Characterizing transmission of *Mycobacterium bovis* in a multi-host system

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Background

In Ireland in 1954, approximately 80% of the cattle herds were infected with *Mycobacterium bovis* (*M. bovis*), causative agent for tuberculosis in cattle. A control/eradication programme based on test and removal commenced. This programme achieved a reduction of >94% of the cattle incidence in less than 10 years. Tuberculosis incidence in cattle has remained stable at a low level since. Subsequent to the discovery of badgers (*Meles meles*) as a second host, badger removal was added to the list of control options that focused on reducing cattle to cattle transmission.

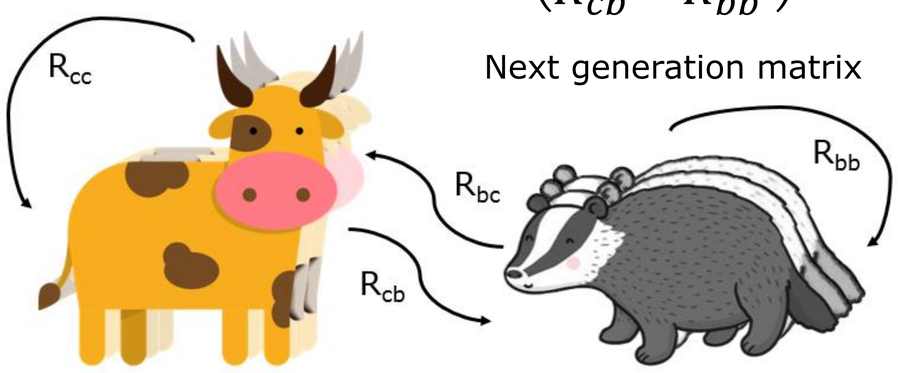
Objectives

- Quantify inter- and intra-species transmission parameters for the *M. bovis* cattle and badger system in Ireland, to determine the quantitative role of each species in total transmission.
- Determine if Bacillus Calmette-Guerin (BCG) badger vaccination could contribute to eradication of *M. Bovis* infection from the cattle and badger system.

Methods

$$\begin{pmatrix} R_{cc} & R_{bc} \\ R_{cb} & R_{bb} \end{pmatrix}$$

Next generation matrix

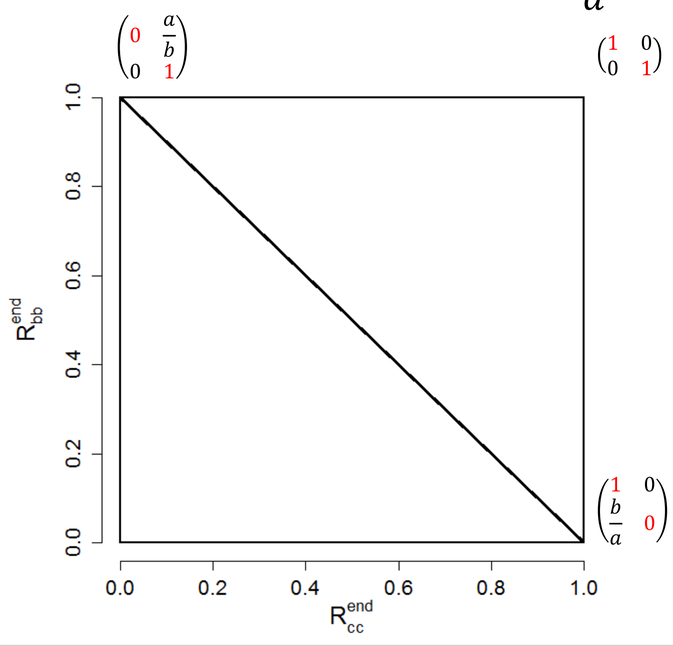


R_{xy} is the average number of new cases of type y caused by an average infected individual of type x in a fully susceptible population.

$$\begin{pmatrix} R_{cc}^{end} & R_{bc}^{end} \\ R_{cb}^{end} & R_{bb}^{end} \end{pmatrix} \begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} a \\ b \end{pmatrix}$$

