

Cattle testing and biosecurity is cheaper than badger culling for bovine TB, says Lord Krebs

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A badger cull to control bovine TB would involve the extermination of at least 170,000 badgers: well over half the UK population, Lord Krebs has warned.

But in an important Opinion feature in Science in Parliament[1], he says that "improved [cattle] testing and incentives to keep badgers away from cattle would cost less and be at least as likely to work".

Lord Krebs produced the report[2] which led to ten years of badger culling trials that ended in 2007. The Independent Scientific Group (ISG) which delivered the trials concluded in June 2007 that badger culling could make "no meaningful contribution" to bovine TB control in Great Britain[3].

But in October 2007, the then chief scientific advisor to the Government, Professor David King, claimed that badger culling could be effective[4]. But Professor King failed to consider the practicalities and costs of badger culling and Lord Krebs, in his latest article, notes that Professor King's group was "smaller ... with less expertise, meeting for a day".

The Badger Trust has also today released a set of minutes obtained under the Freedom of Information Act, agreed by Professor David King and the ISG. In the minutes, Professor King acknowledges the massive logistical hurdles that need to be overcome if badger culling is to make any contribution to bovine TB control[5].

Professor King "confirmed that badger culling would have to be undertaken competently and sustained for a minimum period of four years over a land area of at least 265km² ... Sir David confirmed that conducting badger culls simultaneously over such an area would have to be an essential element of any culling programme ... All present agreed ... that culling conducted over short time periods or in an uncoordinated manner would be very likely to cause detrimental effects".

The latest analysis of the badger culling trial data shows that annual culling would only prevent 12 out of an expected 130 TB outbreaks across 125km² over six years[6].

Trevor Lawson, for the Badger Trust, commented: "Professor King's hasty report was an uncostered and impractical policy proposal. Now, Lord Krebs has effectively devalued it further, pointing out the lesser expertise of Professor King's group and setting ten years' worth of research against a meeting that lasted for just a day.

"Hilary Benn, Secretary of State for the Environment, should reject Professor King's wholly inadequate contribution to this important debate and accept the ISG's advice that badger culling can make no meaningful contribution to bovine TB control. Bovine TB is primarily spread by cattle both to each other and to wildlife. Resources can be focused on cattle and biosecurity far more efficiently and we welcome the fact that this has been recognised by Lord Krebs."

ENDS.

For further comment, contact Trevor Lawson, Badger Trust spokesman, on 07976 262388.

1. Krebs, J. (2008), Opinion, Science in Parliament Vol 65, No 2, 2008
2. Krebs, J. et al, Bovine tuberculosis in cattle and badgers, MAFF, 1997.
3. Bourne, F.J., et al., Bovine TB: The Scientific Evidence. Independent Scientific Group Reports, 2007. Final Report.
4. King, D., Bovine tuberculosis in cattle and badgers. A report by the chief scientific adviser, 2007.
5. [See below]: GofS (2007), Note of a meeting to discuss badgers and bovine TB in cattle, Thursday 13 December 2007, Government Office For Science.
6. Jenkins HE, et al., The effects of annual widespread badger culls on cattle tuberculosis following the cessation of culling, Int J Infect Dis (2008), doi:10.1016/j.ijid. 2008.04.001

NOTE OF A MEETING TO DISCUSS BADGERS AND BOVINE TB IN CATTLE, THURSDAY 13 DECEMBER 2007, GOVERNMENT OFFICE FOR SCIENCE

Present:

Sir David King, Government Chief Scientific Adviser
Professor Tim Roper, University of Sussex
Professor Mark Woolhouse, University of Edinburgh
Professor Robert Watson, Chief Scientific Adviser to Defra
Fiona Stuart, Bovine TB Programme, Defra
Sue Bolton, GO – Science
Vicki Webster, GO – Science
Professor John Bourne, Former Chairman, Independent Scientific Group on Cattle TB (ISG)
Professor Christl Donnelly, Former ISG Deputy Chairman
Dr Rosie Woodroffe, Former ISG Member
Mike Summerskill, Former ISG Secretary

1. Introduction

Sir David King welcomed those present and congratulated the ISG on the scientific evidence base they had presented to Government during the period of their work, in their published papers and in particular in their final report to Ministers in June 2007 (Bourne *et al.*, 2007a).

Sir David explained that Defra Ministers had asked him to assess the scientific evidence on badger culling, which in essence was a challenge function designed to help Ministers understand the science. He had submitted his report in July 2007 (King *et al.*, 2007). [SDK looked at the ISG work and other relevant evidence.]

