPS) collars and proximity-sensing contact-collars to explore opportunities for transmission of Mycobacterium bovis [causal agent of bovine tuberculosis] between cattle and badgers (Meles meles). Cattle pasture was badgers’ most preferred habitat. Nevertheless, although collared cattle spent 2914 collar-nights in the home ranges of contact-collared badgers, and 5380 collar-nights in the home ranges of GPS-collared badgers, we detected no direct contacts between the two species. Simultaneous GPS-tracking revealed that badgers preferred land >50 m from cattle. Very infrequent direct contact indicates that badger-to-cattle and cattle-to-badger M. bovis transmission may typically occur through contamination of the two species’ shared environment. This information should help to inform tuberculosis control by guiding both modelling and farm management.

Farm characteristics and farmer perceptions associated with bovine tuberculosis incidents in areas of emerging endemic spread.

Effective management of infectious disease relies upon understanding mechanisms of pathogen transmission. In particular, while models of disease dynamics usually assume transmission through direct contact, transmission through environmental contamination can cause different dynamics. We used Global Positioning System (GPS) collars and proximity-sensing contact-collars to explore opportunities for transmission of Mycobacterium bovis [causal agent of bovine tuberculosis] between cattle and badgers (Meles meles). Cattle pasture was badgers’ most preferred habitat. Nevertheless, although collared cattle spent 2914 collar-nights in the home ranges of contact-collared badgers, and 5380 collar-nights in the home ranges of GPS-collared badgers, we detected no direct contacts between the two species. Simultaneous GPS-tracking revealed that badgers preferred land >50 m from cattle. Very infrequent direct contact indicates that badger-to-cattle and cattle-to-badger M. bovis transmission may typically occur through contamination of the two species’ shared environment. This information should help to inform tuberculosis control by guiding both modelling and farm management.
Country of Publication
Netherlands

Abstract
While much is known about the risk factors for bovine tuberculosis (bTB) in herds located in high incidence areas, the drivers of bTB spread in areas of emerging endemicity are less well established. Epidemiological analysis and intensive social research identified natural and social risk factors that may prevent or encourage the spread of disease. These were investigated using a case-control study design to survey farmers in areas defined as recently having become endemic for bTB (from or after 2006). Telephone surveys were conducted for 113 farms with a recent history of a bTB incident where their officially tuberculosis free status had been withdrawn (OTFW) (cases) and 224 controls with no history of a bTB incident, matched on location, production type and the rate of endemic bTB spread. Farmers were questioned about a range of farm management strategies, farm characteristics, herd health, wildlife and biosecurity measures with a focus on farmer attitudes and behaviours such as farmers' perception of endemicity and feelings of control, openness and social cohesion. Data generated in the telephone surveys was supplemented with existing herd-level data and analysed using conditional logistic regression. Overall, herd size (OR 1.07), purchasing an animal at a cattle market compared to purchasing outside of markets (OR 2.6), the number of contiguous bTB incidents (2.30) and the number of inconclusive reactors detected in the 2 years prior to the case incident (OR 1.95) significantly increased the odds of a bTB incident. Beef herds using a field parcel more than 3.2 km away from the main farm and dairy herds reporting Johne's disease in the previous 12 months were 3.0 and 4.7 times more likely to have a recent history of a bTB incident, respectively. Beef herds reporting maize growing near, but not on, their farm were less likely to be case herds. Operating a closed farm in the two years prior to the case breakdown did not reduce the odds of a bTB incident. Farmers that had recently experienced a bTB incident were more likely to have implemented badger biosecurity in the previous year, but no more likely than control farms to have implemented cattle biosecurity. Case farmers felt significantly less likely to be influenced by government, vets or other farmers compared to those with no history of bTB. This suggests that alternative methods of engaging with farmers who have recently had a breakdown may need to be developed.

Publication Type
Journal article.
face questionnaire assessing farmers' agreement to 22 statements. All participating farmers found bTB control important and most were keen to learn more about bTB biosecurity measures and were in favour of the cattle-related bTB control measures as presented in the questionnaire (isolation of skin test inconclusive animals, use of the gamma-interferon test and pre-movement testing). The majority of farmers would allow badger vaccination and culling on their own land with an overall preference for vaccination. Highest disagreement was shown for the statements querying a willingness to pay for bTB control measures. There was agreement on most issues between case and control farmers and between different age groups of farmers although case farmers showed more support for additional advice on bTB biosecurity measures (P=0.042). Case farmers were also more in favour of allowing badger vaccination (P=0.008) and culling (P=0.043) on their land and showed less concern for public opposition (P=0.048).

Publication Type
Journal article.

<11>
Accession Number
20163236751
Author
Lederman, Z.
Title
One health and culling as a public health measure.
Source
Public Health Ethics; 2016. 9(1):5-23.
Publisher
Oxford University Press
Location of Publisher
Oxford
Country of Publication
UK
Abstract
One of most pertinent and acute risks that the world is now facing is emerging or re-emerging zoonotic diseases. This article focuses on culling as a measure for zoonotic disease control, specifically the culling of 11,000 badgers as part of the Randomized Badger Culling Trial in the UK and the culling exercises in Singapore. The independent expert panel that devised the UK study concluded that reactive culling was ineffective in reducing the cases of bovine tuberculosis in cattle. The panel also concluded that proactive culling was not cost-effective. Behind the scarcity of empirical evidence to support culling, the resultant reduction in biodiversity can actually harm both animals and humans. Public health policies should be evidence-based, culturally adaptable and ethically justified; a novel biomedical and public health approach, named One Health (OH), plausibly provides a reasonable ethical framework as well as research and interventional methods that square with that framework. OH recognizes that nonhuman animals and humans are interlinked in both sickness and health, since we all share the same ecosystem. OH could potentially replace standard public health strategies, as it provides alternative evidence-based methods for biomedical research and adds a non-anthropocentric component to an ethical decision-making process.
Publication Type
Journal article.

<12>
Accession Number
20163028137
Spatial targeting for bovine tuberculosis control: can the locations of infected cattle be used to find infected badgers?

Abstract
Bovine tuberculosis is a disease of historical importance to human health in the UK that remains a major animal health and economic issue. Control of the disease in cattle is complicated by the presence of a reservoir species, the Eurasian badger. In spite of uncertainty in the degree to which cattle disease results from transmission from badgers, and opposition from environmental groups, culling of badgers has been licenced in two large areas in England. Methods to limit culls to smaller areas that target badgers infected with TB whilst minimising the number of uninfected badgers culled is therefore of considerable interest. Here, we use historical data from a large-scale field trial of badger culling to assess two alternative hypothetical methods of targeting TB-infected badgers based on the distribution of cattle TB incidents: (i) a simple circular 'ring cull'; and (ii) geographic profiling, a novel technique for spatial targeting of infectious disease control that predicts the locations of sources of infection based on the distribution of linked cases. Our results showed that both methods required coverage of very large areas to ensure a substantial proportion of infected badgers were removed, and would result in many uninfected badgers being culled. Geographic profiling, which accounts for clustering of infections in badger and cattle populations, produced a small but non-significant increase in the proportion of setts with TB-infected compared to uninfected badgers included in a cull. It also provided no overall improvement at targeting setts with infected badgers compared to the ring cull. Cattle TB incidents in this study were therefore insufficiently clustered around TB-infected badger setts to design an efficient spatially targeted cull; and this analysis provided no evidence to support a move towards spatially targeted badger culling policies for bovine TB control.

Spatial and temporal analyses of metrics of tuberculosis infection in badgers (Meles meles) from the Republic of Ireland: trends in apparent prevalence.

Title
Spatial and temporal analyses of metrics of tuberculosis infection in badgers (Meles meles) from the Republic of Ireland: trends in apparent prevalence.

