Meeting of the Parliamentary and Scientific Committee on Tuesday 21st January

BADGERS

Adam Quinney
Vice President, NFU

The summaries of the talks given at the meeting by Adam Quinney and Professor Rosie Woodroffe are based on an article by Edward Stansfield CMath FIMA CSci published in Mathematics Today.

Adam Quinney spoke about farming and the effect that TB in cattle is having on the industry. He stressed that the NFU is anti-TB and not anti-badger. He pointed out that not only can badgers transmit TB to cattle, but cattle can transmit TB to badgers. The usual mechanism is via the animal latrines ie in the urine which gets absorbed into the food. TB is a very complicated disease. Animals can be infected but not infectious. The time during which an animal is infected before becoming infectious is very variable – from weeks to months. The infection can also be spread when infected animals bite other animals.

Badger proofing farms is very expensive, and not practical, as it requires fences around fields to be buried to a considerable depth. Experiments using proximity sensors have shown that badgers tend to live in family clusters and generally do not move more than 2km from their setts. Unfortunately, such results have proved to be more useful for learning about badger behaviour than their effect on cattle.

Badgers tend to be up and about at night and sleep in the day, whereas cattle tend to do the opposite – up and about in the day and lying down chewing the cud at night. Hence the importance of badger latrines and cattle fodder. Tests have shown that raising the troughs for cattle food and water reduces the level of TB in cattle.

The primary test for TB in animals is a skin test, which is said to be 90% effective ie on average 10% of infected animals will not be detected to have the disease. The NFU would like to have an effective vaccine for badgers, but this is not easy to find. The best current vaccine has to be injected, which first requires the animals to be caught – no easy task. Oral vaccines are available, but are much less effective. The NFU would also like an effective vaccine for cattle, but this is even more difficult to achieve as cattle are part of the human food chain. Moreover, different parts of a cow or bull are exported to different countries depending on local tastes and requirements; hence many different tests would be required to show that the vaccine is not detrimental to human health.

In conclusion, Adam said that there is no single answer – TB has not so far been stopped, but it has been slowed down.

BADGER CULLING AND ITS EFFECTS ON CATTLE TB

Professor Christl Donnelly
MRC Centre for Outbreak Analysis and Modelling, Department of Infectious Disease Epidemiology, Imperial College London

Cattle tuberculosis (TB) is a serious animal health problem. The disease is caused by the bacteria *Mycobacterium bovis*. Public health measures include pasteurization, which kills any *M. bovis* in milk and dairy products. Routine testing of cattle identifies *M. bovis*-infected cattle to limit onward cattle-to-cattle transmission, to avoid cattle suffering due to TB and to secure public health. Following confirmation of *M. bovis* infection, cattle sales and movements are restricted, and farmers are given detailed biosecurity advice.

Transmission from British wildlife, in particular badgers (*Meles meles*), has hampered cattle-focused efforts to control, and eradicate, the disease. Badger culling has been undertaken, in various forms, since the 1970s. Yet, the role of badgers continues to be fiercely debated, as do the appropriate approaches to limiting badger-to-cattle transmission.

The Independent Scientific Group on Cattle TB (ISG, of which I was the deputy chair) designed, oversaw, analysed and interpreted the Randomised Badger Culling Trial (RBCT). In the RBCT, 30 large (100km^2) areas were selected in ten sets of three, within which one area was randomised to proactive culling, one to reactive culling and one to no culling. Proactive culling was undertaken annually on all accessible land, whereas reactive culling was undertaken only once on and around farmland on which cattle had been confirmed with bovine TB. All badgers culled within the RBCT were captured using baited cage traps and shot.

In 2003, reactive culling was suspended because the incidence of confirmed cattle TB in reactively culled areas was found to be significantly higher than in the matched unculled areas [1]. This unforeseen result caused considerable debate about potential mechanisms for the increased risk and about the robustness of the RBCT. Subsequent analyses of data within the reactive areas (ignoring data from the unculled areas) identified an association between reactive badger culling and increased confirmed cattle TB risks on nearby farms. Furthermore, affected herds in reactively culled areas took longer to clear TB from their cattle than herds in unculled areas.