Sir David said that he had seen the notes submitted to the Environment, Food and Rural Affairs Select Committee by the ISG (Bourne *et al.*, 2007b) and Prof. Denis Mollison, Statistical Auditor to the Randomised Badger Culling Trial (RBCT) (Mollison, 2007) following the evidence session of 24 October 2007 (EFRAC, 2007).

Sir David confirmed that there were significant areas of agreement between his group and the ISG in relation to the science presented by the ISG, and agreed that he had no criticism of the science. However, he added that there were areas of disagreement in interpretation, which he would like to explore further during the meeting.

2. Areas of common ground

Sir David said he believed there were three areas where he and the ISG were in agreement – remit, culling requirements and ecological effects.

Remit

Sir David said his remit and that of the ISG differed because he was asked to focus on the scientific evidence and was not asked to consider cost and practicality issues. He noted that the ISG recognised that this partially explained the differences between the two conclusions. Prof Bourne and Dr Woodroffe argued that the practicality and costs of badger culling constrain the possibilities for conducting culls in large areas (i.e. areas exceeding 100km²) and through farmer licensing and are therefore key issues that should not be disregarded, since they are extremely important to determine whether the outcome of any culling strategy would be beneficial or detrimental. Sir David King agreed but noted that the ISG report looked at the costs and practicalities of badger culling but not of cattle culling. Prof. Bourne agreed because this was beyond the remit of the Group and Defra had been advised to conduct such an analysis. Sir David concluded that the cost and practicality of cattle controls were important issues to consider.

Culling requirements

Sir David said he agreed with the ISG's conclusions regarding the requirements for badger culling to bring about a beneficial effect. He confirmed that badger culling would have to be undertaken competently and sustained for a minimum period of four years over a land area of at least 265km². Sir David said these conditions would enable Ministers to be 95% confident of an overall beneficial effect arising from a badger cull.

In response to a question from Dr Woodroffe, Sir David confirmed that conducting badger culls simultaneously over such an area would have to be an essential element of any culling programme that was deemed to have been undertaken competently. Prof. Bourne reminded those present that the potential beneficial effects of badger culling over an area exceeding 100km² was based on extrapolation of results derived from the RBCT, and that such benefits have not been estimated directly.

Ecological effects

Sir David noted the ISG's previously stated opinion that he had not given complete consideration to the ecological effects of a badger cull but argued that this was not the case, and so, to clarify, he confirmed he agreed with the ISG on ecological effects. He confirmed that he accepted that badger culling will:

- cause immigration of badgers into the culled area and the periphery;
- disturb badger populations in culled areas;
- disrupt badger social groups in culled areas;
- cause some badgers to expand their ranging behaviour;
- reduce spatial clustering of bovine TB infection in badgers;
- elevate bovine TB infection prevalence in the reduced badger population in culled areas.

Dr Woodroffe agreed that this list covered most, though not all, of the key points; she asked those present to note also that in the RBCT it was observed that badger culling reduced spatial clustering of bovine TB infection in cattle in the peripheral non-culled

areas and in reactive culling areas. Sir David agreed that this was an additional effect to be taken into account.

All present agreed that the discussion had covered areas of common ground between Sir David's group and the ISG. The meeting then considered points where there was disagreement.

3. Temporal trends

Analyses of TB incidence in cattle since the end of culling

Prof. Donnelly introduced a confidential paper containing preliminary analyses of cattle TB incidence within RBCT trial areas using VetNet data that she and her colleague, Helen Jenkins, had prepared as part of a post-ISG research contract awarded by Defra to Imperial College London. Prof. Donnelly said that under the terms of the contract, four analyses would be undertaken, once every six months – July 2007, January and July 2008 and January 2009 - to provide about 25 triplet-years' worth of data from the period commencing 12 months after the last proactive cull in each area. She asked those present to respect the confidentiality of these results and not to publish them.

There was discussion about the significance and possible interpretation of the results and all agreed that we could be more confident in the trends than in the results from individual years. The meeting agreed that the new results could become increasingly relevant as their precision increases with further data.

Sir David asked the meeting if everyone agreed that the results show temporal trends. All agreed that there was evidence of a temporal trend towards an increase in the beneficial effects within the culled zone and a reduction in detrimental effects outside (although the 95% confidence intervals of the new "outside" data point were very large and crossed zero). Professor Donnelly noted that the statistical significance of the temporal trend had not yet been investigated including these data.