Source
Preventive Veterinary Medicine; 2015. 122(3):345-354. many ref.
Abstract

Badgers are a wildlife host of Mycobacterium bovis, the causative agent of bovine tuberculosis (bTB), and an important contributor to the epidemiology of bTB in cattle in Ireland and Britain. Repeated culling of badgers in high prevalence cattle bTB areas has been used in the Republic of Ireland as one tool to reduce intra- and interspecific transmission of M. bovis. We assessed factors that influenced infection prevalence of culled badgers from 2009 to 2012 (n=4948) where spatial, temporal and intrinsic factor data were available using multivariable modelling. Prevalence appeared higher in western areas than eastern areas of Ireland and badgers were more likely to be test-positive if caught at a sett (burrow system) which was close to other infected setts (spatial clustering of infection). There was a significant positive association between badger test-status and cattle prevalence of M. bovis infection at a spatial scale of 1 km around setts. Badgers were more likely to be deemed test positive if they were male (OR: 1.9) or a parous female (OR: 1.7), compared to a female who had never conceived. Our results are consistent with different groups within badger populations having differential exposures and therefore infection risk (for example, parous vs. non-parous females). Furthermore, bTB clusters within the badger population, with greater risk to badgers in setts that are closest to other infected setts. The effective scale of the association of bTB risk between badger and cattle populations may be relatively large in Ireland. Our data indicate that the overall trend in prevalence of M. bovis infection in badgers has decreased in Ireland (P<0.001) while controlling for significant confounders over the study period, and follows a longer temporal trend from 2007 to 2013, where unadjusted apparent prevalence declined from 26% to 11% during 2007 to mid-2011, followed by a stable trend between 9 and 11% thereafter (n=10,267).

Publication Type
Journal article.
Accession Number
20153441450
Author
Riviere, J.; Strat, Y. le; Dufour, B.; Hendrikx, P.
Title
Sensitivity of bovine tuberculosis surveillance in wildlife in France: a scenario tree approach.
Source
Publisher
Public Library of Sciences (PLoS)
Location of Publisher
San Francisco
Country of Publication
USA
Abstract
Bovine tuberculosis (bTB) is a common disease in cattle and wildlife, with an impact on animal and human health, and economic implications. Infected wild animals have been detected in some European countries, and bTB reservoirs in wildlife have been identified, potentially hindering the eradication of bTB from cattle populations. However, the surveillance of bTB in wildlife involves several practical difficulties and is not currently covered by EU legislation. We report here the first assessment of the sensitivity of the bTB surveillance system for free-ranging wildlife launched in France in 2011 (the Sylvatub system), based on scenario tree modelling. Three surveillance system components were identified: (i) passive scanning surveillance for hunted wild boar, red deer and roe deer, based on carcass examination, (ii) passive surveillance on animals found dead, moribund or with abnormal behaviour, for wild boar, red deer, roe deer and badger and (iii) active surveillance for wild boar and badger. The application of these three surveillance system components depends on the geographic risk of bTB infection in wildlife, which in turn depends on the prevalence of bTB in cattle. We estimated the effectiveness of the three components of the Sylvatub surveillance system quantitatively, for each species separately. Active surveillance and passive scanning surveillance by carcass examination were the approaches most likely to detect at least one infected animal in a population with a given design prevalence, regardless of the local risk level and species considered. The awareness of hunters, which depends on their training and the geographic risk, was found to affect surveillance sensitivity. The results obtained are relevant for hunters and veterinary authorities wishing to determine the actual efficacy of wildlife bTB surveillance as a function of geographic area and species, and could provide support for decision-making processes concerning the enhancement of surveillance strategies.
Publication Type
Journal article.

Accession Number
20153376085
Author
Donnelly, C. A.; Bento, A. I.; Goodchild, A. V.; Downs, S. H.
Title
Exploration of the power of routine surveillance data to assess the impacts of industry-led badger culling on bovine tuberculosis incidence in cattle herds.
Source
In the UK, badgers (Meles meles) are a well-known reservoir of infection, and there has been lively debate about whether badger culling should play a role within the British Government's strategy to control and eventually eradicate tuberculosis (TB) in cattle. The key source of information on the potential for badger culling to reduce cattle TB in high-cattle-TB-incidence areas remains the Randomised Badger Culling Trial (RBCT). In late 2013, two pilot areas were subjected to industry-led badger culls. These culls differed importantly from RBCT culling in that free-ranging as well as cage-trapped badgers were shot, and culling took place over a longer time period. Their impacts will be harder to evaluate because culling was not randomised between comparable areas for subsequent comparisons of culling versus no culling. However, the authors present calculations that explore the power of routine surveillance data to assess the impacts of industry-led badger culling on cattle TB incidence. The rollout of industry-led culling as a component of a national cattle TB control policy would be controversial. The best possible estimates of the effects of such culling on confirmed cattle TB incidence should be made available to inform all stakeholders and policymakers.

Over the last couple of decades, the UK experienced a substantial increase in the incidence and geographical spread of bovine tuberculosis (TB), in particular since the epidemic of foot-and-mouth disease (FMD) in 2001. The initiation of the Randomized Badger Culling Trial (RBCT) in 1998 in south-west England provided an opportunity for an in-depth collection of questionnaire data (covering farming practices, herd management and husbandry, trading and wildlife activity) from herds having experienced a TB breakdown between 1998 and early 2006 and randomly selected control herds, both within and outside the RBCT (the so-called TB99 and CCS2005 case-control studies). The data collated were split into four separate and comparable substudies related to either the pre-FMD or post-FMD period, which are brought together and discussed here for the first time. The findings suggest that the risk factors associated with TB breakdowns may have changed. Higher Mycobacterium bovis prevalence in badgers following the FMD epidemic may have contributed to the identification of the presence of badgers on a farm as a prominent TB risk factor only...
post-FMD. The strong emergence of contact/trading TB risk factors post-FMD suggests that the purchasing and movement of cattle, which took place to restock FMD-affected areas after 2001, may have exacerbated the TB problem. Post-FMD analyses also highlighted the potential impact of environmental factors on TB risk. Although no unique and universal solution exists to reduce the transmission of TB to and among British cattle, there is an evidence to suggest that applying the broad principles of biosecurity on farms reduces the risk of infection. However, with trading remaining as an important route of local and long-distance TB transmission, improvements in the detection of infected animals during pre- and post-movement testing should further reduce the geographical spread of the disease.

Publication Type
Journal article.

Comments on the presence of tuberculosis in animals except bovine tuberculosis in cattle in Germany: findings from 2002-2014. [German]

In many federal states tuberculosis has sporadically been detected over the years in livestock, companion animals, zoo animals and wildlife. The present report summarizes cases which have been processed in the national veterinary reference laboratory for tuberculosis between 2002 and 2014. Furthermore, tuberculosis in red deer in Bavaria is mentioned. Bovine tuberculosis in cattle is excluded from these considerations. Mycobacterium (M.) bovis was detected twice in swine, in two cats, a psittacid bird, twice in wild boar and in different animal species in one animal park and two zoos. Red deer was identified as wildlife reservoir for M. caprae in the alpine region. Furthermore, M. caprae was isolated from one sheep and one pig. M. microti, the primary causative agent for tuberculosis in wild rodents was isolated from free ranging carnivorous and omnivorous animal species (marten, raccoon, fox, badger, wild boar) as well as four domestic cats having access to natural environment, furthermore in one domestic pig and different exotic species, e. g. squirrel monkey, coati, tapir and llama. M. pinnipedii, causing tuberculosis primarily in seals, was isolated in a zoological garden over several years from seals and other zoo animal species (camel, tapir). M. tuberculosis was isolated from a dog, a parakeet, a pony, an Asian elephant and a pig kept on a cattle farm with tuberculin skin test-positive cattle. The suspicion was confirmed in most cases by isolation of the pathogen post mortem.

Publication Type
Journal article.
In Ireland and in the UK, bovine tuberculosis (bTB) infects cattle and wildlife badgers (Meles meles linnaeus) and badgers contribute to the spread of the disease in cattle. Isotropic and anisotropic spatio-temporal models are fitted to cattle herd and badger sett bTB incidence data from the Four Area Project using sequences of linear geostatistical models. An association was found between the spatial distribution of the disease in cattle and badgers in two of three areas. The limited association may be due to irregularity of sett territories, fragmentation of farms, TB-test insensitivity, temporal lags associated with transmission or non-spatial transmission. A statistical methodology is outlined whereby hypotheses related to spatial correlation structure may be tested.
Use of water troughs by badgers and cattle.

The frequency of visits by badgers and cattle to five water troughs was examined using motion-activated infra-red cameras in a farming landscape in Northern Ireland between May and July 2013. Cattle visit rates varied significantly across troughs, were greatest during daylight periods, and more frequent during dry weather. Badgers were recorded visiting only one of the five water troughs. These visits were recorded on 14 different nights between midnight and 0300h and were mainly by individual badgers. Water troughs were not used concurrently by badgers and cattle and the minimum period between badger and cattle use was 3 days. Although badgers used water troughs rarely during the study there remains the potential for indirect transmission of a bacterium such as Mycobacterium bovis that may merit further investigation.

