Annex E

Veterinary assessment of the risk factors associated with proactive badger culling

Executive summary

1. The Coalition Government has committed, as part of a package of measures, to develop affordable options for a carefully-managed and science-led policy of badger control in areas with high and persistent levels of bovine TB.
2. Results from the Randomised Badger Culling Trial show that, with large scale activity, culling can reduce the incidence of TB in cattle. However, the results also show that incidence can increase under certain conditions, and the Independent Scientific Group on Cattle TB hypothesise and present evidence to show that this is the result of perturbation.
3. Therefore, for badger culling to decrease the incidence of TB in cattle, a culling strategy must take into account factors that will mitigate perturbation. A culling strategy should be
    a. **Sustained** (at least annual), undertaken on a regular basis over a period of at least 4 years in order to achieve low local badger populations in high TB incidence areas;
    b. **Over a large area** (the evidence suggests a minimum area of 150 km^2);
    c. Conducted where land access is **over 70 %** of the area;
    d. **Effective and humane** and conducted by competent operators; and
    e. Where possible, conducted in areas with **boundaries or buffers** (such as motorways, conurbations, coast, and substantial rivers) around the culled area to mitigate any risks from the perturbation effect.
4. The licensed BadgerBCG vaccine could also be used as a tool to mitigate the negative effects of perturbation. This is likely to be beneficial but not fully protective against the negative effects of perturbation. Immunity takes time to develop and so vaccination would need to precede culling. There is limited evidence about the impact of vaccination in field conditions.
5. If a different culling strategy to that conducted in the RBCT is used, the effect on TB incidence and the degree of the resulting perturbation is uncertain.
6. It is essential that any culling is carried out using methods that are both effective[1] and humane.
7. Training in capture and culling techniques will be needed to ensure that the operators are competent and that culling is as effective as possible, in order

[1] In the Defra report entitled *Review of effectiveness, environmental impact, humaneness and feasibility of lethal methods for badger control*, effectiveness is defined as the proportion of the target population that could reasonably be culled and efficiency is the likely number of animals culled for a given unit of effort.

to minimise perturbation. Education will also help to ensure understanding of the risks of inefficient culling and ensure adherence to welfare requirements.

8. Badger carcases should be removed in adherence to legal requirements for animal by-products.

Introduction and background

9. TB is a chronic, slowly developing disease caused by the bacterium *Mycobacterium bovis* (*M. bovis*). It is a "slow moving" disease. One infected animal is thought to infect one other as the reproductive ratio, or "R_0" number, has been estimated to be close to 1 for cattle (Cox and others 2005) and an early estimate for badgers was similar (Anderson and Trewhella 1985). R_0 is an estimate of the number of animals one infected animal will, in turn, infect.

10. Therefore, it is possible to hypothesise that the cumulative effect of several intervention approaches that result in changes to transmission risk, such as through a package of measures, should have significant effects over time, bringing the R_0 number below 1, indicative of a reducing disease trend.

11. One part of a package of measures that could help achieve this state is badger culling. The aims of any culling activity are:

    a. To reduce the (infected) animal population so as to reduce the weight of infection; and

    b. To reduce the contact rate between susceptible animals (between badgers and between badgers and cattle reducing both direct and indirect transmission, see **figure 1**).

12. The specific veterinary disease risk with culling is an increase in, or failure to reduce, the level of TB in cattle as a result of a badger culling policy.

13. Key issue: The risk that culling fails to reduce the level of TB arises from the perturbation of badgers as a result of culling. **Therefore minimising perturbation, and/or its negative consequences, is central to risk management.**

14. Perturbation is the "*substantial disruption to the social organisation and behaviour patterns of individuals in a population*" (Carter and others 2007).

15. The Independent Scientific Group on Cattle TB (ISG) reported a rise in TB prevalence in badgers during the Randomised Badger Culling Trial (RBCT) and concluded this was due to culling-induced perturbation (Bourne and others 2007). They found that as the number of badgers went down, their range of movements increased and that the prevalence of TB in badgers culled in later operations rose. The ISG hypothesized that this perturbation increased badger and cattle contact and so led to an increase in TB incidence in the reactive cull areas and up to 2 km outside the proactively culled areas. There was controversy over the ISG conclusions; for instance the analysis of reactive cull did not allow sufficient time for the transmission

of TB after perturbation to occur (Godfray and others 2004; More and others 2007).

16. Both uninfected and infected badgers could be perturbed and both groups could increase the prevalence of TB in the badger population through increased badger to badger contact.

17. Perturbation reduces the chances of culling of fulfilling the aims listed above (paragraph 11) and therefore, for any culling operation to be successful, it must be conducted in a way that mitigates the negative consequences of perturbation (the so-called “perturbation effect”).