Dr Woodroffe asked those present to note that these preliminary results related to cattle TB incidence after badger culling had stopped. In response to questions from Profs. Woolhouse and Roper about why there were no badger data available for this period, Dr Woodroffe confirmed that this was because no culling was taking place and there was therefore no reliable way of monitoring the prevalence of infection in badgers, nor were there any on-going investigations of badger behaviour in the RBCT areas. Prof. Donnelly noted that badger movement data in this post culling time period could have been obtained via a bait marking study. Such a study could have ascertained, amongst other things, whether the social perturbation identified by the ISG continued after culling stopped. A proposal by the ISG that CSL continue this study beyond March 2007 was not supported by Defra.

Sir David suggested that on the basis of the available data the detrimental effect of culling seems to be transient and in time, badger culling will lead to an overall beneficial effect by reducing cattle TB incidence. Prof. Donnelly confirmed that with these data there is clear evidence of a statistically significant benefit *inside* culled areas, but it is not at all clear that it will be an overall benefit on cattle TB incidence when both culled areas and land within 2km of the area boundaries are included. Professor Donnelly explained that she had not yet analysed the entire dataset – both inside and outside for all the years during and after RBCT culling – and explained that further analysis were planned on the combined effect over the whole time period. Sir David suggested that this would affect the cost benefit analysis of culling. Dr Woodroffe also asked the meeting to note

that these data were based on the situation after one year without badger culling, following an average of five culls per trial area.

Sir David suggested that if culling were to be performed over a larger area, the results would be even more promising. Prof. Donnelly agreed but noted that the benefits were still likely to be modest and the economic costs of culling likely to exceed the economic benefits.

Data accrued between first and second culls

Sir David said he accepted the former ISG members' comments (Bourne *et al.*, 2007b) sent to the EFRA Select Committee, that the observed results between the first and second culls would have been much larger had they reflected the incidence of new cattle infections rather than the incidence of detected herd breakdowns. As such, they are an underestimate. He continued to have concerns about the biological plausibility of the rate of transmission accepted by the ISG and the speed of changes in the incidence of cattle TB that the ISG attributed to the impact of badger removal.

Prof. Donnelly proposes to analyse the data set further to estimate the effect of culling on the incidence of new cattle infections, if she receives funding from Defra to do so.

Prof. Bourne said the biological explanation for detrimental effects and their temporal trends had been discussed in depth with the Veterinary Laboratories Agency (VLA), and others, and was not therefore merely an ISG opinion in isolation from the available data. This had been fully explained, along with experimental data, in the 2007 report (Bourne *et al.*, 2007a). A detailed discussion of this issue had also been included in the peer-reviewed Supplementary Information of Donnelly *et al.* (2006).

The meeting then discussed the VLA work on bovine TB infection rates in cattle. Fiona Stuart said the current VLA experiment on transmission has not recorded responsiveness to the tuberculin test among susceptible cattle exposed to infected cattle during one year of close contact, although the in-contact animals rapidly became IFN gamma test positive. Prof. Bourne pointed out that, in the Institute for Animal Health (IAH) a scientifically controlled low dose experimental exposure study cattle became responsive to the tuberculin test within three weeks of exposure to an experimental dose (10^4 organisms) shown to generate pathology similar to that recorded among naturally infected animals observed in the field. A response to repeated skin testing at 60 day intervals was the cornerstone of cattle TB control programmes and positive skin tests were recorded in calves at 42 days of age or less. Fiona Stuart reminded the meeting of the findings at VLA in the early 1980s that cattle kept in close contact with either naturally or experimentally infected badgers became tuberculin test positive after 6-8 months (Little, Naylor and Wilesmith 1982).

Sir David concluded that the data point to a temporal trend in the impacts of proactive culling, despite some meeting participants having difficulty accepting the mechanism whereby effects of culling become detectable within the first year following initial proactive badger culls.

All present agreed with Dr Woodroffe's view that sustained, coordinated culling conducted simultaneously over the whole area would be necessary to achieve any improving temporal trend in the effects of culling on cattle TB incidence, and that culling conducted over short time periods or in an uncoordinated manner would be very likely to cause detrimental effects.