Evaluating the tuberculosis hazard posed to cattle from wildlife across Europe.

Tuberculosis (TB) caused by infection with Mycobacterium bovis (M. bovis) and other closely related members of the M. tuberculosis complex (MTC) infects many domestic and wildlife species across Europe. Transmission from wildlife species to cattle complicates the control of disease in cattle. By determining the level of TB hazard for which a given wildlife species is responsible, the potential for transmission to the cattle population can be evaluated. We undertook a quantitative review of TB hazard across Europe on a country-by-country basis for cattle and five widely-distributed wildlife species. Cattle posed the greatest current and potential TB hazard other cattle for the majority of countries in Europe. Wild boar posed the greatest hazard...
of all the wildlife species, indicating that wild boar have the greatest ability to transmit the disease to cattle. The most common host systems for TB hazards in Europe are the cattle-deer-wild boar ones. The cattle-roe deer-wild boar system is found in 10 countries, and the cattle-red deer-wild boar system is found in five countries. The dominance of cattle with respect to the hazards in many regions confirms that intensive surveillance of cattle for TB should play an important role in any TB control programme. The significant contribution that wildlife can make to the TB hazard to cattle is also of concern, given current population and distribution increases of some susceptible wildlife species, especially wild boar and deer, and the paucity of wildlife TB surveillance programmes.

Publication Type
Journal article.

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Accession Number
20143384027

Author
Byrne, A. W.; White, P. W.; McGrath, G.; O'Keeffe, J.; Martin, S. W.

Title
Risk of tuberculosis cattle herd breakdowns in Ireland: effects of badger culling effort, density and historic large-scale interventions.

Source
Veterinary Research; 2014. 45(109):(26 October 2014). 46 ref.

Publisher
BioMed Central Ltd

Location of Publisher
London

Country of Publication
UK

Abstract
Bovine tuberculosis (bTB) continues to be a problem in cattle herds in Ireland and Britain. It has been suggested that failure to eradicate this disease is related to the presence of a wildlife reservoir (the badger). A large-scale project was undertaken in the Republic of Ireland during 1997-2002 to assess whether badger removal could contribute to reducing risk of cattle herd breakdowns in four areas. During the period of that "four area" study, there was a significant decrease in risk in intensively culled (removal) areas relative to reference areas. In the present study, we revisit these areas to assess if there were any residual area effects of this former intervention a decade on (2007-2012). Over the study period there was an overall declining trend in bTB breakdown risk to cattle herds. Cattle herds within former removal areas experienced significantly reduced risk of breakdown relative to herds within former reference areas or herds within non-treatment areas (OR: 0.53; P<0.001). Increased herd breakdown risk was associated with increasing herd size (OR: 1.92-2.03; P<0.001) and herd bTB history (OR: 2.25-2.40; P<0.001). There was increased risk of herd breakdowns in areas with higher badger densities, but this association was only significant early in the study (PD*YEAR interaction; P<0.001). Badgers were culled in areas with higher cattle bTB risk (targeted culling). Risk tended to decline with cumulative culling effort only in three counties, but increased in the fourth (Donegal). Culling badgers is not seen as a viable long-term strategy. However, mixed policy options with biosecurity and badger vaccination, may help in managing cattle breakdown risk.

Publication Type
Journal article.

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Accession Number
20143255964
Author
Chambers, M. A.; Carter, S. P.; Wilson, G. J.; Jones, G.; Brown, E.; Hewinson, R. G.; Vordermeier, M.
Title
Vaccination against tuberculosis in badgers and cattle: an overview of the challenges, developments and current research priorities in Great Britain.
Source
Veterinary Record; 2014. 175(4):90-96. many ref.
Publisher
BMJ Publishing Group
Location of Publisher
London
Country of Publication
UK
Abstract
Bovine tuberculosis (TB) is a significant threat to the cattle industry in England and Wales. It is widely acknowledged that a combination of measures targeting both cattle and wildlife will be required to eradicate bovine TB or reduce its prevalence until European official freedom status is achieved. Vaccination of cattle and/or badgers could contribute to bovine TB control in Great Britain, although there are significant gaps in our knowledge regarding the impact that vaccination would actually have on bovine TB incidence. Laboratory studies have demonstrated that vaccination with BCG can reduce the progression and severity of TB in both badgers and cattle. This is encouraging in terms of the prospect of a sustained vaccination programme achieving reductions in disease prevalence; however, developing vaccines for tackling the problem of bovine TB is challenging, time-consuming and resource-intensive, as this review article sets out to explain.
Publication Type
Journal article.

Accession Number
20143256339
Author
Bielby, J.; Donnelly, C. A.; Pope, L. C.; Burke, T.; Woodroffe, R.
Title
Badger responses to small-scale culling may compromise targeted control of bovine tuberculosis.
Source
Publisher
National Academy of Sciences
Location of Publisher
Washington
Country of Publication
USA
Abstract
Where wildlife disease requires management, culling is frequently considered but not always effective. In the British Isles, control of cattle tuberculosis (TB) is hindered by infection in wild badger (Meles meles) populations. Large-scale badger culling can reduce the incidence of confirmed cattle TB, but these benefits are undermined by culling-induced changes in badger behavior (termed perturbation), which can increase transmission among badgers and from badgers to cattle. Test-vaccinate/remove (TVR) is a novel approach that entails testing individual badgers for infection, vaccinating test-negative animals, and killing test-positive animals. Imperfect capture success, diagnostic sensitivity, and vaccine effectiveness mean that TVR would
be expected to leave some infected and some susceptible badgers in the population. Existing simulation models predict that TVR could reduce cattle TB if such small-scale culling causes no perturbation, but could increase cattle TB if considerable perturbation occurs. Using data from a long-term study, we show that past small-scale culling was significantly associated with four metrics of perturbation in badgers: expanded ranging, more frequent immigration, lower genetic relatedness, and elevated prevalence of Mycobacterium bovis, the causative agent of TB. Though we could not reject the hypothesis that culling up to three badgers per social group might avoid perturbation, we also could not reject the hypothesis that killing a single badger prompted detectable perturbation. When considered alongside existing model predictions, our findings suggest that implementation of TVR, scheduled for 2014, risks exacerbating the TB problem rather than controlling it. Ongoing illegal badger culling is likewise expected to increase cattle TB risks.

**Publication Type**
Journal article.

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<26>
**Accession Number**
20143159763

**Author**
Mullineaux, E.

**Title**
Badgers and bovine TB: what the small animal vets needs to know.

**Source**

**Publisher**
British Small Animal Veterinary Association

**Location of Publisher**
Quedgeley

**Country of Publication**
UK

**Publication Type**
Conference paper.

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<27>
**Accession Number**
20143159120

**Title**
Bovine TB eradication programme IAA badger vaccination programme. Year 2 report.

**Source**

**Publisher**
Welsh Government

**Country of Publication**
UK

**Abstract**
This reports on the vaccination programme that was carried out between May and November 2013 as part of the five year vaccination project in the Intensive Action Area (IAA) in West Wales which is part of the Welsh Government's wider programme of work to eradicate tuberculosis (TB) from cattle in Wales. The report highlights that in 2013, over 1350 badgers were successfully trapped and vaccinated in the IAA. And
in 2012 just over 1400 badgers were vaccinated. A review on the latest TB figures indicate that the level of Bovine TB in Wales has significantly reduced and that new incidents of the disease are down by nearly a quarter on the previous year.

Publication Type
Miscellaneous.

