Estimating badger numbers from badger survey signs, with applications to bovine TB prediction

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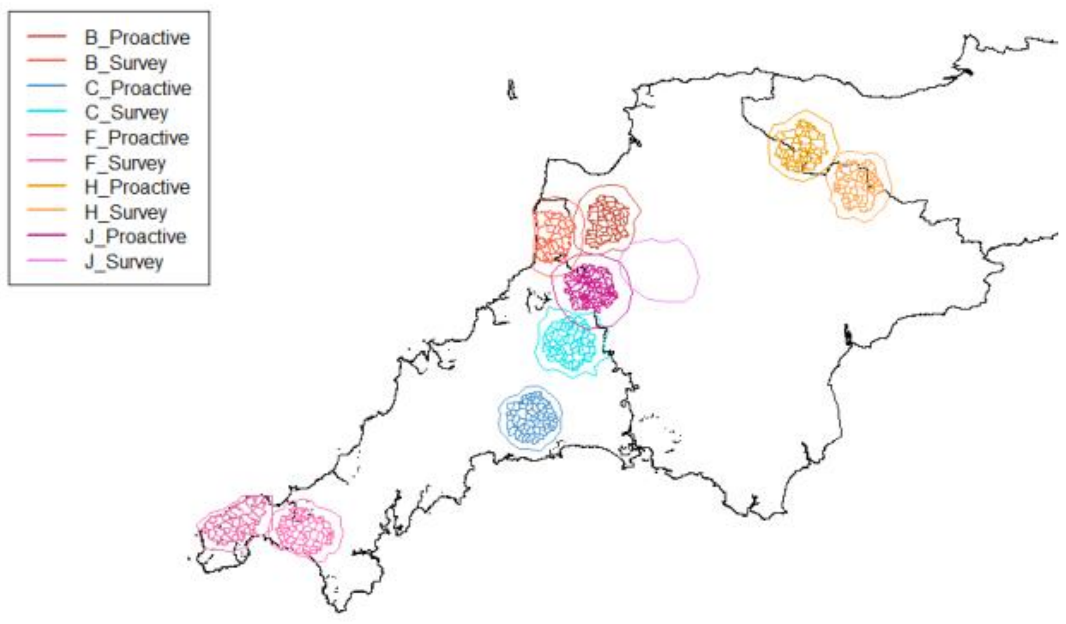
Introduction

- Estimation of badger numbers often has to rely on indirect signs of activity as direct and undisruptive methods are expensive and difficult to implement.
- Badgers are considered to be a reservoir for bovine tuberculosis (bTB).
- The Randomised Badger Culling Trial was conducted in England between 1998-2005 to investigate the effect of intensive culling of badgers on bTB incidence.
- Areas in South West England were chosen and paired into control (badger survey only) and treatment (proactive badger culls) areas.



Aims of this study

Using badger numbers estimated from the number of badgers culled in the proactive areas,
1- To assess the feasibility of using badger signs from field surveys as a proxy for estimating badger numbers;
2- To compare quality of predictions from different models via cross-validation.

Data

- Badger activity signs from the 1st survey (table 1) were collated at the badger social group level in 5 of the 10 proactive areas.
- Number of badgers for each social group in every area were computed from the numbers trapped in that social group.
- Badger age was used to decide whether a trapped badger would have been alive at the time of the 1st survey.

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Table 1: List of badger signs used in the models

MS	Number of main setts
AH	Number of active holes
IH	Number of inactive holes
L	Number of latrines
MSCor	Number of main setts corrected by the % of the social group area surveyed
AHCor	Number of active holes corrected as above
IHCor	Number of inactive holes corrected as above
LCor	Number of latrines corrected as above
LTS2C	Log of number of traps set to catch badgers (used both as fixed effect and offset)

Models

- 4 model-types fitted: Log Normal, Poisson, Poisson with extra-variance to capture overdispersion, and negative binomial.
- All models fitted with WinBUGS, using flat prior distributions; iterations: 1000 burnin, and 140000 update.

