Local reservoirs of *Mycobacterium bovis* infection in the Edge Area of England

December 2020

Contents

Summary

The Bovine Tuberculosis (TB) strategy recognises that disease levels vary across the Edge Area, and in the response to the Godfray Review (https://www.gov.uk/government/publications/a-strategy-for-achieving-bovine-tuberculosis-free-status-for-england-2018-review-government-response), the government committed to defining areas with a significant reservoir of TB infection in badgers.

The Animal and Plant Health Agency (APHA) was asked to developed criteria to identify areas with a likely reservoir of TB infection in badgers. However, since infection data from badgers in the Edge were sparse, criteria were developed using TB surveillance data from cattle, because cattle and wildlife, including badgers, can share the same reservoirs of infection. The accompanying map shows the estimated spatial distribution of local reservoirs of TB across 25 km^2 hexagonal spatial units in the Edge, noting that there is uncertainty in the precise distribution without confirmed infection data from wildlife. The local reservoirs that have been identified all have evidence for TB in cattle not attributed to cattle purchasing, for persistent or recurrent infection in cattle since 2013 and for recent infection in cattle confirmed by post-mortem tests. A buffer has been added to the putative reservoir boundaries, which encompasses the usual maximum ranging of badgers.

The detail of this work is being submitted for publication through the peer reviewed scientific press. However, due to ongoing consultations between Government, the farming industry and other stakeholders about badger controls, the map showing current understanding of the locations for *Mycobacterium bovis* (*M. bovis)* infection reservoirs has been published, before the external peer review of this work has been completed.
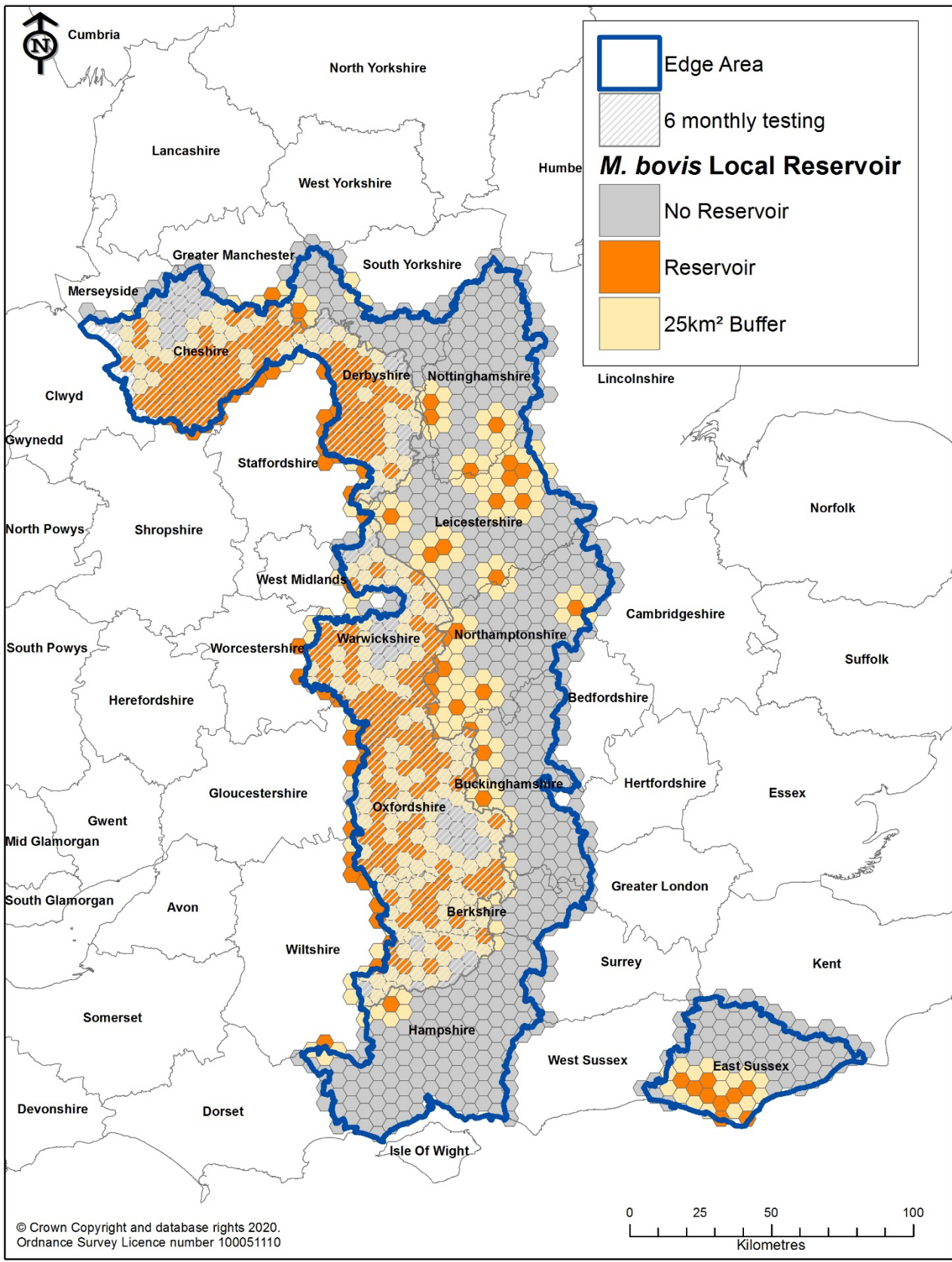
Figure 1: Local reservoirs for *M. bovis* in the Edge Area of England using a cattle-based definition.