Interactions between wild boars, badgers and cattle in Cote-d'Or : which opportunity for the transmission of Mycobacterium bovis? [French]

Abstract
France is officially free of bovine tuberculosis but the infection has been reported to re-occur in cattle and also in wildlife, especially in wild boars and badgers in some regions such as Cote-d'Or. Wild hosts may act as reservoirs and may thus hamper efforts being made to control the infection in livestock. To quantify the level of indirect contact between those wild species and cattle and better understand how transmission may occur, ten badgers and eleven wild boars were tracked in the infected area of Cote-d'Or between August 2011 and December 2012. For each individual, we computed the number of relocations in pastures per night and the area of pasture land covered in the home range per month. Then we analyzed how these estimators varied using generalized linear mixed models evaluating the impact of several variables. The distance between pastures and the sett for badgers and the availability of pasture for wild boars appeared to be important drivers for the use of pastures by these animals. Badgers preferred grassland in the spring compared to other seasons; this was particularly true when daily temperatures were low. Wild boars used pastures mostly in the summer and less in winter except when mild and wet weather made earthworms more accessible. These data give an insight into the risk of tuberculosis transmission between badgers, wild boars and cattle. M. bovis infection level, its persistence in the environment and the density of animal populations are needed to assess the risk of transmission between these two wild species and cattle in Cote-d'Or.

Conference paper.
Mycobacterium bovis infection in domestic pigs in Great Britain.
Source
Veterinary Journal; 2013. 198(2):391-397. 41 ref.
Publisher
Elsevier Ltd
Location of Publisher
Oxford
Country of Publication
UK
Abstract
Mycobacterium bovis, the causative agent of bovine tuberculosis (TB), infects a wide range of wild and domestic mammals. Despite a control programme spanning decades, M. bovis infection levels in cattle in Great Britain (GB) have continued to rise over recent years. As the incidence of infection in cattle and wildlife may be linked to that in swine, data relating to infection of pigs identified at slaughter were examined in this study. Between 2007 and 2011, almost all M. bovis-infected pigs originated from farms in the South-West and West-Midland regions of England. The data suggest that pigs raised outdoors or on holdings with poor biosecurity may be more vulnerable to infection with M. bovis. In the majority of cases, the same strains of M. bovis were found in pigs and cattle, despite the fact that direct contact between these species was rarely observed. Genotyping and geographical mapping data indicated that some strains found in pigs may correlate better with those present in badgers, rather than cattle. In consequence, it is proposed that pigs may represent a useful sentinel for M. bovis infection in wildlife in GB. Given the potential implications of this infection for the pig industry, and for the on-going effort to control bovine TB, the importance of understanding the epidemiology and pathogenesis of M. bovis infection, as well as monitoring its prevalence, in pigs should not be underestimated.
Publication Type
Journal article.

<30>
Accession Number
20143035365
Author
Broughan, J. M.; Downs, S. H.; Crawshaw, T. R.; Upton, P. A.; Brewer, J.; Clifton-Hadley, R. S.
Title
Source
Veterinary Journal; 2013. 198(2):339-345. many ref.
Publisher
Elsevier Ltd
Location of Publisher
Oxford
Country of Publication
UK
Abstract
Mycobacterium bovis, the causative agent of bovine tuberculosis (bTB), can infect a broad range of mammalian species in addition to domestic and feral cattle and badgers. Since legislation introduced in 2006 in Great Britain requires animal keepers, meat inspectors and veterinarians to notify the authorities of suspect bTB lesions or the isolation of M. bovis in any mammal excluding humans, the organism has been increasingly identified in domestic species other than cattle. Although in most cases 'spill-over' hosts, these remain a potential source of infection for cattle, wildlife, and possibly humans. In this first part of a two-part review of M. bovis infections in non-bovine domestic species, current knowledge of the epidemiology of such infections is presented along with novel data relating to diagnostic submissions for mycobacterial culture.
between 2004 and 2010. Over this period M. bovis infection was identified in 116 cats, 7 dogs, 34 llamas, 133 alpacas, 35 goats, 24 sheep and 85 pigs and wild boar. The risk that such infections pose to the control of bTB, and as zoonoses, is discussed. In part two, the options available to diagnose bTB in these species, as well as the challenges posed to disease detection and control will be discussed in depth.
between cattle and badgers. Culture and molecular typing data were available for cattle culled during the national tuberculosis (TB) eradication campaigns between 2008 and 2012, as well as from 171 necropsied badgers and 60 live animals trapped and examined over the same time period. Mycobacterium tuberculosis complex strains were isolated from pooled tissues of 14 (8.2%) necropsied badgers, of which 11 were identified as M. bovis: six different spoligotypes of M. bovis were subsequently identified. In two geographical locations where these isolates were shared between cattle and badgers, infected cattle herds and badgers lived in close contact. Although it remains unclear if badgers are a maintenance or spill-over host of M. bovis in this setting, it would appear prudent to have precautionary measures in place to reduce contact between cattle and badgers.

Publication Type
Journal article.

Accession Number
20133401181
Author
Buddle, B. M.; Parlane, N. A.; Wedlock, D. N.; Heiser, A.
Title
Overview of vaccination trials for control of tuberculosis in cattle, wildlife and humans.
Source
Transboundary and Emerging Diseases; 2013. 60(s1):136-146. many ref.
Publisher
Wiley-Blackwell
Location of Publisher
Berlin
Country of Publication
Germany
Abstract
Vaccination is a key strategy for control of tuberculosis (TB), and considerable progress has been made in the past 5 years to develop improved vaccines for humans and animals, differentiate vaccinated animals from those infected with Mycobacterium bovis and deliver vaccines to wildlife. Studies have moved from testing vaccines in small animal models to clinical trials in humans and from experimental challenge studies in cattle and wildlife to evaluation of vaccines in the field. Candidate vaccines undergoing testing in humans include live mycobacterial vaccines to replace bacille Calmette Guerin (BCG), subunit vaccines (virus vector or protein) to boost BCG and therapeutic vaccines used as an adjunct to chemotherapy. In cattle, a number of diagnostic tests have been developed and successfully tested for differentiating infected from vaccinated animals, which will facilitate the use of BCG vaccine in cattle. Encouraging results have been obtained from recent field trials in cattle using BCG vaccine to protect against natural exposure to M. bovis. To date, no subunit TB vaccines have induced improved protection compared with that for BCG, but prime-boost combinations of BCG with DNA, protein or virus-vectored vaccines have induced better protection than BCG vaccine alone. Development of an oral bait BCG formulation has demonstrated the practicality of delivering TB vaccines to wildlife. Oral BCG preparations have induced protection against experimental challenge of M. bovis in possums, badgers, wild boar and white-tailed deer and against natural exposure to M. bovis in possums. Recent progress in TB vaccine development has provided much impetus for their future use.

Publication Type
Journal article
Conference paper.
Accession Number
20133401180
Author
Gormley, E.; Corner, L. A. L.
Title
Control strategies for wildlife tuberculosis in Ireland.
Source
Transboundary and Emerging Diseases; 2013. 60(s1):128-135. 44 ref.
Publisher
Wiley-Blackwell
Location of Publisher
Berlin
Country of Publication
Germany
Abstract
The principal domestic maintenance host for Mycobacterium bovis is infected cattle. In countries where comprehensive surveillance schemes have been applied, tuberculosis rarely affects an animal to the extent that it presents with clinical disease. In the latter stages of an eradication campaign, the aim is to maintain the disease-free status of clear herds and eliminate foci of infection in herds as well as restricting movement of infected animals from these herds, other than to slaughter. However, the eradication of tuberculosis from cattle herds may be compromised if infected wildlife species, such as Eurasian badgers (Meles meles), share the same environment and contribute to transmission of infection. The options for dealing with tuberculosis in the wildlife reservoir hosts are limited to segregation of domestic animals from the wildlife, culling of the wildlife host or vaccination. Options are further limited by conservation and social reasons, particularly where culling is concerned. In Ireland and the UK, vaccination of badgers against M. bovis, if successfully employed, could directly facilitate the completion of bovine tuberculosis eradication. Programmes of research into vaccination of badgers are being undertaken in both countries, and there is clear evidence that vaccination induces protection. Vaccine trials in captive badgers have established that the M. bovis bacille Calmette-Guerin (BCG) vaccine can induce a protective response that limits the distribution and severity of tuberculosis disease following experimental challenge. In Ireland, a large-scale field trial of oral BCG vaccination is being conducted to measure the protection generated in wild badgers subjected to natural transmission of infection and to estimate vaccine efficacy. The results will provide a framework for the development and implementation of a national strategy to address the disease in badger populations and if successful will remove this major impediment to tuberculosis eradication from cattle.
Publication Type
Journal article
Conference paper.