4. Mathematical modelling

R₀ estimates

- 4.1 All present agreed with Sir David that there were four possible routes of transmission: badger-to-badger, badger-to-cattle, cattle-to-badger and cattle-to-cattle.
- 4.2 Prof. Woolhouse said that Annex 2 of Sir David's report submitted to the Secretary of State, DEFRA on 30 July 2007 (King *et al.*, 2007) was in line with Prof. Mollison's previously stated views (Mollison, 2007) and that it was accepted that Sir David Cox's model considered two species (Cox *et al.*, 2005).
- 4.3 Sir David King said that R₀ for bovine TB in a mixed population appears to be approximately 1.1, and all present agreed that the aim must be to halt the spread of bovine TB in cattle and reduce R₀ to below 1. But Sir David said that he took issue with the likely success of culling just one species (i.e. cattle) whilst not tackling the other species (badger).
- 4.4 Prof. Bourne said that the published (Cox *et al.*) transmission model was not a single species model, as the King report had previously suggested. Regardless of this misunderstanding, he said that whatever policy is developed, it must have an impact on national trends, and if the policy included badger culling, the culling must be widespread, coordinated, simultaneous and sustained, as discussed and agreed earlier in the meeting. Prof. Donnelly said that ISG modelling had suggested that addressing the cattle element of the disease would lead to lower cattle-to-cattle, and cattle-to-badger, transmission rates, leading to R₀ becoming less than 1. However, this may not necessarily keep it below 1 indefinitely.
- 4.5 Prof. Woolhouse contested that, based on the Cox *et al.* transmission model, one could increase the benefit accrued from tackling the cattle element by introducing simultaneously a modest intervention aimed at the badger; importantly, this would increase the rate of decline in cattle TB incidence. Prof. Woolhouse explained that the Cox *et al.* model suggests between 0-85% of cattle infection could be caused by transmission from badgers.

[Footnote: Sir David Cox has commented on this minute and recognises a misunderstanding has arisen that could have been resolved by more in-depth discussions. He reaffirms the conclusions of the Cox *et al.* paper.]

Professor Roper explained that if you reduce badger to badger transmission you may get disproportionate benefits in the cattle population. Professor Donnelly added that it depends what the main source of infection is. Dr Woodroffe argued that no "modest intervention" was available to target badgers; it had previously been agreed that only a draconian intervention would entail benefits for the control of cattle TB. She noted that the Cox *et al.* model takes no account of badger perturbation, which all present had previously agreed was a very important consideration. Prof. Roper explained that within the culled area the results are made up of a combination of the negative effects of perturbation (increased badger ranging) and the positive effects of culling (reduced badger density), whereas in the outside area only the perturbation effect is seen. Dr Woodroffe agreed that, as culling was continued, badger ranging and badger density would change in different ways and that this could contribute to temporal trends in the effect of culling on cattle TB incidence.

Prof. Bourne said that the impact of cattle controls alone is being experienced in Northern Ireland – after four years they have managed to reduce the incidence of bovine TB in cattle by over 45% (since the peak in 2002) without resorting to badger culling. Colleagues from Northern Ireland report that this has been achieved by

improved diagnosis and more rigid cattle movement control; made possible by a more effective cattle tracing system than that available in GB with no exceptions, ensuring that all cattle are tested at least annually with necessary forward tracing. In this regard it is very different from the GB situation. Prof. Bourne noted that bovine TB incidence in cattle in Northern Ireland was now less than that being experienced in the West of England. He also said that incidence in cattle in Eire is increasing (although these data are not available officially, they were subsequently reported in the Irish Farmers Journal, 2 Feb 2008), despite large scale culling that had now extended over more than half of the designated badger removal area. Prof. Bourne also asked the meeting to note that the results (not disclosed) of soon to be published work by Professor Laura Green, of Warwick University, underpinned the relevance of a cattle-based approach to TB control (Carrique-Mas, Medley, Green (2008) *Prev Vet Med* 84, 85-93). Fiona Stuart said that in both countries in Ireland, the official data show a fall in cattle TB from a relatively high level over the past 5 years. The culling strategy in Republic of Ireland, although now covering considerable areas of the country, is reactive over small areas of land subsequent to herd breakdowns, but with maintained badger removal and the coalescence of areas to achieve badger removal over large areas.

The contribution of cattle movements to herd breakdowns

- 4.6 Prof. Donnelly presented paper ISG 1717. This reported on the effect of excluding herd breakdowns in RBCT areas which are likely to have been caused by movements into the herd of cattle that had become infected elsewhere. Those present were asked to note that the paper did not estimate the contribution of cattle movements to herd breakdowns, as the meeting agenda had suggested, and would not be possible since the diagnostic test is not fully sensitive and cattle movement records probably not complete, but had been prepared to try to assess the impact of badger culling on herds where cattle movements could be ruled out as a likely source of infection.
- 4.7 Prof. Donnelly said that analyses of the impact of badger culling in the RBCT were based on all recorded confirmed herd breakdowns in and around trial areas. The analyses identified relatively few (up to 6.6%) confirmed herd breakdowns involving cattle confirmed as infected (identified within 30 days of the breakdown start date) which had moved into the herd in the previous year. (Some recently moved-in infected animals might not be detected by the tuberculin test or might be detected by the tuberculin test and not subsequently confirmed.) The exclusion of these breakdowns from the analyses had little impact on the estimated effects of badger culling. Prof. Donnelly said it was not possible to stratify herd breakdowns with certainty into those caused by cattle infected elsewhere and those due to other causes, but on the basis of the data available, the estimates of the effects of RBCT proactive culling are virtually identical to those based on the total incidence of confirmed herd breakdowns.