... affected herds in reactively culled areas took longer to clear TB ...

An ecological hypothesis proposed to explain the reactive culling finding was that one-off localized culling disrupted badgers' territorial behaviour, thereby increasing contacts between infected badgers and cattle. The impacts of culling on badger activity, in particular ranging behaviour, were measured using bait marking. Coloured baits were fed to badgers at their setts (dens) and the resulting colour-marked bait returns (faeces) were mapped for proactively culled, reactively culled and unculled areas, as well as on land up to 2km outside proactively culled areas [2]. Badger home ranges, estimated from bait returns, were consistently larger and overlapped more in culling areas. Furthermore, in unculled areas, badger home ranges increased with proximity to the boundaries of proactive culling areas. The finding that badger behaviour was affected up to 2km from the proactive culling areas suggested to the ISG that cattle TB incidence should also be examined up to 2km outside RBCT areas.

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In 2006, the ISG and colleagues reported that proactive culling had reduced the incidence of confirmed cattle TB among herds in proactively culled areas, compared with herds in unculled areas [3-4]. However, we also reported that proactive culling increased the incidence of confirmed cattle TB among herds on land up to 2km outside proactively culled areas, compared with herds on land up to 2km outside unculled areas, though this increase disappeared after annual culling stopped [3-4].

These results, although biologically sound, have created particular challenges for policymakers and stakeholders. The estimated positive and negative impacts of proactive culling are such that the net benefit (that is the cattle herd incidents prevented inside the culling area minus the cattle herd incidents caused up to 2km outside the culling area) will be greater for larger roughly circular culling areas.

Everything else being equal, the best shape for a landlocked proactive culling area is circular as it minimizes the ratio of land up to 2km outside the culling area to the land area within the culling area. For example for a $100km^2$ circular culling area, $83.5km^2$ of land is up to 2km outside it (ratio=0.835), whereas for a $200km^2$ circular culling area, $112.8km^2$ of land is up to 2km outside it (ratio=0.564). It was on this basis that we found, in 2010, that we could only be (95%) confident of avoiding net increases in confirmed cattle TB across the entire affected area for circular culling areas greater than $141km^2$ in size [4].

In 2011, Defra published details on an approach to license farmer-led badger culls [5]. The approach differed importantly from proactive culling in the RBCT in that

i) it allowed the shooting of free-ranging badgers, as well as cage-trapping, raising concerns for animal welfare and for health and safety;

ii) it allowed culling to take place over a 6-week period each year (instead of the intensive 11 consecutive nights of cage trapping and shooting in the RBCT);

iii) it required culls to be organised and undertaken by farmers and their contractors rather than government Wildlife Unit staff.

In order to be licensed, applicants had to demonstrate that they would meet several licensing requirements including that culling areas were large, at least $150km^2$ in size. This was informed by the finding on net benefits from idealised circular culling areas greater than $141km^2$ in size[4].

Because shooting free-ranging badgers was an untested culling method, there was concern over whether these culls could remove the minimum number of badgers required to reduce the estimated badger population of the culling area by at least 70%[5]. Moreover, to provide statistical confidence that at least 70% of badgers had been removed, the minimum number of badgers to be culled was considerably more than 70% of the estimated size of the local badger population, due to imprecision in the population estimate[6].

In late 2013, initial culls were undertaken in two pilot culling areas, in Gloucestershire and Somerset, following delays due to difficulties in estimating the resident badger population. The Independent Expert Panel reported that "The combined approach of controlled shooting and cage trapping also did not remove at least 70% of the population inside either pilot area; substantially fewer than 70% were removed in both areas." [7] The government announced on 3rd April 2014 that annual culling will resume in the pilot areas, but no new cull licences will be granted for the time being [8].

Time will tell whether subsequent culls in the pilot areas will be more effective than the initial culls. If they are not, the risk is that herds within the pilot areas will experience increased TB risks (as in reactively culled areas) rather than decreased TB risks (as in proactively culled areas).

References

1. Donnelly CA, Woodroffe R, Cox DR, Bourne J, Gettinby G, et al. (2003) Impact of localized badger culling on TB incidence in British cattle. *Nature* 426: 834–837.

