

Modelling freedom from Bovine Tuberculosis in herds in England and Wales.

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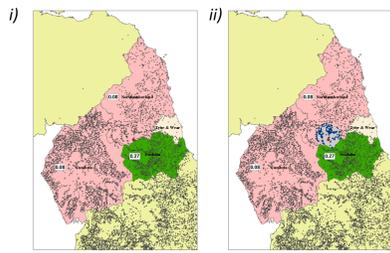
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1. Introduction

Bovine Tuberculosis (BTb) is an infectious disease of cattle caused by the bacterium *Mycobacterium bovis* and can additionally cause disease in other livestock, wildlife and companion animals. The disease is endemic in England and Wales and cases are generally detected through routine screening using comparative tuberculin skin tests and meat inspection at slaughter. Whilst disease surveillance and epidemiology are extensive, establishing disease prevalence is complicated by variations in test sensitivity, risk-based testing regimes, geographical clustering of disease, animal movements and wildlife involvement.

3. Approaches

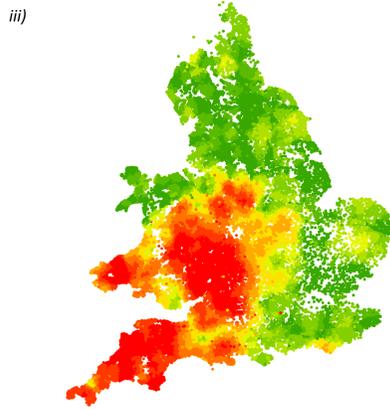
A. Force of infection



One of the major input parameters into the model is an estimate of incidence that provides an estimate of the local infection pressure for the herd in question. This infection pressure includes estimates for the probability of disease exposure via movements, wildlife, recurrence and local infection via contiguous farms.

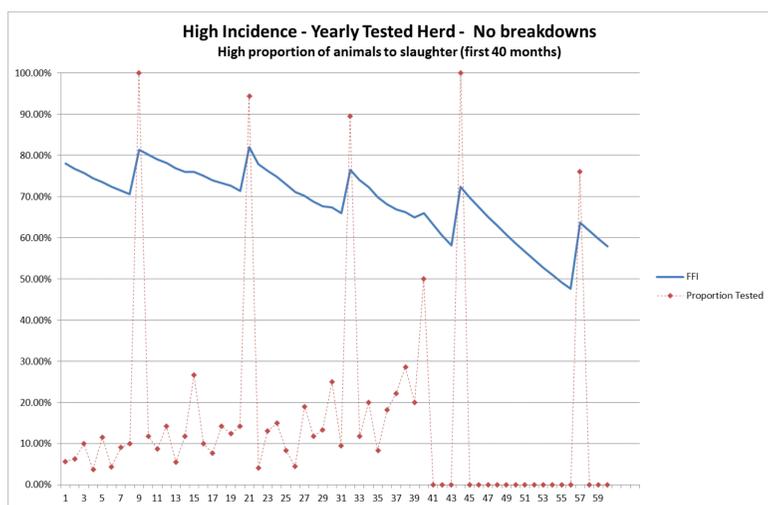
Historically, incidence for bTB has been calculated at parish and county level, however for this model we wanted a finer resolution of detail that wasn't dependent on political boundaries and took into account historical bTB test results. For this purpose we used the Time at Risk (TAR) incidence rate (number of new bTB incidents in the time period / time herd was at risk) described by Downs et al (2013) using the spatially closest 200 farms to the index farm in question.

Figures (i) and (ii) on the left describe the selection of farms and figure (iii) shows the geographical variation in final TAR across England and Wales. In the final model, the TAR incidence rate was recalculated on a yearly basis.



B. Bayesian approach to testing

- The force of infection parameter as described above is used as both an informed prior at the initialisation stage and to reduce the probability that the herd is free from BTb at monthly intervals.
- Every recorded clear test on the herd in question then affects the probability the herd is actually free from disease via bayesian inference. The degree to which this changes depends on the proportion of animals in the herd tested and the sensitivity of the tests used.
- The tool uses all tests recorded including, routine herd tests, tracing tests, pre and post movement tests, meat inspection at slaughterhouse, inconclusive reactor retests. Whilst control tests are included, in practice these have no impact on disease freedom as herds are reported as infected whilst under movement restriction.
- The chart below shows a high incidence herd and its FFI score changing over time (the blue line) whilst the herd is continuously tested through part and whole herd tests.



