Bovine Tuberculosis

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http://www.efsa.europa.eu/en/scdocs/doc/12e.pdf

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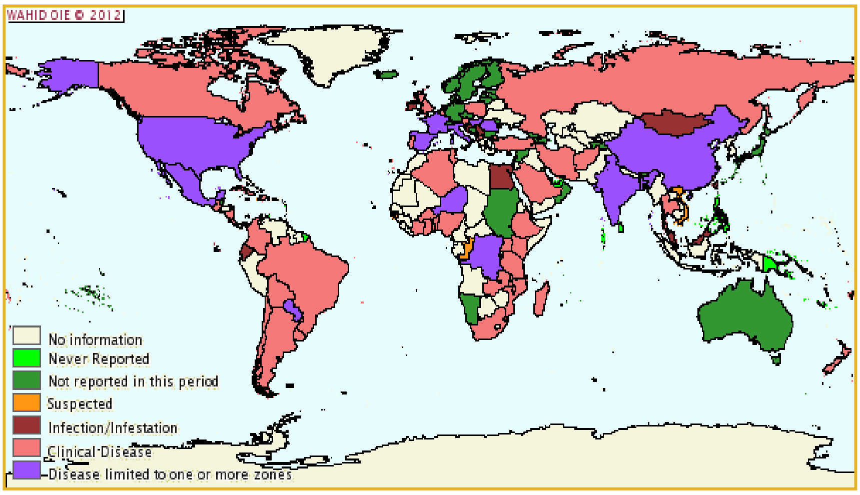
Geographic Distribution of *M. bovis* infection in cattle



This map, from the World Organization for Animal Health (OIE) shows the distribution of bovine TB from January to June 2011. Red indicates a current disease event, purple indicates disease limited to one or more zones, dark green indicates disease not reported in this period, and light green indicates disease never reported.

Species Affected by TB

- Eradication programmes based on the test-and-slaughter policy in the EU have proved successful in some countries but have failed to eradicate disease in other member states due, at least in part, to the presence of reservoirs of bTB in wildlife.
- Maintenance hosts world-wide
  - Cattle
  - Badgers
  - Wild boar, Red deer
  - Opossums
  - Bison, elk
  - Kudu, African buffalo
  - White-tailed deer

- Spillover hosts
  - Ferrets, deer, sheep, goats, horses, pigs, dogs, cats, rhinos, lions, foxes, seals, sea lions, rabbits, lynx, humans and others

Cattle are the primary hosts for *M. bovis*, but other domesticated and wild mammals can also be infected. Known maintenance hosts include brush–tailed opossums (and possibly ferrets) in New Zealand, badgers in the United Kingdom and Ireland, bison and elk in Canada, and kudu and African buffalo in southern Africa. White-tailed deer in the United States (Michigan) have been classified as maintenance hosts; however, some authors now believe this species may be a spillover host that maintains the organism only when its population density is high. Species reported to be spillover hosts include sheep, goats, horses, pigs, dogs, cats, ferrets, camels, llamas, many species of wild ruminants including deer and elk; elephants, rhinoceroses, foxes, coyotes, mink, primates, opossums, otters, seals, sea lions, hares, raccoons, bears, warthogs, large cats (including lions, tigers, leopards, cheetahs and lynx) and several species of rodents. Most mammals may be susceptible.

[Photo: White-tailed deer. U.S. Fish and Wildlife Service National Digital Library]

Major wildlife Reservoirs in EU

- Historically TB spilled over from cattle to wildlife
- TB in EU wildlife was first described in 1960s and 1970s
- Eurasian badger (*Meles meles*) main reservoir host in UK and ROI
- Wild boar (*Sus scrofa*), deer species (*Cervinae*) especially fallow and red deer are the main reservoir hosts on mainland Europe (and Badgers?)

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Wildlife disease control options

- Population reduction – culling or fertility control
- Vaccination
- Reduce contact – ‘Biosecurity’

- These options are not mutually exclusive and could be combined.
- Need to understand the local epidemiological and ecological situation to target the **right tools, at the right place at the right time.**

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The last two are only likely to be cost effective where the objective is to protect highly endangered species.

Culling the host

Reductions in density = reductions in transmission

- Density-dependent?
- Persistence thresholds?

