What is the role of badger culling as a control measure for bovine TB?

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IN an article summarised on p 239 of this issue of *Vet Record*, Langton and colleagues analysed the incidence of bovine TB (bTB) breakdowns in cattle herds since the introduction of England's controversial policy of badger culling in 2013.[1] Despite exhaustive statistical analysis of large amounts of data, they were unable to find conclusive evidence that the culling of badgers was associated with changes in the incidence of bTB in cattle.

Although the data analysis revealed a demonstrable decline in the bTB herd breakdown incidence since 2013, it was not possible to attribute this decline to badger culling. Other bTB control measures have also been introduced since 2013 – all of which would be expected to decrease the incidence of new outbreaks. Furthermore, the breakdown incidence declined at a similar rate in areas where badgers were culled and areas with no culling. Thus, Langton and colleagues concluded that the observed decline in bTB incidence was most likely due to factors other than badger culling.[1]

Ever since the first reports of badgers infected with bTB appeared in 1971,[2] it has been assumed that badgers are responsible for significant disease transmission to cattle. This assumption culminated in the randomised badger culling trial (RBCT) – carried out in England between 1998 and 2007. The central conclusion of the RBCT was that badger culling decreased confirmed bTB herd breakdowns by 23.2 per cent (95 per cent confidence interval [CI] 12.4–32.7 per cent).[3] This clearly contrasts with the findings of Langton and colleagues' study.[1]

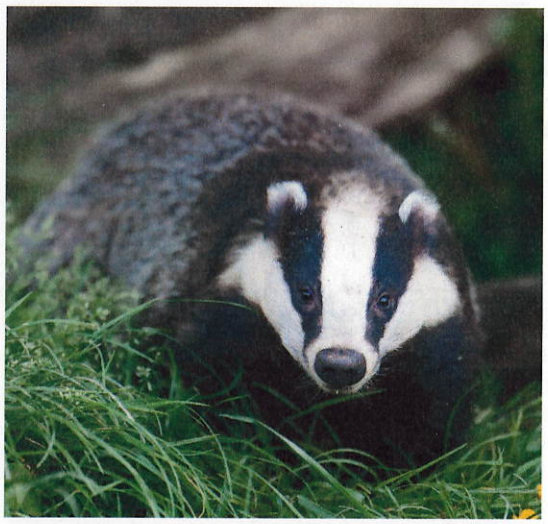
So, what could be the reason for these conflicting conclusions? There is a well-documented reproducibility problem in science, with up to 70 per cent of published studies unable to be replicated by other researchers.[4] Perhaps the RBCT is one such study with unreproducible findings? If so, what could be the reason for this?

A statistical anomaly could have produced a false positive, although this seems unlikely as the reported lower bound of the CI was 12.4 per cent.[3] However, the RBCT reported no significant differences in herd breakdowns between the cull and control areas if unconfirmed breakdowns were included in the analysis. Unconfirmed breakdowns include those where at least one animal in a herd had a positive single intradermal comparative cervical skin test (SICCT), but it was either not possible to culture *Mycobacterium bovis* or there were no characteristic lesions found at postmortem examination.[5]

The specificity of the SICCT has been estimated to be approximately 100 per cent (95 per cent CI 99–100 per cent) in the UK and Ireland.[6] Thus, excluding unconfirmed breakdowns will remove a number of herds that suffer a bTB

WHAT YOU NEED TO KNOW

- Evidence suggests that the controversial policy of badger culling has had no significant effect on the incidence of bovine TB (bTB) in cattle herds in England. However, due to insufficient data being available, the effect of badger culling on bTB is still unclear.
- While badgers are known to transmit bTB to cattle, most cattle infected with bTB will have acquired the infection from other cattle. Therefore, a greater focus on controlling cattle-to-cattle transmission is necessary to reduce the incidence of herd breakdowns.
- The animal-level sensitivity of the single intradermal comparative cervical skin test (SICCT) has been estimated to be as low as 50 per cent, meaning that for each cow that tests positive with the SICCT there will be a further infected cow that tests negative.
- The herd-level sensitivity of the SICCT is better, but it is estimated that approximately 15 per cent of infected herds will pass the SICCT and be deemed officially tuberculosis free (OTF) – allowing them to trade and move animals on or off the farm.
- All cattle offered for sale should have tested negative for bTB and come from an OTF herd. A herd that has a history of bTB restrictions is likely to be high risk, and it is advised that farmers avoid purchasing cattle from such herds.



Extensive statistical analysis of long-term bovine TB (bTB) herd incidence data from culled and unculled areas across the whole high-risk area of England found no conclusive evidence that the culling of badgers was associated with changes in the incidence of bTB in cattle

breakdown from the breakdown group in the analysis, which will bias the results. However, no diagnostic test for bTB has both 100 per cent sensitivity and specificity, so there will inevitably be misclassifications at both the animal and herd levels, which should be accounted for in any analysis.[7] Although More and McGrath[8] dismissed such issues in respect to the RBCT, the inclusion of unconfirmed breakdowns in the final conclusions of the RBCT would have led to a different interpretation.