Cross-validation principle

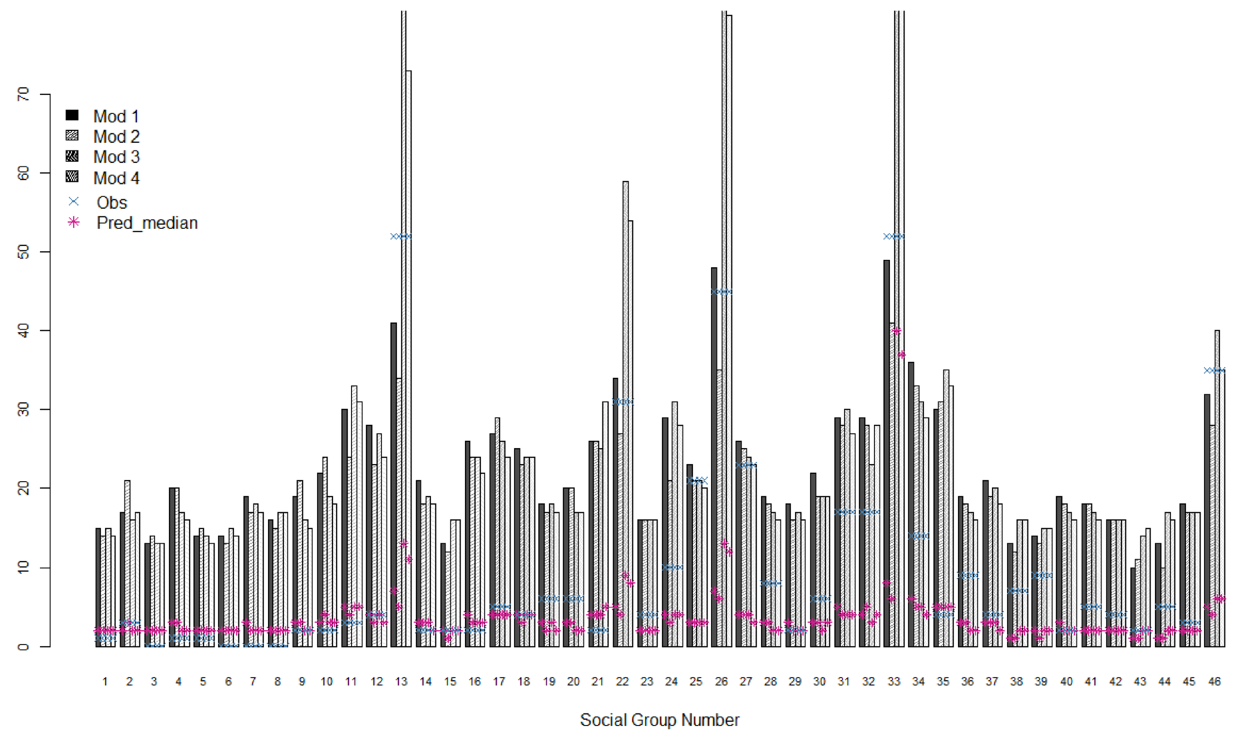
- Data from 4 out of 5 areas used to estimate model parameters.
- Badger numbers in the social groups for the 5th area estimated using these parameter estimates.
- Prediction compared using
  - Predicted Mean Squared Error (PMSE):