- Relationship between host population size and pathogen transmission is not simple e.g. culling may promote increased dispersal of surviving animals, and increased immigration into the culled area thus increasing contact rates between animals.

- Confounded by
  - population structure
  - demographic responses
  - behavioural responses
  - protected species

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Indirect effects of interventions

- Wild host populations do not live in isolation
- Complex inter-dependencies with other species
- You cannot change just one component
- Cascade of consequences
- Potential to change ecology at the landscape scale
- Difficult to predict outcomes

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Culling Badgers

- Large field experiments in the UK and the RoI demonstrated that widespread, proactive badger culling reduced the incidence of bTB in cattle within culled areas.
- However, in the UK, the same experimental work also identified increases in bTB incidence in immediately adjacent unculled areas, which then diminished with time after culling ceased.
- This was not observed in ROI.
- Localized reactive culling in response to recent cattle bTB outbreaks was also associated with increased incidence of bTB in cattle, although this finding is the subject of ongoing scientific debate.

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Vaccinating Badgers

- BCG is currently only vaccine (only partial protection provided)
- Oral vaccine - licensed vaccine at least 4-5 years away
- Results of field trial based on oral delivery of BCG in ROI expected soon.
- Injectable badger vaccine:
  - Licensed & available for use
  - Need to vaccinate every year for 4-5 years
- Does not eliminate infection from infected badgers
- Has not been demonstrated to have effects on cattle TB breakdowns (although would be expected to).

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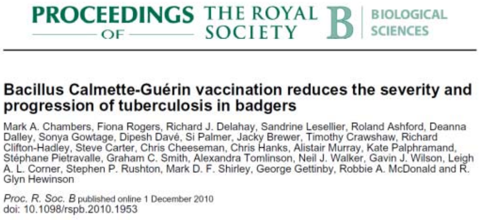
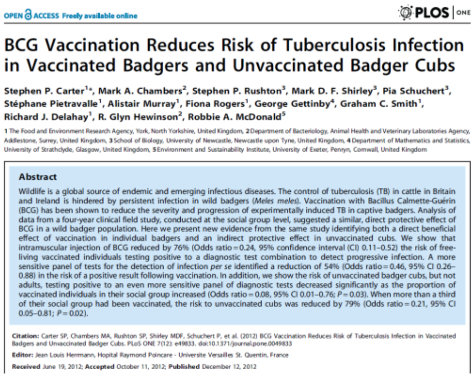


PROCEEDINGS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

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

Mark A. Chambers, Fiona Rogers, Richard J. Delahay, Sandrine Lesellier, Roland Ashford, Deanna Dalley, Sonya Gowtage, Dipesh Davé, Si Palmer, Jacky Brewer, Timothy Crawshaw, Richard Clifton-Hadley, Steve Carter, Chris Cheeseman, Chris Hanks, Alistair Murray, Kate Palphramand, Stéphane Pietravalle, Graham C. Smith, Alexandra Tomlinson, Neil J. Walker, Gavin J. Wilson, Leigh A. L. Corner, Stephen P. Rushton, Mark D. F. Shirley, George Gettinby, Robbie A. McDonald and R. Glyn Hewinson

Proc. R. Soc. B published online 1 December 2010
doi: 10.1098/rspb.2010.1953



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BCG Vaccination Reduces Risk of Tuberculosis Infection in Vaccinated Badgers and Unvaccinated Badger Cubs

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Abstract

Wildlife is a global source of endemic and emerging infectious diseases. The control of tuberculosis (TB) in cattle in Britain and Ireland is hindered by persistent infection in wild badgers (*Meles meles*). Vaccination with Bacillus Calmette-Guérin (BCG) has been shown to reduce the severity and progression of experimentally induced TB in captive badgers. Analysis of data from a four-year clinical field study, conducted at the social group level, suggested a similar, direct protective effect of BCG in a wild badger population. Here we present new evidence from the same study identifying both a direct beneficial effect of vaccination in individual badgers and an indirect protective effect in unvaccinated cubs. We show that intramuscular injection of BCG reduced by 76% (Odds ratio = 0.24, 95% confidence interval (CI) 0.11–0.52) the risk of free-living vaccinated individuals testing positive to a diagnostic test combination to detect progressive infection. A more sensitive panel of tests for the detection of infection *per se* identified a reduction of 54% (Odds ratio = 0.46, 95% CI 0.26–0.88) in the risk of a positive result following vaccination. In addition, we show the risk of unvaccinated badger cubs, but not adults, testing positive to an even more sensitive panel of diagnostic tests decreased significantly as the proportion of vaccinated individuals in their social group increased (Odds ratio = 0.08, 95% CI 0.01–0.76; $P = 0.03$). When more than a third of their social group had been vaccinated, the risk to unvaccinated cubs was reduced by 79% (Odds ratio = 0.21, 95% CI 0.05–0.81; $P = 0.02$).