$$R_{bc}^{end} = \frac{a}{b}(1 - R_{cc}^{end})$$

$$R_{cb}^{end} = \frac{b}{a}(1 - R_{bb}^{end})$$

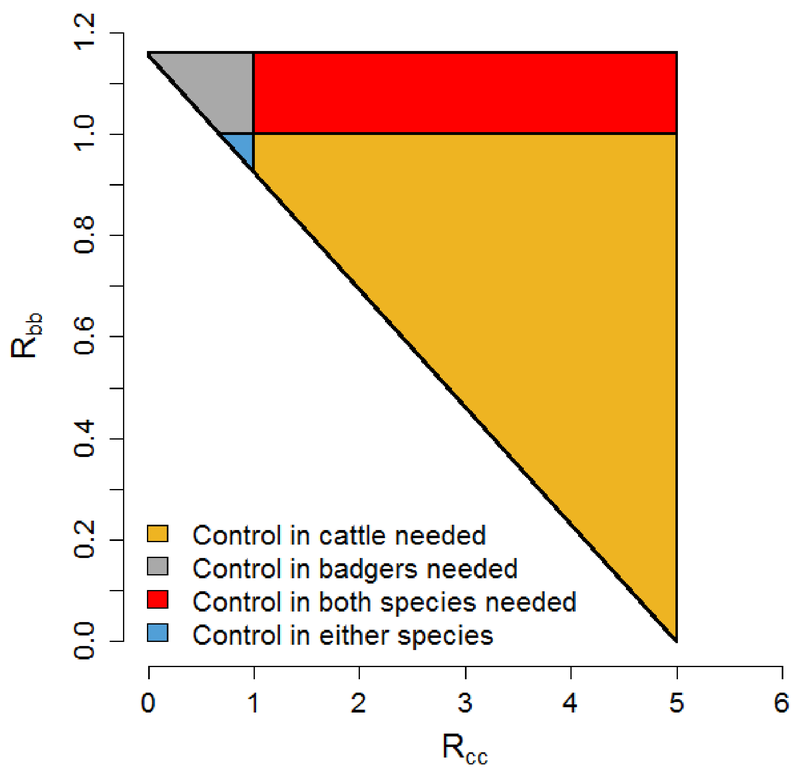


Results

Before test and removal

Cattle herd prevalence 80% → R_c = 5

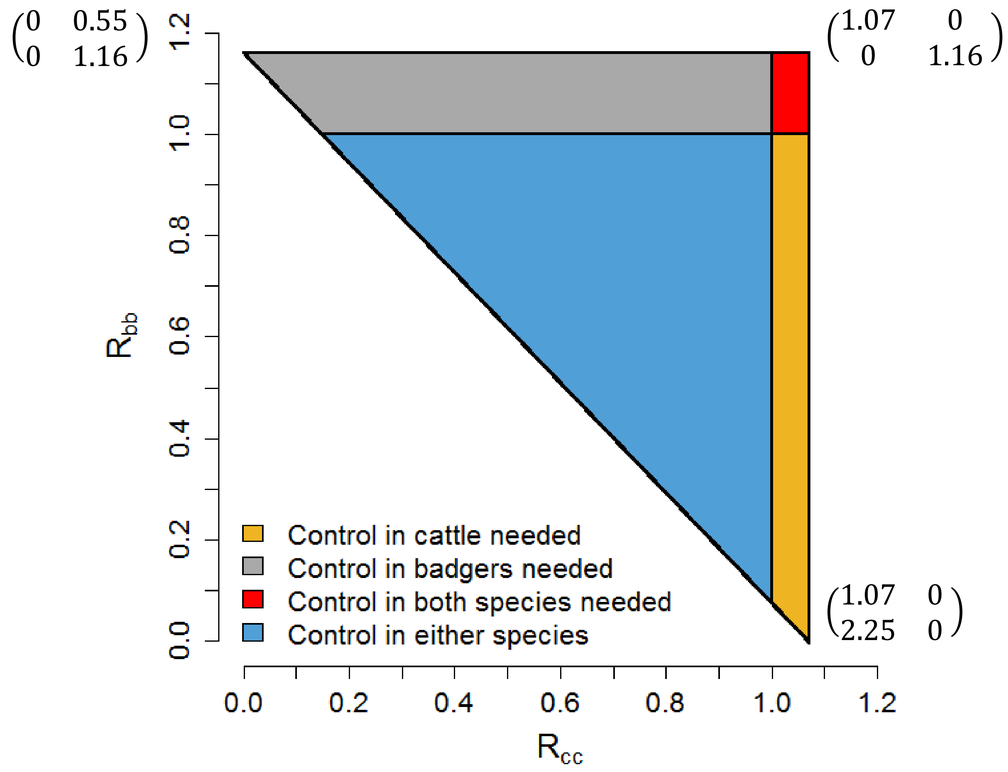
Badger prevalence 14% → R_b = 1.16



After test and removal

Cattle herd prevalence 6% → R_c = 1.07

Badger prevalence 14% → R_b = 1.16



Conclusions

Eradication is only possible when $\min(R_{cc}^{max}, R_{bb}^{max}) < 1$, and certain when $\max(R_{cc}^{max}, R_{bb}^{max}) < 1$.

For almost all plausible transmission scenarios (blue and grey in the figures): BCG badger vaccination could successfully eradicate *M. bovis* infection from the system when used in addition to the current control measures.

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