Transmission pathway

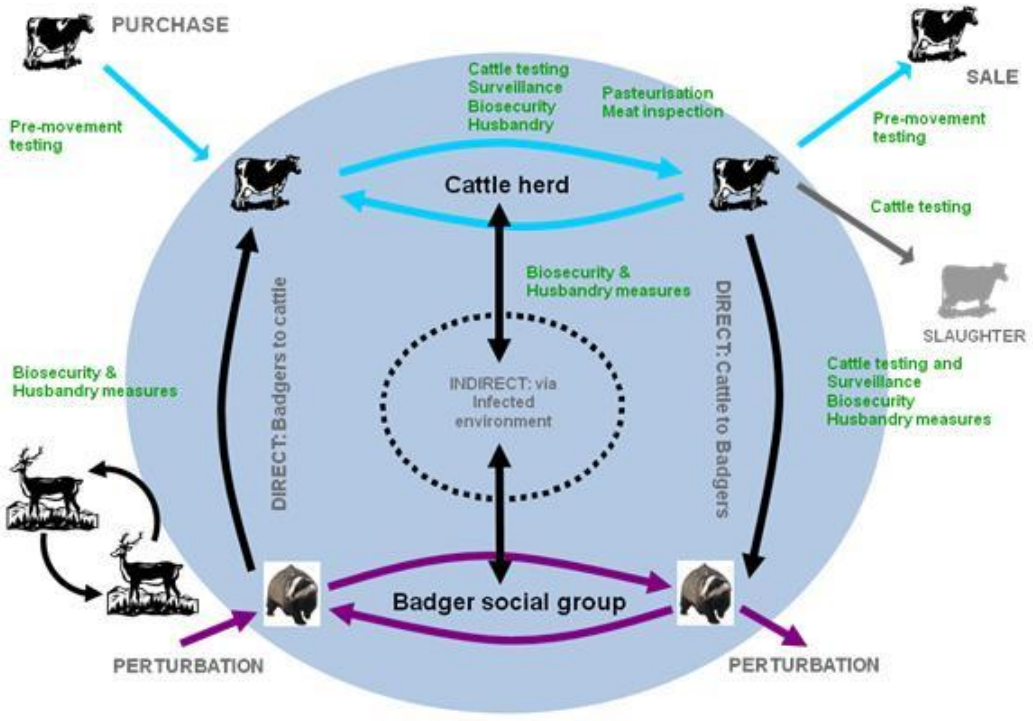

Figure 1: Routes of *M. bovis* transmission and current controls

TB transmission occurs between badgers, between cattle and between the two species. In some rare circumstances, deer populations might also be able to maintain TB infection and therefore spread it to other animals, but it is unlikely that this plays a significant role in the epidemiology of the disease in England.

The veterinary assessment

18. This assessment will look at the factors associated with a proactive cull of badgers (repeated culling across all accessible land) that could prevent a cull achieving the aims outlined above (paragraph 11). It will then discuss how these factors could be managed or mitigated.

19. The veterinary concerns are two-fold:

a. As a result of a proactive culling approach, *M. bovis* incidence in cattle fails to decrease, or even increases; and

b. That the welfare of culled badgers (and non-target species) is at risk through the culling approach adopted.

20. Externalities relating to spill-over infection risks to non-bovine species and human health aspects will not be considered here.

Summary of risk factors

21. Key issue: The major factor that could prevent badger culling decreasing TB incidence in cattle is **perturbation**.

22. Little is known about how the level of perturbation changes with the extent of culling. However, it is likely that the degree of perturbation will be affected by the effectiveness and the efficacy of the field culling operation (i.e. the proportion of the badger population that can be culled in a given timeframe). This in turn will be dependent on a number of variables including

    a. The size of the area for culling

    b. The inclusion of badger-impenetrable or limiting boundaries

    c. The frequency of the culling operation

    d. The duration of the culling operation

    e. The proportion of land area included in any culling operations

    f. The type of cull operation (e.g. reactive versus proactive cull)

    g. The level of farmer co-operation

    h. The level of co-operation between neighbouring farms

    i. Potential interference by animal rights activists.

23. The risk of TB transmission (badger to badger and/or badger to cattle) will be affected by

    a. The disposal methods used for the carcases

    b. The ability of the *M. bovis* organism to persist within a sett, even when badgers are no longer present.

24. Welfare risks will be affected by

    a. An inhumane killing technique

    b. Poor implementation of a humane technique

    c. Not adhering to the closed season (the badger breeding season during which culling is not permitted)

    d. Trapping under adverse weather conditions

    e. Capture of non-target species.

25. In addition, badgers regulate their own population size through specialised reproductive physiology and behaviour (they exhibit delayed embryo implantation and infanticide by the alpha sow). Disrupting the social group through culling will also disrupt this normal population regulation, and will work against the population decline created by culling.

26. The role of culled badgers in the transmission of TB in an area will affect the ability of culling to decrease disease in cattle: if the removed badger population is not playing a significant role in disease in cattle, culling will not decrease the incidence of TB in cattle.

Summary of management options

27. Key issue: The majority of the management options discussed mitigate the risks from perturbation but are **unlikely to eliminate the risk completely**.