Accession Number
20133245315
Author
Warren, M.; Lobley, M.; Winter, M.
Title
Farmer attitudes to vaccination and culling of badgers in controlling bovine tuberculosis.
Source
Veterinary Record; 2013. 173(2):40.
Publisher
BMJ Publishing Group
Location of Publisher
London
Country of Publication
UK
Abstract

Controversy persists in England, Wales and Northern Ireland concerning methods of controlling the transmission of bovine tuberculosis (bTB) between badgers and cattle. The National Trust, a major land-owning heritage organisation, in 2011, began a programme of vaccinating badgers against bTB on its Killerton Estate in Devon. Most of the estate is farmed by 18 tenant farmers, who thus have a strong interest in the Trust's approach, particularly as all have felt the effects of the disease. This article reports on a study of the attitudes to vaccination of badgers and to the alternative of a culling programme, using face-to-face interviews with 14 of the tenants. The results indicated first that the views of the respondents were more nuanced than the contemporary public debate about badger control would suggest. Secondly, the attitude of the interviewees to vaccination of badgers against bTB was generally one of resigned acceptance. Thirdly, most respondents would prefer a combination of an effective vaccination programme with an effective culling programme, the latter reducing population of density sufficiently (and preferably targeting the badgers most likely to be diseased) for vaccination to have a reasonable chance of success. While based on a small sample, these results will contribute to the vigorous debate concerning contrasting policy approaches to bTB control in England, Wales and Northern Ireland.

Accession Number
20133227230
Author
Broadbent, R. S.
Title
Badgers and TB - understanding the argument.
Source
Publisher
Wiley-Blackwell
Location of Publisher
Oxford
Country of Publication
UK
Abstract
This article sets out to put into perspective the arguments about the role badgers play in the transmission of bovine TB. It is based upon a lecture given at last year's BVNA Conference.

Accession Number
20133149921
Author
Donnelly, C. A.; Hone, J.
Title
Is there an association between levels of bovine tuberculosis in cattle herds and badgers?
Source
Statistical Communications in Infectious Diseases; 2010. 2(1):Article 3. 30 ref.
Publisher
De Gruyter
Location of Publisher
Berlin
Country of Publication
Germany
Abstract
Wildlife diseases can have undesirable effects on wildlife, on livestock and people. Bovine tuberculosis (TB) is such a disease. This study derives and then evaluates relationships between the proportion of cattle herds
with newly detected TB infection in a year and data on badgers, in parts of Britain. The relationships are
examined using data from 10 sites which were randomly selected to be proactive culling sites in the UK
Randomized Badger Culling Trial. The badger data are from the initial cull only and the cattle incidence data
pre-date the initial badger cull. The analysis of the proportion of cattle herds with newly detected TB infection
in a year, showed strong support for the model including significant frequency-dependent transmission
between cattle herds and significant badger-to-herd transmission proportional to the proportion of M. bovis-
infected badgers. Based on the model best fitting all the data, 3.4% of herds (95% CI: 0-6.7%) would be
expected to have TB infection newly detected (i.e. to experience a TB herd breakdown) in a year, in the
absence of transmission from badgers. Thus, the null hypothesis that at equilibrium herd-to-herd
transmission is not sufficient to sustain TB in the cattle population, in the absence of transmission from
badgers cannot be rejected (p=0.18). Omitting data from three sites in which badger carcass storage may
have affected data quality; the estimate dropped to 1.3% of herds (95% CI: 0-6.5%) with p=0.76. The results
demonstrate close positive relationships between bovine TB in cattle herds and badgers infectious with M.
bovis. The results indicate that TB in cattle herds could be substantially reduced, possibly even eliminated, in
the absence of transmission from badgers to cattle. The results are based on observational data and a small
data set to provide weaker inference than from a large experimental study.

<4>
Accession Number
20133078372
Author
Weber, N.; Bearhop, S.; Dall, S. R. X.; Delahay, R. J.; McDonald, R. A.; Carter, S. P.
Title
Denning behaviour of the European badger (Meles meles) correlates with bovine tuberculosis infection
status.
Source
Behavioral Ecology and Sociobiology; 2013. 67(3):471-479. 73 ref.
Publisher
Springer Berlin
Location of Publisher
Heidelberg
Country of Publication
Germany
Abstract
Heterogeneities in behaviours of individuals may underpin important processes in evolutionary biology and
ecology, including the spread of disease. Modelling approaches can sometimes fail to predict disease
spread, which may partly be due to the number of unknown sources of variation in host behaviour. The
European badger is a wildlife reservoir for bovine tuberculosis (bTB) in Britain and Ireland, and individual
behaviour has been demonstrated to be an important factor in the spread of bTB among badgers and to
cattle. Radio-telemetry devices were deployed on 40 badgers from eight groups to investigate patterns of
den (sett) use in a high-density population, where each group had one or two main and three to eight outlier
setts in their territory. Badgers were located at their setts for 28 days per season for 1 year to investigate
how patterns differed between individuals. Denning behaviour may have a strong influence on contact
patterns and the transmission of disease. We found significant heterogeneity, influenced by season, sex and
age. Also, when controlling for these, bTB infection status interacting with season was highly correlated with
sett use. Test-positive badgers spent more time away from their main sett than those that tested negative.
We speculate that wider-ranging behaviour of test-positive animals may result in them contacting sources of
infection more frequently and/or that their behaviour may be influenced by their disease status. Measures to
control infectious diseases might be improved by targeting functional groups, specific areas or times of year
that may contribute disproportionately to disease spread.

<5>
The European Badger (Meles meles) has been implicated in the epidemiology of bovine tuberculosis in cattle populations in the Republic of Ireland. Badger populations have been subject to a culling regime in areas with chronic histories of bTB cattle herd breakdowns. Removal data from 2004 to 2010 were used to model the impact of culling on populations in areas under capture. Additionally, changes in field signs of badger activity were used as an index of abundance to support, or otherwise, the outcomes of the removal models. Significant reductions in standardised badger captures over time were found across three large study areas (total area, 1,355 km²). Assuming that all inactive setts were vacant, an overall linear trend model suggested that badger captures had decreased by 78% for setts with 6 years of repeated capturing operations. Given the uncertainty associated with the relationship between sett activity and badger presence, we repeated the linear modelling using two 'what if' scenarios. Assuming that individual badgers were missed on 10% or 20% of occasions at inactive setts, the estimated decline over 6 years is lowered to 71% or 64%, respectively. The decline profile consisted of a steep initial decrease in captures within the first 2 years, followed by a more gradual decrease thereafter. The number of active openings at setts (burrows) declined significantly in all three areas; but the magnitude of this decline varied significantly amongst study areas (41-82%). There was a significant increase in the probability of setts becoming dormant with time. The removal programme was more intense (mean, 0.45 badgers culled km² year⁻¹) than previous experimental badger removals in Ireland but some captures may be attributed to immigrant badgers as no attempt was made to limit inward dispersal from areas not under management. Results from this study suggest that significant reductions in badger density occurred in the areas where management had taken place. Since other non-culled badger populations in Northern Ireland and Britain exhibited stable population trends, we attribute the reduction in relative abundance to the culling regime. Further studies of the dynamics of this reduction are required to quantify how it is counteracted by immigration from populations outside of culled areas.
Abstract
This issue is comprised of 17 papers covering several mycobacterial diseases in the goat, sheep, wild boar, cattle, elk, white-tailed deer, reindeer, horse, red deer, opossum, buffalo, badger and man. Focus is given on the detection, isolation, diagnosis, prevalence, control, prevention, risk factors and transmission of Mycobacterium tuberculosis, M. avium subsp. paratuberculosis and M. bovis.

<7>
Accession Number
20133009209
Author
Title
The distribution of Mycobacterium bovis infection in naturally infected badgers.
Source
Publisher
Elsevier Ltd
Location of Publisher
Oxford
Country of Publication
UK
Abstract
Populations of Eurasian badgers (Meles meles) with tuberculosis (Mycobacterium bovis infection) are a significant reservoir of infection for cattle in Ireland and the United Kingdom. In this study the distribution of infection, histological lesions and gross lesions was determined in a sample of 132 culled badgers from naturally-infected wild populations. Badgers were culled when an epidemiological investigation following a tuberculosis breakdown in a cattle herd implicated badgers as the probable source of infection. The definition of tuberculosis infection was based on the isolation of M. bovis from tissues or clinical samples. An accurate diagnosis of infection was achieved by culturing a wide range of lymph nodes (LN) and organ tissues (mean 32.1) and clinical samples (faeces and urine) from each badger. Infection was detected in 57/132 badgers (43.2%). Histological lesions consistent with tuberculosis were seen in 39/57 (68.4%) culture-positive and 7/75 (9.3%) culture-negative animals.