It is also important to consider other evidence regarding the possibility of badger-to-cattle transmission of bTB. For example, studies tracking badgers have demonstrated that there is very little direct contact between badgers and cattle.[9] Consequently, it is assumed that infection of cattle occurs indirectly through contamination of pasture where cattle are grazing or through contaminated fomites. However, most TB lesions in cattle are found in the upper or lower respiratory tract or associated lymph nodes,[10] suggesting direct aerosol transmission.

Although transfer of ingested *M bovis* from the rumen to the respiratory tract via eructation has been suggested as a mechanism by which respiratory tract lesions can develop in the absence of aerosol transmission, early studies of bovine TB demonstrated that cattle subjected to oral challenge tend to develop lesions primarily in the alimentary tract and abdomen.[11] This suggests that indirect transmission from badgers to cattle is not the primary driver of disease in cattle.

Furthermore, while similarities in the spoligotypes of *M bovis* isolated from cattle and badgers suggest that there is likely to be some transmission between the two species, recent evidence indicates that cattle are predominantly infected by other cattle and badgers are usually infected by other badgers. Indeed, the rate of within-species transmission is several orders of magnitude higher than either badger-to-cattle or cattle-to-badger transmission.[12-15]

Taken together, these studies indicate that cattle-to-cattle transmission is the primary driver of bTB herd breakdowns. Indeed, van Tonder and colleagues[13] concluded that 'the transmission clusters in different parts of south-west England that are still evident today were established by long-distance seeding events involving cattle movement, not by recrudescence from a long-established wildlife reservoir.' Furthermore, recent studies of infected badgers in the English edge areas found little evidence to link the expansion of the bTB epidemic in cattle to widespread badger infection.[16] This casts further doubt on the role of badgers in transmitting TB to cattle.

Although models from a study investigating the contribution of badgers to confirmed TB in cattle in high-incidence areas suggested that only 5.7 per cent (CI 0.9–25 per cent) of transmission to cattle herds was directly from badgers, the authors argued the greater implied effect size of badger removal in the RBCT was due to prevention, by badger removal, of secondary onward transmission between cattle.[17] However, this view needs revisiting, not least because the sensitivity of the SICCT may be as low as 50 per cent at the animal level.[6]

At the herd level, the sensitivity of the SICCT is higher. However, data suggest that approximately 15 per cent of bTB breakdowns in the high-risk area of England were only detected by abattoir surveillance.[18] Therefore, 15 per cent of herds that are infected with bTB could potentially pass the routine surveillance test and be able to trade and move their cattle. In this respect, recorded cattle movements consistently outperformed environmental, topographic and other anthropogenic variables as the main predictor of disease occurrence.[19] This raises questions regarding the current approach to bTB control in Great Britain.

In 2014, it was shown that 92 per cent of

the animal health surveillance budget in Great Britain was spent on the surveillance of bTB.[20] Furthermore, the Godfray report[21] devoted considerable debate to the cost of the bTB control programme, including the £9 million per annum for wildlife control and a further £2–3 million per annum for research into diagnostics and vaccines for badgers. However, Langton and colleagues' study[1] suggests that the costs of intervention in badgers have derived no demonstrable benefit, which must flag it for urgent ethical reconsideration.

While the analysis by Langton and colleagues[1] does not prove that badgers do not transmit bTB to cattle, it does provide evidence that badger culling, as implemented, has had no significant effect on the incidence of herd breakdowns. However, it might be argued that this is not the same as saying that there is evidence per se that culling has no effect at all on bTB incidence.

No data were available on the numbers of badgers culled or the proportion of the badger population culled. Therefore, these data could not be introduced as quantitative variables in the analysis. Nevertheless, Langton and colleagues[1] give an exhaustive statistical analysis of the data with badger culling included as a qualitative variable, and their results indicate it is unlikely that the addition of these missing data would have significantly changed the conclusions reached.

In conclusion, evidence is accumulating that a low proportion of bTB infections in cattle can be attributed to badger-to-cattle transmission. As such, reductions in bTB herd breakdown incidence are most likely to be achieved through interventions targeting cattle-to-cattle transmission.

Indeed the results from the RBCT led the Independent Scientific Group on Cattle TB to conclude that 'weaknesses in cattle testing regimes mean that cattle themselves contribute significantly to the persistence and spread of disease in all areas where TB occurs, and in some parts of Britain are likely to be the main source of infection. Scientific findings indicate that the rising incidence of disease can be reversed and geographical spread contained by the rigid application of cattle-based measures alone.'[22]

Similarly, the more recent Godfray report[21] also noted that there is 'no scientific consensus about whether the disease is self-sustaining in badgers' and that the politicisation of the debate around badger culling has deflected focus from the extent to which trading in high-risk cattle is hampering disease control.

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