Further detail about the methodology used to define local reservoirs for *M. bovis* infection

A working group of APHA scientists reviewed previous criteria used to identify areas with badgers infected with TB. No attempt had been made previously to define a reservoir of *M. bovis* infection associated with badgers in the Edge Area. It was recognised that *M. bovis* infection data from badgers were the most relevant data. However, since badgers and cattle can share the same infection reservoirs; TB data relating to cattle in the Edge Area were also considered. Potentially relevant data sources identified included:

- Ad hoc surveys for *M. bovis* infection in badgers such as in badgers found dead after road traffic accidents,
- *M. bovis* genotype data from infected cattle and badgers in the Edge Area
- Test results from surveillance for TB in cattle on the APHA TB management system,
- Information recorded on Disease Report Forms (DRFs) completed by APHA veterinarians during investigation and management of TB incidents in cattle herds.

The badger infection data were sparse and the surveys that had been conducted did not sample badgers across the entire Edge Area or use probability-based sampling frames. Surveys carried out by the Universities of Nottingham and Surrey, can be accessed at (http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19579&FromSearch=Y&Publisher=1&SearchText=se3054&SortString=ProjectCode&SortOrder=Asc&Paging=10%20-%20Description). Genotype data were not informative because of the sparse data from badgers. Data from TB tests in cattle were less subject to sampling bias because surveillance is conducted routinely in all cattle herds, although testing frequency between herds can vary. It was noted that DRF data relies on veterinary expertise but infection attributed to cattle purchasing is validated using cattle trading data.

Recognising the limitations to the available data the working group embarked on a two-pronged approach. Firstly, definitions for a *M. bovis* reservoir were developed using cattle surveillance data and calculated for hexagonal spatial units of 25 km^2, 50 km^2 and 100 km^2 in size. Secondly, the accuracy of final cattle-based definition selected by the working group was evaluated using the data from surveys of infection in dead badgers, local knowledge and a previous study that had developed a definition for endemic TB. The methodology was reviewed by scientists uninvolved in the work and their comments were addressed.

The final cattle-based definition excluded TB incidents where the source of infection was predominantly attributed to cattle brought into a herd. It included areas with evidence for persistent or recurrent *M. bovis* infection in cattle over several years and recent evidence for *M. bovis* infection confirmed by post-mortem evidence. The latter criterion was included because studies measuring the association between badger culling and TB in cattle have

reported stronger associations where cattle have confirmed infection (Donnelly et al, 2007, Downs et al, 2019). In addition anecdotal reports from local veterinarians that suggest that badger involvement in cattle TB was more common where TB has been confirmed by post-mortem tests. The final definition for an *M. bovis* reservoir was compliance with all of the following three criteria:

1. At least one OTF-W (Officially Tuberculosis Free – Withdrawn) incident not attributed to cattle purchasing in 2018 or in 2019.
2. More OTF-W incidents than Officially Tuberculosis Free – Suspended (OTF-S) incidents in cattle herds in 2018 or in 2019.
3. At least one TB incident (OTF-S or OTF-W) in at least three of the previous seven years (2013-2019).