Gross lesions were seen in only 30/57 (52.6%) infected badgers, leaving a high proportion (47.4%) of infected animals with latent infection (no grossly visible lesions). The most frequently infected tissues were the lungs and axillary LN, followed by the deep cervical LN, parotid LN and tracheobronchial LN. The data support the hypotheses that in badgers there are only two significant routes of infection, namely, the lower respiratory tract and bite wounds, and that badgers are very susceptible to infection but resistant to the development and progression of the disease. At all levels of disease severity, infection was found in widely dispersed anatomical locations suggesting that there is early dissemination of infection in the period preceding the development of active immunity.

<8>
Accession Number
20123263559
Title
Cage-trapping and shooting of badgers under licence to prevent the spread of bovine TB in cattle: best practice guidance.
Source
Publisher
Department for Environment, Food and Rural Affairs (DEFRA)
Abstract
The regulatory and welfare aspects of trapping and shooting wild badgers (Meles meles) which act as reservoirs for Mycobacterium bovis in order to control the disease in cattle in the UK are discussed.

Accession Number
20123263558

Title
Controlled shooting of badgers in the field under licence to prevent the spread of bovine TB in cattle: best practice guidance.

Source
Controlled shooting of badgers in the field under licence to prevent the spread of bovine TB in cattle: best practice guidance; 2012. ;17 pp.

Publisher
Department for Environment, Food and Rural Affairs (DEFRA)

Abstract
The regulatory and welfare guidelines for culling badgers (Meles meles) which act as a reservoir for Mycobacterium bovis in order to control the disease in cattle in the UK are presented.

Accession Number
20123270309

Author
Robinson, P. A.; Corner, L. A. L.; Courcier, E. A.; McNair, J.; Artois, M.; Menzies, F. D.; Abernethy, D. A.

Title
BCG vaccination against tuberculosis in European badgers (Meles meles): a review.

Source
Comparative Immunology, Microbiology & Infectious Diseases; 2012. 35(4):277-287.

Abstract
Tuberculosis (TB) is a significant animal health problem in many parts of the world, and reservoirs of infection in wild animals complicate disease control efforts in farmed livestock, particularly cattle. Badgers (Meles meles) are a significant wildlife reservoir of Mycobacterium bovis infection for cattle in the United Kingdom (UK) and Republic of Ireland (ROI). Vaccination of badgers using an M. bovis strain bacille Calmette-Guerin (BCG) vaccine could potentially be an option in the national TB eradication strategy. Wildlife vaccination has been used successfully for other diseases in wildlife species, and may have a role to play in reducing M. bovis transmission at the wildlife-livestock interface. Research to date has provided evidence that BCG is protective in badgers, and a parenteral badger BCG vaccine has been licensed in the UK. Further research is required to develop effective strategies for vaccine deployment and to determine the effect of badger vaccination on cattle TB incidence.
France attained 'Officially Tuberculosis-Free' status in 2000. However, the Cote d'Or department (a French administrative unit) has since seen an increase in bovine tuberculosis (bTB) cases, with 35% of cases attributed to neighbourhood contamination. The aim of this study was to investigate the characteristics of neighbourhood contacts in an area affected by bTB in 2010, through the use of social network methods. We carried out a survey to determine the frequency and distribution of between-herd contacts in an area containing 22 farms. Contacts were weighted, as not all types of contact carried the same risk of bTB transmission. Cattle movement was considered to be associated with the highest risk, but was not observed within the studied area during the study period. Contact with wild boars was the most frequent type of contact, but was associated with a very low risk. Direct cattle-to-cattle contacts in pasture and contacts with badger latrines were less frequent, but entailed a greater risk of M. bovis transmission. Centrality values were heterogeneous in these two networks. This would enable the disease to spread more rapidly at the start of epidemics than in a perfect randomly mixed population. However, this situation should also result in the total number of infected herds being smaller. We attributed 95% of the contacts to direct contact in pasture or contact with wild boars or badger latrines. Other kinds of contact occurred less frequently (equipment sharing, cattle straying) or did not occur at all (attendance at a show). Most of the contact types were correlated, but none was sufficient in itself to account for all contacts between one particular farm and its neighbours. Contacts with neighbours therefore represent a challenge for the implementation or improvement of control measures.

Comparing badger (Meles meles) management strategies for reducing tuberculosis incidence in cattle.

France attained 'Officially Tuberculosis-Free' status in 2000. However, the Cote d'Or department (a French administrative unit) has since seen an increase in bovine tuberculosis (bTB) cases, with 35% of cases attributed to neighbourhood contamination. The aim of this study was to investigate the characteristics of neighbourhood contacts in an area affected by bTB in 2010, through the use of social network methods. We carried out a survey to determine the frequency and distribution of between-herd contacts in an area containing 22 farms. Contacts were weighted, as not all types of contact carried the same risk of bTB transmission. Cattle movement was considered to be associated with the highest risk, but was not observed within the studied area during the study period. Contact with wild boars was the most frequent type of contact, but was associated with a very low risk. Direct cattle-to-cattle contacts in pasture and contacts with badger latrines were less frequent, but entailed a greater risk of M. bovis transmission. Centrality values were heterogeneous in these two networks. This would enable the disease to spread more rapidly at the start of epidemics than in a perfect randomly mixed population. However, this situation should also result in the total number of infected herds being smaller. We attributed 95% of the contacts to direct contact in pasture or contact with wild boars or badger latrines. Other kinds of contact occurred less frequently (equipment sharing, cattle straying) or did not occur at all (attendance at a show). Most of the contact types were correlated, but none was sufficient in itself to account for all contacts between one particular farm and its neighbours. Contacts with neighbours therefore represent a challenge for the implementation or improvement of control measures.
Bovine tuberculosis (bTB), caused by Mycobacterium bovis, continues to be a serious economic problem for the British cattle industry. The Eurasian badger (Meles meles) is partly responsible for maintenance of the disease and its transmission to cattle. Previous attempts to manage the disease by culling badgers have been hampered by social perturbation, which in some situations is associated with increases in the cattle herd incidence of bTB. Following the licensing of an injectable vaccine, we consider the relative merits of management strategies to reduce bTB in badgers, and thereby reduce cattle herd incidence. We used an established simulation model of the badger-cattle-TB system and investigated four proposed strategies: business as usual with no badger management, large-scale proactive badger culling, badger vaccination, and culling with a ring of vaccination around it. For ease of comparison with empirical data, model treatments were applied over 150 km² and were evaluated over the whole of a 300 km² area, comprising the core treatment area and a ring of approximately 2 km. The effects of treatment were evaluated over a 10-year period comprising treatment for five years and the subsequent five year period without treatment. Against a background of existing disease control measures, where 144 cattle herd incidents might be expected over 10 years, badger culling prevented 26 cattle herd incidents while vaccination prevented 16. Culling in the core 150 km² plus vaccination in a ring around it prevented about 40 cattle herd breakdowns by partly mitigating the negative effects of culling, although this approach clearly required greater effort. While model outcomes were robust to uncertainty in parameter estimates, the outcomes of culling were sensitive to low rates of land access for culling, low culling efficacy, and the early cessation of a culling strategy, all of which were likely to lead to an overall increase in cattle disease.