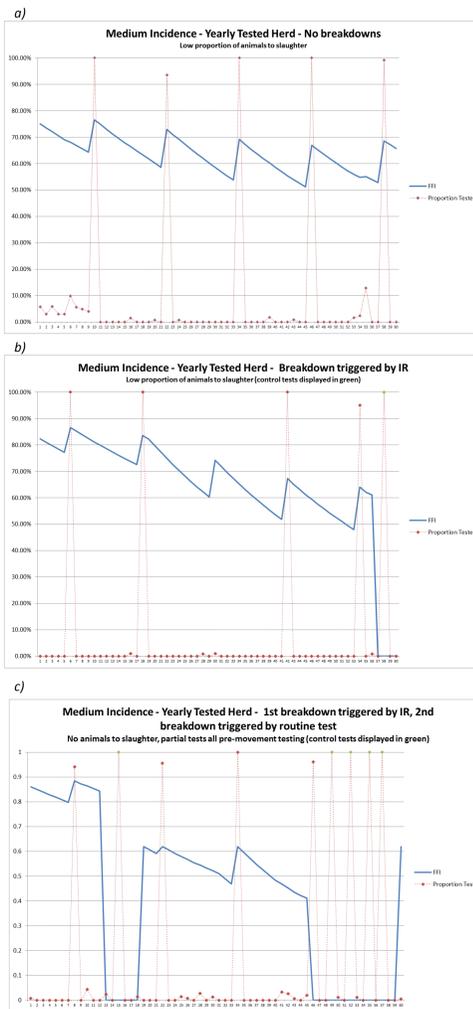
E. References

- Downs SH, et al. Meta-analysis of diagnostic test performance and modelling of testing strategies for control of bovine tuberculosis in GB. In: Proceedings of SVEPM. Leipzig, Germany, 2011, pp. 139–153.
Downs SH, et al. Tuberculin manufacturing source and breakdown incidence rate of bovine tuberculosis in British cattle, 2005–2009. Veterinary Record, 2013;172:98

2. Objectives

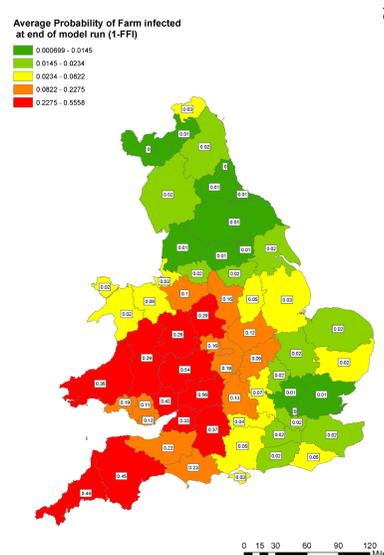
- The main objective of this model was to obtain estimates of freedom of BTb infection (FFI) of all herds in England and Wales active between 2006 and 2010.
- This was to be achieved by modifying an existing model developed by AUSVET (Downs et al, 2011) as a proof of concept for a previous project and to allow the use of historical data to create a working tool for evaluation FFI over time of real herds in England and Wales

C. Freedom over time for individual holdings



- Herds (a), (b) and (c) are in medium incidence areas subject to yearly testing.
- With each month that passes the probability that each herd is free from Btb decreases relative to the local force of infection.
- Testing, both at animal and herd level, increase the probability that the herd is free from disease
- Herd (a) shows an example where the disease pressure is similar to the disease freedom suggested by routine testing.
- Herd (b) shows an example where the disease pressure is higher than the freedom implied from the volume of testing.
- Herd (c) is similar to herd (b) but in addition is complicated by detection of BTb and subsequent movement restrictions

D. Freedom over time at county level



The final output produced monthly FFI scores for 5 years for 60335 herds in England and Wales. The map to the left shows probability that a farm is infected at the end of the 5 years aggregated to county level.

This model went on to be used as a proxy for true disease prevalence in a project evaluating potential schemes to help inform the creation of a risk-based trading policy in England and Wales.

The model is fully stochastic allowing for modelling of uncertainty with regards to test sensitivities and specificities.



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