28. The effectiveness of a cull can be improved by only allowing culling over a large enough land area; ensuring repeat culling over a minimum time period (Sir David King recommended at least 4 years); and monitoring the number of animals removed. Educating operators in the risks associated with an inefficient cull will be essential.

29. The risk of a poorly coordinated cull can be mitigated by designing a policy to cover a large enough area with sufficient land access (e.g. 70 % uptake as seen in the RBCT). Vaccination could be used where farmers and land owners are unwilling to cull, although this will need to be planned carefully as it takes time for immunity to develop. Vaccination could be beneficial but not fully protective against the negative effects of perturbation. Immunity takes time to develop and so vaccination would need to precede culling. There is limited evidence about the impact of vaccination in field conditions (see **Annex D**).

30. To limit re-colonisation by badgers from outside the culled area, boundaries and buffers to badger movements should be utilised where possible. Ring vaccination could also be used to limit the risks from re-colonising badgers but, as above, protection from the perturbation effect would not be complete.

31. It is essential that any culling method used is humane. A closed season should be in place to protect dependent cubs below ground. There should be consideration of vaccination, rather than trapping, at the edges of inaccessible land as the ISG concluded this policy was the most risky for leaving dependent cubs (Bourne and others 2007). Injuries and their incidence should be monitored and audited, particularly with free-shooting where less evidence exists. Protocols should be in place in the event of the capture of non-target species.

32. Badger carcases removed in a culling strategy are likely to be infected with *M. bovis* and any removal would need to comply with the legal requirements for animal by-products.

Summary of uncertainties

33. Key issue: The main uncertainty is the **significance and extent of perturbation, and/or its consequences, resulting from a different culling regime than that used in the RBCT**.

34. This includes uncertainty resulting from a cull that is industry-led, rather than governed as in the RBCT.

35. The size of the badger population in TB-endemic areas and the prevalence of TB in these badgers are uncertain. There have been no recent studies to look at these factors (see **Annex D**).

Summary of assumptions

36. In line with the Government's commitment (paragraph 1), culling will only be in areas of high and persistent TB incidence in cattle.

37. Only proactive culling is considered here. We do not have sufficient evidence that a reactive or selective cull would reduce TB incidence. On the contrary, preliminary results from the RBCT suggested that reactive culling made matters worse, although there is controversy over these results.

38. In the short term, available culling methods are limited to cage trapping and shooting and free-shooting.

Conclusions and recommendations

39. For culling to decrease the incidence of TB in cattle, a culling strategy must take into account factors that will mitigate perturbation. A culling strategy should be

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40. The licensed BadgerBCG vaccine could also be used as a tool to mitigate the negative effects of perturbation. This is likely to be beneficial but not fully protective against the negative effects of perturbation. Immunity takes time to develop and so vaccination would need to precede culling. There is limited evidence about the impact of vaccination in field conditions.

41. Training in capture and culling techniques will be needed to ensure that the operators are competent and that culling is as effective as possible, in order

to minimise perturbation. Education will also help to ensure understanding of the risks of inefficient culling and ensure adherence to welfare requirements.

42. Badger carcases should be removed in adherence to legal requirements for animal by-products.

Defra veterinary advice
endorsed by the
Chief Veterinary Officer

References

ANDERSON, R. M. & TREWHELLA, W. (1985) Population Dynamics of the Badger (Meles meles) and the Epidemiology of Bovine Tuberculosis (Mycobacterium bovis). Philosophical Transactions of the Royal Society of London. B, Biological Sciences 310, 327-381

BOURNE, F. J., DONNELLY, C. A., COX, D. R., GETTINBY, G., MCINERNEY, J. P., MORRISON, I. & WOODROFFE, R. (2007) Bovine TB: The Scientific Evidence. Ed DEFRA. London

CARTER, S. P., DELAHAY, R. J., SMITH, G. C., MACDONALD, D. W., RIORDAN, P., ETHERINGTON, T. R., PIMLEY, E. R., WALKER, N. J. & CHEESEMAN, C. L. (2007) Culling-induced social perturbation in Eurasian badgers Meles meles and the management of TB in cattle: an analysis of a critical problem in applied ecology. Proc Biol Sci 274, 2769-2777

COX, D. R., DONNELLY, C. A., BOURNE, F. J., GETTINBY, G., MCINERNEY, J. P., MORRISON, W. I. & WOODROFFE, R. (2005) Simple model for tuberculosis in cattle and badgers. Proc Natl Acad Sci U S A 102, 17588-17593

GODFRAY, H. C. J., CURNOW, R. N., DYE, C., PFEIFFER, D., SUTHERLAND, W. J. & WOOLHOUSE, M. E. J. (2004) Independent Scientific Review of the Randomised Badger Culling Trial and Associated Epidemiological Research Ed DEFRA. London

MORE, S. J., CLEGG, T. A., MCGRATH, G., COLLINS, J. D., CORNER, L. A. & GORMLEY, E. (2007) Does reactive badger culling lead to an increase in tuberculosis in cattle? Vet Rec 161, 208-209