The working group agreed that the definition pertained to a "local reservoir of infection" rather than a purely "badger-associated reservoir of infection" since the reservoir could include other local *M. bovis* infection sources such as infection from deer and residual sources. The definition was applied to 25 km² hexagonal spatial units because these provided the finest scale over which a cattle-based definition could be reasonably calculated and the width of a hexagon (5.4-6.2 km) approximated best to the maximum ranging distance for badgers. It was recognised that the sensitivity of the cattle-based definition declined as herd density declined in the hexagons. However, the main purpose of the work was to identify areas where badger controls could reduce cattle TB.

The validity of the cattle-based definition was evaluated as follows:

1. Latent class analysis (LCA) was conducted calculating the accuracy of the cattle-based definition by comparing the areas classified as positive or negative for a local reservoir according to the cattle-based definition to areas classified as positive or negative according to the ad hoc surveys of infection in dead badgers.
2. Areas detected using the cattle-based definition were compared to areas defined as having endemic TB in a method developed for measuring spatial spread and retraction of TB (Brunton et al, 2015).
3. Veterinary Advisors with detailed knowledge of the disease situation in the Edge Area evaluated the areas detected using the cattle-based definition against local knowledge of TB incidents and putative infection sources.

The cattle-based definition for a local reservoir of *M. bovis* infection performed reasonably well in all evaluations. The performance of the definition measured through the LCA varied according to the weight given to detection of infected badgers in an area.

The working group recognised uncertainty in the location of local reservoirs of *M. bovis* infection as defined. Aggregating data to a grid of hexagons enabled comparisons across the Edge but there was increased uncertainty in areas where few hexagons met the definition. Cattle surveillance data could only provide evidence for an infection reservoir where cattle exist to test and the boundaries of the local reservoir could be larger than those indicated. For this reason a buffer was added to the putative boundary

encompassing the usual maximum ranging of badgers. Additionally, cattle and badgers may not share a common infection reservoir and the local reservoirs could also be smaller than the boundaries indicated.

The working group also advised that badger controls (whether culling or vaccination) should take account of other factors that could affect efficacy of controls against TB including advice from APHA field staff and stakeholders with local knowledge. Furthermore, the distribution of TB is subject to change over time and the distribution of the reservoirs should be reassessed periodically.

The work is being submitted for publication through the peer reviewed scientific press.

References

Brunton L.A., Nicholson R., Ashton A., Alexander N., Wint W., Enticott G., Ward K., Broughan J.M., Goodchild A.V. (2015). A novel approach to mapping and calculating the rate of spread of endemic bovine tuberculosis in England and Wales. Spatial Spatiotemporal Epidemiology. 13, 41-50. doi: 10.1016/j.sste.2015.04.002.

Donnelly C.A., Wei G., Johnston W.T., Cox D.R., Woodroffe R., Bourne F.J., Cheeseman C.L., Clifton-Hadley R.S., Gettinby G., Gilks P., Jenkins H.E., Le Fevre A.M., McInerney J.P., Morrison W.I. (2007) Impacts of widespread badger culling on cattle tuberculosis: concluding analyses from a large-scale field trial. Int J Infect Dis. 11, 300-308.doi: 10.1016/j.ijid.2007.04.001.

Downs S.H., Prosser A., Ashton A., Ashfield S., Brunton L.A., Brouwer A., Upton P., Robertson A., Donnelly C.A., Parry J.E. (2019) Assessing effects from four years of industry-led badger culling in England on the incidence of bovine tuberculosis in cattle, 2013-2017. Sci Rep. 9, 14666. doi: 10.1038/s41598-019-49957-6.