Citation: Carter SP, Chambers MA, Rushton SP, Shirley MDF, Schuchert P, et al. (2012) BCG Vaccination Reduces Risk of Tuberculosis Infection in Vaccinated Badgers and Unvaccinated Badger Cubs. PLoS ONE 7(12): e49833. doi:10.1371/journal.pone.0049833

Editor: Jean Louis Hermann, Hopital Raymond Poincare - Universite Versailles St. Quentin, France

Received June 19, 2012; **Accepted** October 11, 2012; **Published** December 12, 2012

- Badgers were not killed for post-mortem confirmation of TB; relied on three 'live' tests
- 2010: Significant reduction (of 74%) in new incidence of antibody positive results at social group level as a result of vaccination
  - Consistent with protective effect of vaccination, as antibody production positively correlated with extent & severity of TB in badgers
- 2012: Further analysis of study data identifies a direct beneficial effect of vaccination in individual badgers and an indirect protective effect in unvaccinated cubs ('herd effect')
  - 54% reduction (Odds ratio = 0.46) in incidence of a 'triple test' result
  - Risk of unvaccinated badger cubs testing positive to TB decreased significantly as the proportion of vaccinated individuals in their social group increased (Odds ratio = 0.08)
  - When more than a third of their social group had been vaccinated, the risk to unvaccinated cubs was reduced by 79% (Odds ratio = 0.21)
- But, blood tests are not an absolute indicator of protection from disease so the results cannot tell us the degree of vaccine efficacy

Wildlife biosecurity for disease control

- Restrict direct contact with cattle.
    - Mixing at pasture
    - Housed animals
- Protect cattle feed and water sources from contamination.
    - Protect stores
    - Control provision of outdoor feed
    - Watering holes
- Integrate game management with disease control objectives for cattle?

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Southern Europe

- Wild boar and cattle share the same strain of bovine TB.
- Red deer involved in Spain.
- Game management practices implicated.
- Spill-over to Iberian lynx in Spain.
- Vaccine baits under development for wild boar.
- Recent research indicates some disease benefits of culling boar.

In both Italy and Spain infection has been detected in Wild boar, and appears to persist in the absence of sources of re-infection, suggesting that they can maintain the infection.

In both countries boar and cattle share the same strain of bovine TB suggesting that transmission may occur between the two.

In Spain red deer are also involved and the management of estates where deer and boar are at very high densities appears to be a significant risk factor.

Clinical TB was identified in an Iberian lynx from Donana National Park in Spain. In a subsequent survey of 68 lynx in the Park, 3 tested positive for *M. bovis* antibodies. Interestingly, about 19% of badgers examined were also positive.

Infection in Iberian lynx (and particularly the possibility of clinical cases) is a serious concern because these carnivores are endangered and only exist in small fragmented populations.

Recent research showed that culling wild boar resulted in reductions in *M. bovis* prevalence in boar of 21-48% in treatment sites, and in one instance a reduction in prevalence was also observed in local red deer.

Need to weigh up costs and benefits of management interventions

- Cost of living with disease
- Cost of intervention
- Benefit of reduced disease

} Cost-benefit analysis

- Welfare costs - ethics

- Cryptic costs – changes in host and pathogen abundance or distribution
    - ecological change
    - epidemiological consequences

} Often externalised

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Conclusions

- Interventions can invoke complex ecological processes (direct & indirect)
- Epidemiological consequences
- Need to develop tools to provide more effective interventions – e.g. biosecurity, culling, fertility control, vaccination
- Need better evidence base to guide use of interventions (‘Right tool, right place, right time’)
- Need to develop (adapt) tools to assess impacts of interventions

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