Accession Number
20123174752
Author
Reid, N.; Etherington, T. R.; Wilson, G. J.; Montgomery, I.; McDonald, R. A.
Title
Monitoring and population estimation of the European badger Meles meles in Northern Ireland.
Source
Publisher
Nordic Board for Wildlife Research
Location of Publisher
Ronde
Country of Publication
Denmark
Abstract

The estimation of animal abundance has a central role in wildlife management and research, including the role of badgers Meles meles in bovine tuberculosis transmission to cattle. This is the first study to examine temporal change in the badger population of Northern Ireland over a medium- to long-term time frame of 14-18 years by repeating a national survey first conducted during 1990-1993. A total of 212 1-km² squares were surveyed during 2007-2008 and the number, type and activity of setts therein recorded. Badgers were widespread with 75% of squares containing at least one sett. The mean density of active main setts, which was equivalent to badger social group density, was 0.56 (95% CI: 0.46-0.67) active main setts per km² during 2007-2008. Social group density varied significantly among landclass groups and counties. The total number of social groups was estimated at 7,600 (95% CI: 6,200-9,000) and, not withstanding probable sources of error in estimating social group size, the total abundance of badgers was estimated to be 34,100 (95% CI: 26,200-42,000). There was no significant change in the badger population from that recorded during 1990-1993. A resource selection model provided a relative probability of sett construction at a spatial scale of 25 m. Sett locations were negatively associated with elevation and positively associated with slope, aspect, soil sand content, the presence of cover, and the area of improved grassland and arable agriculture within 300 m.
This paper examines UK farmers' levels of confidence in vaccinating badgers against bovine tuberculosis (bTB) and their trust in the Government's ability to deal with bTB. In 2010, a badger vaccine based on the BCG vaccine was licensed following field trials and used as part of the UK Government's Badger Vaccination Deployment Project. A stratified random sample of cattle farmers in five different locations of England was surveyed using a telephone survey to elicit their views of badger vaccination. The survey provided a total of 341 responses with a response rate of 80 per cent. Results suggest that the farmers are cautious about badger vaccination, appearing to be neither overly confident nor unconfident in it. However, the farmers did not reveal high levels of trust in the Government to manage bTB policy or badger vaccination. There were no differences in the levels of confidence or trust between farms that were under bTB restrictions at the time of the survey and those that were not or between farms with historically high levels of bTB. Analysis of principal components suggests that 33 per cent of the farmers accepted badger vaccination, but that acceptance is dependent on the wider social and political environment.

As a part of bovine tuberculosis eradication strategy, the Welsh Government has proposed a badger cull in a defined area in and around North Pembrokeshire, and has published information on herd densities and incidence levels within and close to the area. In the present study, three sets of previously published data relating the impact of badger culling inside and around previous culling areas to distances from culling area boundaries have been used to model possible impacts of the proposed cull, taking account of three possible scenarios in which geographic boundaries reduce, to varying extents, adverse effects caused by increased
badger movements. For the scenarios considered, the results predict average changes in confirmed herd incidences (CHIs) in the range -15.7 (-29.1 to 1.6 per cent) to -25.3 per cent (-52.2 to 46.1 per cent) over a period of 10 years, comprising average changes in the culling area in the range -26.1 (-34.8 to -14.8 per cent) to -32.6 per cent (-59.6 to 47.6 per cent), and average changes on adjoining land in the range 4.5 (-21.8 to 39.8 per cent) to 7.8 per cent (-16.1 to 38.5 per cent). The overall impacts equate to average reductions in the number of CHIs of between 122 (37 to 187) and 158 (-254 to 304).

In the UK, attempts since the 1970s to control the incidence of bovine tuberculosis (bTB) in cattle by culling a wildlife host, the European badger (Meles meles), have produced equivocal results. Culling-induced social perturbation of badger populations may lead to unexpected outcomes. We test predictions from the 'perturbation hypothesis', determining the impact of culling operations on badger populations, movement of surviving individuals and the influence on the epidemiology of bTB in badgers using data derived from two study areas within the UK Government's Randomised Badger Culling Trial (RBCT). Culling operations did not remove all individuals from setts, with between 34-43% of badgers removed from targeted social groups. After culling, bTB prevalence increased in badger social groups neighbouring removals, particularly amongst cubs. Seventy individual adult badgers were fitted with radio-collars, yielding 8,311 locational fixes from both sites between November 2001 and December 2003. Home range areas of animals surviving within removed groups increased by 43.5% in response to culling. Overlap between summer ranges of individuals from Neighbouring social groups in the treatment population increased by 73.3% in response to culling. The movement rate of individuals between social groups was low, but increased after culling, in Removed and Neighbouring social groups. Increased bTB prevalence in Neighbouring groups was associated with badger movements both into and out of these groups, although none of the moving individuals themselves tested positive for bTB. Significant increases in both the frequency of individual badger movements between groups and the emergence of bTB were observed in response to culling. However, no direct evidence was found to link the two phenomena. We hypothesise that the social disruption caused by culling may not only increase direct contact and thus disease transmission between surviving badgers, but may also increase social stress within the surviving population, causing immunosuppression and enhancing the expression of disease.
Farm-scale risk factors for bovine tuberculosis incidence in cattle herds during the Randomized Badger Culling Trial.

Source
Epidemiology and Infection; 2012. 140(2):219-230. 41 ref.

Publisher
Cambridge University Press

Location of Publisher
Cambridge

Country of Publication
UK

Abstract
We analysed the incidence of cattle herd breakdowns due to bovine tuberculosis (Mycobacterium bovis) in relation to experimental badger culling, badger populations and farm characteristics during the Randomized Badger Culling Trial (RBCT). Mixed modelling and event history analysis were used to examine the individual risk factors. The interdependencies of covariates were examined using structural equation modelling. There were consistent findings among the different analyses demonstrating that during a badger culling programme farms experiencing: reactive culling, larger herd sizes, larger holdings and holdings with multiple parcels of land were all at greater risk of a herd breakdown. Proactive culling reduced risks within the culling area, but we did not assess any potential effects in the periphery of the treatment area. Badger-related variables measured prior to the start of culling (number of social groups and length of badger territorial boundaries) did not consistently point to an increase in risk, when set against a background of ongoing badger culling. This could be because (1) the collected variables were not important to risk in cattle, or (2) there were insufficient data to demonstrate their importance. Our findings highlight the difficulty in identifying simple predictors of spatial variation in transmission risks from badger populations and the consequent challenge of tailoring management actions to any such field data.

Evaluating selective culling with vaccination to control wildlife disease: badgers and bovine tuberculosis (bTB).

Source

Publisher
Julius Kuhn Institut, Bundesforschungsinstitut fur Kulturpflanzen

Location of Publisher
Quedlinburg

Country of Publication
Germany

Abstract
Emerging infectious diseases often originate in wildlife, but the complex dynamics of wild animal populations mean that disease control is a major scientific and policy challenge. Culling and vaccination can be effective but the ecological characteristics of wild animals may confound the outcomes of simple management programs. In Britain, badgers Meles meles are a recognized reservoir of Mycobacterium bovis, the causative agent of bovine tuberculosis (bTB), and are involved in its transmission to cattle. Experiments have shown that culling badgers can increase bTB incidence in badgers and cattle, by perturbing the social structure of badger populations, and increasing contact rates. Selectively removal of infected badgers and vaccination of the remainder has recently been advocated as a potential solution. Simulation modelling suggests that this intuitively appealing policy could at best deliver only a minor advantage over thoroughly applying either vaccination or culling, but carries a risk of making the disease problem much worse. We suggest this counterintuitive outcome arises because: 1, not all animals can be
caught and tested 2, some genuinely infected animals will be test negative 3, selective culling leaves a larger population of susceptible hosts than non-selective culling 4, some susceptible hosts will not respond to vaccination and 5, perturbation increases contact and transmission rates among a relatively high density population of infectious and susceptible animals.
vaccination levels (100%, 50% and 0%) will be allocated to the three zones in a way that a gradient of vaccination coverage North to South is achieved. The middle zone (zone B) will be vaccinated at a 50% coverage but zone A and C will be randomly allocated with 100% or 0% vaccination coverage. Vaccination within zone B will be done randomly at individual badger level. The objective of this paper is to describe the design of a field tuberculosis vaccination trial for badgers, the epidemiological methods that were used to design the trial and the subsequent data analysis. The analysis will enable us to quantify the magnitude of the observed vaccination effect on M. bovis transmission in badgers under field conditions and to improve our knowledge of the biological effects of vaccination on susceptibility and infectiousness.
The causative agent of bovine tuberculosis (bTB; Mycobacterium bovis) has a broad host range. The role of each animal species in spreading the disease depends on how transmission occurs, on the abundance of each host, and on the interactions between hosts. This paper explores differences in the roles individual host species can play in allowing M. bovis infection to persist and spread within a multi-species complex, using New Zealand as a case study. In New Zealand, four wild mammal species are frequently infected. Of these the brushtail possum is now regarded as the only true “maintenance” host. Red deer and ferrets can become maintenance hosts where their densities are exceptionally high, but more often they are “spillover” hosts, with most infection arising from moderately frequent inter-species transmission from possums. The latter situation is even more strongly the case for feral pigs. Spillover hosts may occasionally play a crucial epidemiological role by transmitting infection back to a potential maintenance host (spillback). Three key factors make spillback transmission far more epidemiologically important than its low frequency of occurrence might suggest - amplification of the reservoir of bTB, far greater spatial spread than by the maintenance host, and greater persistence of bTB in long-lived spillover hosts extending the risk of spillback far into the future. The risk of spillback is undoubtedly low, but it nonetheless determines the nature, scale and duration of management required. Eradication of the disease may require management of both the infection in maintenance hosts and reduction or elimination of any risk of spillback.

