Performance of an environmental test to detect *Mycobacterium bovis* infection in badger social groups

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A STUDY by Courtenay and others (2006) demonstrated that the probability of detecting *Mycobacterium bovis* by PCR in soil samples from the spoil heaps of main badger setts correlated with the prevalence of excretion (infectiousness) of captured badgers belonging to the social group. It has been proposed that such a test could be used to target badger culling to setts containing infectious animals (Anon 2007). This short communication discusses the issues surrounding this concept, with the intention of dispelling any misconceptions among relevant stakeholders (farmers, policy makers and conservationists).

The study by Courtenay and others (2006) included 22 contiguous badger social group territories, where samples of faeces, urine, sputum and bite wound swabs had been taken from live badgers for diagnosis by culture on up to four occasions per year (Delahay and others 2000). A positive result from any sample indicated that the individual was infectious (that is, excreting bacilli) at that time. In the study population, 100 per cent of the main setts tested positive for *M bovis* by PCR on soil samples, and in 16 of the 22 social groups at least one culture-positive badger was detected during the 32 months before environmental sampling. In the other six social groups no excreting badgers were detected, despite the presence of environmental *M bovis* at the sett.

There are a number of plausible explanations for the apparently low specificity of the environmental test (Courtenay and others 2006). One important issue is the ability to identify social groups containing infectious badgers using diagnostic tests on live animals. Formally, this will be related to the probability that an infectious badger is captured (capture rate [c]), the number of times a captured individual is tested (t), the number of infectious badgers in the social group (i), and the probability of correctly diagnosing an infectious individual at a single capture (s).

Values of s and c for the study population are available from published literature: the intermittent nature of excretion of tubercule bacilli (Chambers and others 2002) and the less than 100 per cent sensitivity of tissue culture against visible lesions at postmortem examination (Pritchard and others 1986, Nolan and Wilesmith 1994) mean that there is only a one in four chance (s=0·25) of detecting a tuberculous badger at a single capture (Cheeseman and others 1985, Pritchard and others 1986, Chambers and others 2002). The annual capture rate for the badger population as a whole has been estimated as 0·85 (Wilkinson and others 2000), which, for the 2·7-year study period, gives $c=1-(1-0{\cdot}85)^{2{\cdot}7} = 0{\cdot}99$. In fact, the probability of recapture of excreting badgers is likely to be lower, due to their high mortality rate relative to uninfected badgers (36 to 68 per cent v 24 to 32 per cent) (Wilkinson and others 2000).

Using these estimates, the probability (P) that a social group tests negative by the culture of excretory products if it contains i infectious individuals is:

$$P = [c(1-s)^t + (1-c)]^i$$

Thus, values of P can be calculated for each of the six negative social groups, making the assumption that there is i=1 infectious badger in each, and using mean values of t=1·3 to 4·0 for each social group, calculated from the testing records. For comparative purposes, values of P were also calculated for c=0·85 and c=0·70.

Fig 1 shows that, for c=0·70, the probability of failing to detect infectiousness in a social group containing one infectious badger is P=0·63 (95 per cent confidence interval [CI] 0·54 to 0·75), which decreases to P=0·48 (95 per cent CI 0·36 to 0·65) at a higher capture probability of c=0·99. The variation in P for any given value of c arises from the difference in mean testing frequency, t, for captured badgers in different social groups.

Some stakeholders favour the development of a sett-based environmental test that could identify setts containing infectious animals to enable targeted culling. However, the effectiveness of any such diagnostic tool to reduce bovine tuberculosis (TB) in cattle is likely to be constrained not only by the specificity and sensitivity of the test, but also by the disruption of badger social groups and enhanced rates of movement attributed to the incomplete removal of badger populations, as have been documented in focal and blanket culling operations (Donnelly and others 2003, 2005, Woodroffe and others 2006). Courtenay and others (2006) estimated by a cross-sectional survey that approximately 60 per cent of setts per PCR-positive farm within bovine TB hotspot regions of the UK do not contain excreting badgers. This suggests that a sett-by-sett test and slaughter policy would result in greater piecemeal culling (and counterproductive outcomes as listed above) than were described in the culling trials.

Despite current uncertainties, the development of a non-invasive environmental tool remains highly desirable for a wider range of applications, including farm biosecurity assessment, the evaluation of potential environmental contamination arising from future badger vaccine baits, and for related scientific research. This work is currently underway.

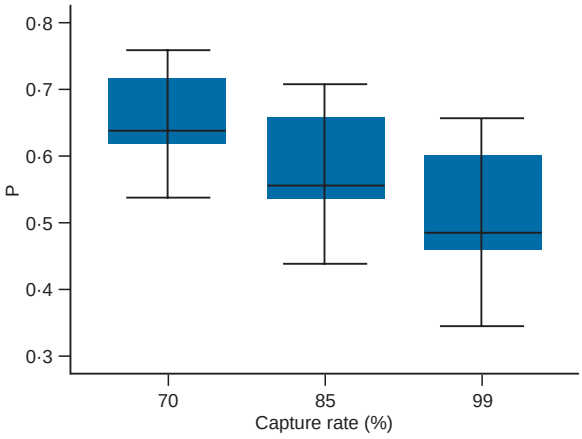

FIG 1: Probability (P) of a social group of badgers with one infectious individual testing clinically negative for bovine tuberculosis. The median, 95 per cent confidence interval and interquartile range are shown for P using sampling data from six badger social groups in Gloucestershire with no observed excreting badgers for capture rates of 70 per cent, 85 per cent and 99 per cent

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