2. Woodroffe R, Donnelly CA, Cox DR, Bourne FJ, Cheeseman CL, et al. (2006) Effects of culling on badger *Meles meles* spatial organization: implications for the control of bovine tuberculosis. *Journal of Applied Ecology* 43: 1–10.

3. Donnelly CA, Woodroffe R, Cox DR, Bourne FJ, Cheeseman CL, et al. (2006) Positive and negative effects of widespread badger culling on cattle tuberculosis. *Nature* 439: 843–846.

4. Jenkins HE, Woodroffe R, Donnelly CA (2010) The Duration of the Effects of Repeated Widespread Badger Culling on Cattle Tuberculosis Following the Cessation of Culling. *PLoS ONE* 5(2): e9090.

5. Defra (2011) The Government's policy on Bovine TB and badger control in England https://www.gov.uk/government/publications/the-government-s-policy-on-bovine-tb-and-badger-control-in-england

6. Donnelly CA, Woodroffe R (2012) Epidemiology: Reduce uncertainty in UK badger culling. *Nature* 485: 582.

7. Independent Expert Panel (2014) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300383/ahvla-efficacy-report.pdf

8. Defra (2014) https://www.gov.uk/government/publications/pilot-badger-culls-in-somerset-and-gloucestershire-defra-response-to-the-report-by-the-independent-expert-panel

Excerpts from the Independent Expert Panel's report: **Monitoring the efficacy of badger population reduction by controlled shooting during the first six weeks of the pilots**[7]

Para 4.6 "In the Gloucestershire pilot area a total of 708 badgers were removed during the first six weeks of culling, with an estimated cull efficacy of 27.5 to 39.1% from cull sample matching and 21.8 to 50.8% from capture-mark-recapture analysis. The number removed by shooting was 543 and was 165 by cage trapping, giving an estimated shooting efficacy of 25.3 to 37.1% from cull sample matching and 16.7 to 39.0% from capture-mark-recapture analysis. …"

… particular challenges for policymakers …

Para 4.7 "In the Somerset pilot area a total of 866 badgers were removed during the first six weeks of culling, with an estimated cull efficacy of 34.5 to 48.1% from cull sample matching and 45.5 to 101.9% from capture-mark-recapture analysis. The number reported to be removed by shooting was 398 and was 467 by cage trapping, giving an estimated shooting efficacy of 14.6 to 24.8% from cull sample matching and 20.9 to 46.8% from capture-mark-recapture analysis. …"

BADGER CULLING AND VACCINATION

Professor Rosie Woodroffe
Senior Research Fellow, Institute of Zoology

Rosie Woodroffe entitled her talk Badger Culling and Vaccination. What she did was show how the results described by the previous two speakers can be explained in terms of mathematically modelling the way that diseases spread across an area. This involves three kinds of animal: those that are susceptible, those that are immune, and those that are infected. Disease spreads by infected animals mixing with susceptible animals, some of which then also become infected. The progress of a disease depends on many factors, not least of which are the level of mixing, the area over which they roam, the rate at which the young are born, the rate at which the old die and the effect of the disease on mortality. Of course, culling and vaccination both directly affect the model.

Rosie referred to these effects as "disease dynamics". New born animals in the wild are susceptible, but can become immune either by vaccination or by getting better after being infected after mixing with the infectious. Culling in general will affect both the susceptible and the immune, and will change the balance, but it does provide fewer opportunities for infected and susceptible animals to mix. Culling can produce two opposing consequences – fewer badgers (which is good), but the proportion of infected badgers may increase (which is bad). The graph illustrates this, based on the results of the recent trials in Gloucester and Somerset ending on 1 November 2013. When possums were culled in New Zealand some years ago, similar effects were observed.

For vaccination programmes to be effective, all young badgers need to be protected, and this means that the programme has to be repeated every year. Over time, this will eradicate the disease. Each year the risk of infection will be reduced. Studies have shown that in the first year the overall risk of new infections is reduced by 76%, and 79% in cubs if more than 30% of the adults have been vaccinated. This doesn't reduce the number of badgers, but it does reduce the risk of infection. *However, the effect that this has on TB in cattle is not yet known.*

How does changing badger density influence TB risk to cattle?