Bacillus Calmette-Guerin vaccination reduces the severity and progression of tuberculosis in badgers.

Control of bovine tuberculosis (TB) in cattle has proven particularly challenging where reservoirs of infection exist in wildlife populations. In Britain and Ireland, control is hampered by a reservoir of infection in Eurasian badgers (Meles meles). Badger culling has positive and negative effects on bovine TB in cattle and is difficult, costly and controversial. Here we show that Bacillus Calmette-Guerin (BCG) vaccination of captive badgers reduced the progression, severity and excretion of Mycobacterium bovis infection after experimental challenge. In a clinical field study, BCG vaccination of free-living badgers reduced the incidence of positive serological test results by 73.8 per cent. In common with other species, BCG did not appear to prevent infection of badgers subjected to experimental challenge, but did significantly reduce the overall disease burden. BCG vaccination of
badgers could comprise an important component of a comprehensive programme of measures to control bovine TB in cattle.

<24>
Accession Number
20113146195
Author
Vial, F.; Johnston, W. T.; Donnelly, C. A.
Title
Local cattle and badger populations affect the risk of confirmed tuberculosis in British cattle herds.
Source
Publisher
Public Library of Sciences (PLoS)
Location of Publisher
San Francisco
Country of Publication
USA
Abstract
Background: The control of bovine tuberculosis (bTB) remains a priority on the public health agenda in Great Britain, after launching in 1998 the Randomised Badger Culling Trial (RBCT) to evaluate the effectiveness of badger (Meles meles) culling as a control strategy. Our study complements previous analyses of the RBCT data (focusing on treatment effects) by presenting analyses of herd-level risks factors associated with the probability of a confirmed bTB breakdown in herds within each treatment: repeated widespread proactive culling, localized reactive culling and no culling (survey-only). Methodology/Principal Findings: New cases of bTB breakdowns were monitored inside the RBCT areas from the end of the first proactive badger cull to one year after the last proactive cull. The risk of a herd bTB breakdown was modeled using logistic regression and proportional hazard models adjusting for local farm-level risk factors. Inside survey-only and reactive areas, increased numbers of active badger setts and cattle herds within 1500 m of a farm were associated with an increased bTB risk. Inside proactive areas, the number of M. bovis positive badgers initially culled within 1500 m of a farm was the strongest predictor of the risk of a confirmed bTB breakdown. Conclusions/Significance: The use of herd-based models provide insights into how local cattle and badger populations affect the bTB breakdown risks of individual cattle herds in the absence of and in the presence of badger culling. These measures of local bTB risks could be integrated into a risk-based herd testing programme to improve the targeting of interventions aimed at reducing the risks of bTB transmission.

<25>
Accession Number
20113055652
Author
Corner, L. A. L.; Murphy, D.; Gormley, E.
Title
Mycobacterium bovis infection in the eurasian badger (Meles meles): the disease, pathogenesis, epidemiology and control.
Source
Publisher
Elsevier Ltd
Location of Publisher
Oxford
Country of Publication
UK
Abstract
Eurasian badgers (Meles meles) are an important wildlife reservoir of tuberculosis (Mycobacterium bovis) infection in Ireland and the United Kingdom. As part of national programmes to control tuberculosis in livestock, considerable effort has been devoted to studying the disease in badgers and this has lead to a rapid increase in our knowledge of tuberculosis in this host. Tuberculosis in badgers is a chronic infection and in a naturally-infected population the severity of disease can vary widely, from latent infection (infection without clinical signs and no visible lesions) to severe disease with generalized pathology. The high prevalence of pulmonary infection strongly supports the lungs as the principal site of primary infection and that inhalation of infectious aerosol particles is the principal mode of transmission. However, other routes, including transmission via infected bite wounds, are known to occur. The ante-mortem diagnosis of infection is difficult to achieve, as clinical examination and immunological and bacteriological examination of clinical samples are insensitive diagnostic procedures. Because infection in the majority of badgers is latent, the gross post-mortem diagnosis is also insensitive. A definitive diagnosis can only be made by the isolation of M. bovis. However, to gain a high level of sensitivity in the bacteriological examination, a large number of tissues from each badger must be cultured and sensitive culture methods employed. The transmission and maintenance of M. bovis in badger populations are complex processes where many factors influence within-population prevalence and rates of transmission. Badger social structures and the longevity of infected animals make them an ideal maintenance host for M. bovis infection. Badgers are directly implicated in the transmission of infection to cattle and the inability to eradicate the disease from cattle is, in part, a consequence of the interactions between the two species. A detailed understanding and knowledge of the epidemiology and pathogenesis of the disease are recognized as fundamental for devising new strategies to control infection with a view to limiting interspecies transmission. Vaccination, in spite of formidable challenges, is seen as the best long-term strategy option and studies with captive badgers have shown that vaccination with M. bovis bacillus Calmette-Guerin (BCG) induces protection when delivered by a variety of routes. Continued research is required to develop effective technologies to control the disease both in badgers and cattle. A combination of strategies, which employ the optimal use and targeting of resources, is likely to make a significant contribution towards eradication of the disease.

Accession Number
20103287263
Author
Title
Oral vaccination of badgers (Meles meles) with BCG and protective immunity against endobronchial challenge with Mycobacterium bovis.
Source
Vaccine; 2010. 28(38):6265-6272. 42 ref.
Publisher
Elsevier Ltd
Location of Publisher
Oxford
Country of Publication
UK
Abstract
Eurasian badgers (Meles meles) are a reservoir host of Mycobacterium bovis and are implicated in the transmission of tuberculosis to cattle in Ireland and Great Britain. The development of a vaccine for use in badgers is considered a key element of any long-term sustainable campaign to eradicate the disease from livestock in both countries. The aim of this study was to investigate the protective response of badgers vaccinated orally with Bacille Calmette-Guerin (BCG) encapsulated in a lipid formulation, followed by experimental challenge with M. bovis. A group of badgers was vaccinated by inoculating the BCG-lipid mixture containing approximately 10^8 colony forming units (cfu) of BCG into the oesophagus. The control group was sham inoculated with the lipid formulation only. Thirteen weeks after vaccination all
the badgers were challenged with approximately $10^4$ cfu of M. bovis delivered by endobronchial inoculation. Blood samples were taken throughout the study and the cell mediated immune (CMI) responses in peripheral blood were monitored by the IFN-\gamma ELISA and ELISPOT assay. At 17 weeks after infection all the badgers were examined post-mortem to assess the pathological and bacteriological responses to challenge. All badgers in both groups were found to be infected. However, a significant protective effect of BCG vaccination was measured as a decrease in the number and severity of gross lesions, lower bacterial load in the lungs, and fewer sites of infection. The analysis of immune responses showed that vaccination with BCG did not generate any detectable CMI immunological responses, however the levels of the responses increased in both groups following M. bovis infection. The results of the study showed that vaccination with oral BCG in the lipid formulation generated a protective effect in the badgers.

Accession Number
20103150012
Author
Blowey, R.
Title
TB in cattle.
Source
Publisher
UK Vet Publications
Location of Publisher
Newbury
Country of Publication
UK
Abstract
The history of bovine tuberculosis and its control in the UK are described, including the role of badgers (Meles meles) in disease transmission.

Accession Number
20103076319
Author
Ward, A. I.; Judge, J.; Delahay, R. J.
Title
Farm husbandry and badger behaviour: opportunities to manage badger to cattle transmission of Mycobacterium bovis?
Source
Preventive Veterinary Medicine; 2010. 93(1):2-10. many ref.
Publisher
Elsevier B.V.
Location of Publisher
Amsterdam
Country of Publication
The Netherlands
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.