5. Soft boundaries

Sir David said he understood perfectly well that there would be badger movement in arable land, but noted that, as there would be no cattle, there would be no deleterious effect on herd breakdowns.

Dr Woodroffe agreed with this point and noted that it had first been suggested in the ISG's final report. However, she noted that the ISG had felt compelled to respond to the EFRA Select Committee (Bourne *et al.*, 2007b) on this issue, since Sir David's report (King *et al.*, 2007) had referred to such cattle-free areas as 'soft boundaries' expected to reduce badger movement.

Dr Woodroffe then confirmed the ISG's views on hard boundaries that were likely to impede badger movement, and on the ability of such boundaries to reduce culling-associated increases in the prevalence of *M. bovis* infection in badgers, as presented in their June 2007 report (Bourne *et al.*, 2007a) and in a peer-reviewed paper published in PNAS in 2006 (Woodroffe *et al.* 2006). She noted that the only effects of such boundaries detected in the course of the RBCT were effects on the prevalence of infection in badgers. Analyses of the cattle data, presented in the Supplementary Information of the ISG's most recent *Nature* paper (Donnelly *et al.*, 2006) and in their 2007 IJID paper (Donnelly *et al.*, 2007), showed no such effects. However, all present agreed that the RBCT had not been designed to detect such effects, and that effects on cattle could reasonably be expected given the documented effects on badgers. It was also noted that the ISG have cited the presence of hard boundaries as one factor contributing to the greater reductions in cattle TB incidence reported from the Irish "Four Areas" trial, in comparison with the RBCT.

6. Cost and practicability

Sir David asked the ISG if the cost-benefit analyses (CBA) in their June 2007 report (Bourne *et al.*, 2007a) had been peer-reviewed. Prof. Bourne confirmed that Chapter 9 *Economic aspects of TB control* had not been submitted for publication in a peer-reviewed journal, but said that at his insistence an independent audit had been undertaken by Defra and was available as a public record. Prof Bourne had also sought the view of a non- agricultural economist; reference to this is to be found in ISG minutes.

Prof. Bourne said ISG analyses estimated that over the course of 5-years' culling in ten 100km² areas, 14 potential herd breakdowns had been avoided overall. From this, and other economic analyses detailed in Chapter 9 of their June 2007 report, the ISG had concluded that the potential for culling to lower the incidence of herd breakdowns appears to be so poor that the inherent economic weakness of any badger culling strategy can be seen from simple cost and benefit accounting. He said Chapter 9 made it clear that, on this evidence, there was no need for the ISG to conduct a formal CBA.

In response to a question asking whether the ISG had conducted a cattle culling or cattle control CBA, Prof. Bourne said that because disease in cattle was a public health issue, it was not within the ISG's remit to conduct such a CBA. The analysis to be conducted by the ISG had been agreed with Ministers and outlined in the second ISG report. Prof Bourne also noted that Lord Rooker in recent evidence presented to EFRAC had said that Defra had not themselves carried out such an analysis. Sir David suggested that an overall CBA, to include badger culling and cattle controls would be helpful, to which Prof. Bourne replied that this, too, was outside the ISG's remit.

7. Concluding discussion

Concluding the meeting, Sir David noted Prof. Bourne's comment that the ISG's June 2007 report (Bourne *et al.*, 2007a) provided a basis for tackling bovine TB via the cattle route, adding that if there is to be a coherent argument for a badger cull to be part of a future disease control policy, that will be for Defra to address, and not for him to decide. Prof Bourne re-iterated that for culling to have a meaningful impact on national disease trends, not only would all culling requirements need to be met but it would need to be conducted over a vast swathe of GB. Prof Bourne commented that the ISG had been involved throughout their study in an ongoing scientific discussion, involving in particular, but by no means limited to, Defra VLA and CSL scientists. Prof. Bourne stated that it was unfortunate that Sir David conducted his review of ISG work in July and did not meet with ISG members to discuss the issues of concern until December.

[Footnote: This minute should be read with ISG response to the King et al report submitted to EFRAC Jan 15th 2008]

December 2007

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