$$\frac{\sum_{i=1}^{N}\left(Y_i-\hat{Y}_i\right)^2}{N}$$

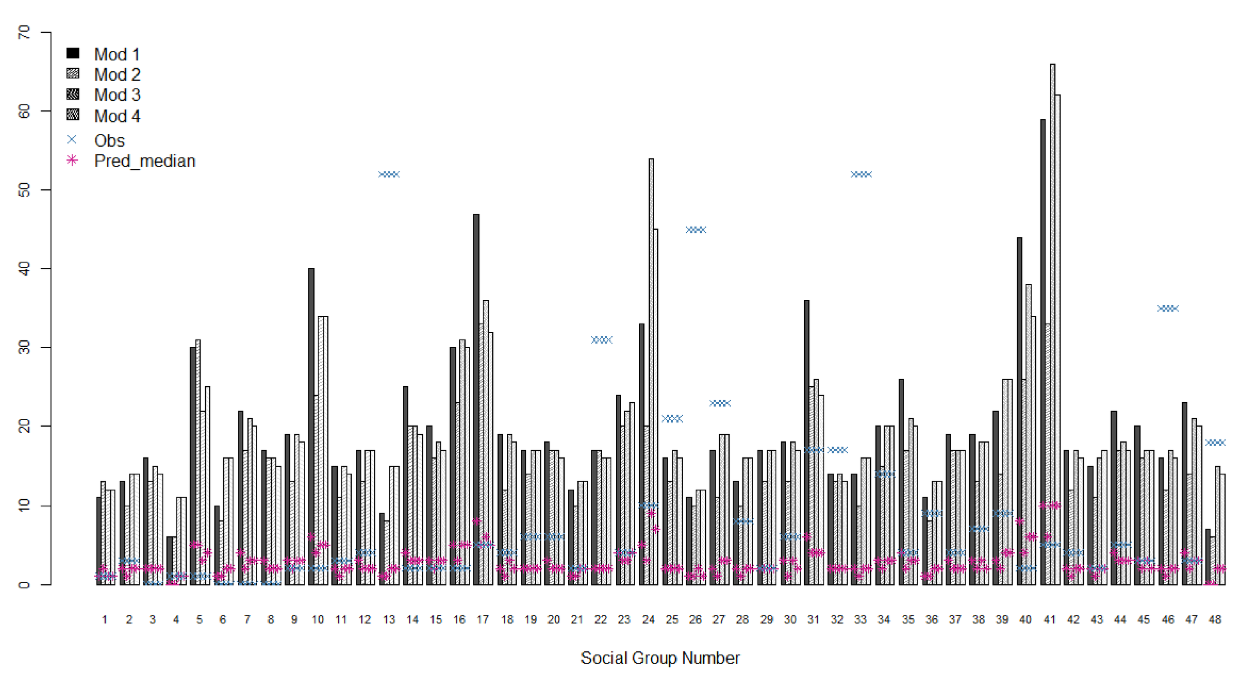
-Coverage :

$$\frac{\left(\sum_{i=1}^{N} I\left(\hat{Y}_i^{2.5}\le Y_i\le \hat{Y}_i^{97.5}\right)\right)}{N}$$

Result 2: Number of badgers predicted by the models for 2 of the 5 areas



Area B



Area H

Result 1: Model comparison

Model	Distribution	PMSE	Coverage (%)
Mod 1 ~ log(MS) + log(AH) + log(IH) + LTS2C	Log Normal	214	73
Mod 2 ~ log(MSCor) + log(IHCor) + LTS2C	Log Normal	219	74
Mod 3 ~ MSCor + AHCor + IHCor + LTS2C	Log Normal	208	72
Mod 4 ~ MS + AH + IH + LTS2C	Log Normal	210	74
Mod 5 ~ log(MS) + log(IH) + LTS2C	Poisson + Ov	224	70
Mod 6 ~ log(MS) + log(IH) +LTS2C	Neg Binomial	221	68
Mod 7 ~ log(MSCor)+log(AHCor)+log(IHCor)+log(LCor)+LTS2C	Poisson	223	51

Conclusions

Using signs of badger activity, we were able to estimate the number of badgers per social group with an average coverage over 70 % (95% credibility intervals).
The numbers estimated can be used as predictors in models of bTB.
However, the confidence intervals around those estimates are wide, reflecting the variability in the data records.
The different models tested were also very similar in the prediction accuracy.

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