Bayesian risk assessment on BSE in imported cattle

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Introduction

In this study we developed an Bayesian model to quantify the BSE risk associated with the disposal of imported cattle on a yearly basis. This was based on a synthesis of two sub-models: a method to Estimate Missing Data (EMD) on imported cattle and a Prevalence model of BSE in Countries of Origin (PCO).

Materials & methods

Available annual data on the Country of Origin (CO), the Year of Birth (YB), Year of Import (YI) and the Year of Disposal (YD) of individual cattle was gathered from a total of 1984 imported animals during 1980-2002. Data on Apparent Prevalence (AP) of BSE in the COs were gathered from the reports of the EU Commission (2003-2005).

(1) The EMD-model utilizes all partial cattle specific data to estimate the missing data as Bayesian posterior distributions. (2) The PCO-model describes the true prevalence in each CO as a time series model bounded by min and max values. The computations of the whole combined model were performed using WinBUGS 1.4.

Bayesian modeling

(1) Estimating missing data (EMD)

$$P(\mu_1,\ldots,\mu_8,\Sigma_1,\ldots,\Sigma_8,x_1^{\text{mis}},\ldots,x_8^{\text{mis}} \mid x_1^{\text{obs}},\ldots,x_8^{\text{obs}}) \propto \prod_{c=1}^{8}\prod_{i=1}^{n_c} \text{MN}(z_{c,i} \mid \mu_c,\Sigma_c) I_{\{z_{c,i}\in Z_{c,i}\}} P(\mu_c,\Sigma_c \mid c) P(c)$$

c = import country, i = index of the animal.

$x_{c,i} = (x_{c,i}^{(1)}, x_{c,i}^{(2)}, x_{c,i}^{(3)})$= year of birth, import & disposal

$z_{c,i} = (z_{c,i}^{(1)}, z_{c,i}^{(2)}, z_{c,i}^{(3)})$= latent variable for $x_{c,i}$.

(2) probability of BSE per country of origin (PCO)

$$P(\text{BSE true} \mid c, x_{c,i}^{(1)} = t) = p_{c,t}$$

$$P(\log p_{c,t} \mid \log p_{c,t-1}) = \text{N}(\log p_{c,t-1}, \sigma^2) I(\log a_{c,t}, \log b_{c,t})$$

$$a_{c,t} \sim \text{Beta}(x_{c,t}+1, n_{c,t}-x_{c,t}+1)$$

$$b_{c,t} \sim \text{Beta}(x_{\text{UK},t}+1, n_{\text{UK},t}-x_{\text{UK},t}+1)$$

$$P(\text{BSE apparent} \mid c, x_{c,i}^{(1)} = t) = a_{c,t}$$

$$\#_{c,t}^{\text{apparent}} \sim \text{Bin}(N_{c,t}, a_{c,t}) \qquad \#_{c,t}^{\text{true}} \sim \text{Bin}(N_{c,t}, p_{c,t})$$

t = year of birth (cohort).

$a_{c,t}$ = lowest true prevalence in country c.

$b_{c,t}$ = highest true prevalence in country c.

$x_{c,t}$ = no. of positive BSE tests, in country c.

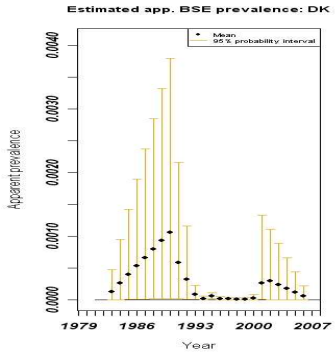
$n_{c,t}$ = no. of BSE tests taken, in country c.

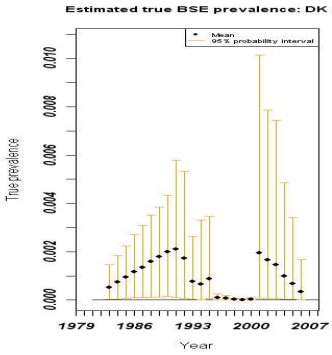
$x_{\text{UK},t}$ = no. of positive BSE tests, in UK.

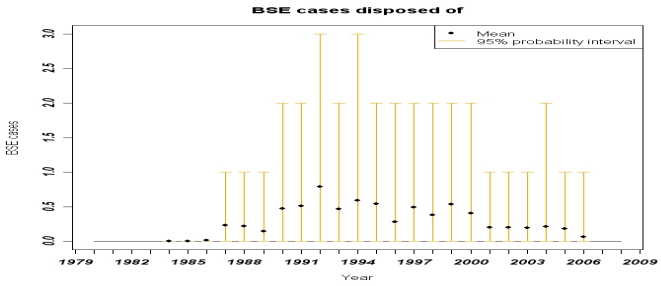
$n_{\text{UK},t}$ = no. of BSE tests taken, in UK.

$N_{c,t}$ = no. of imported cattle, from country c.

Results







Time span	Risk management in force	No. of imported cattle disposed of (*) 2.5%	mean	97.5%
1980-1995	-	0/0/193	0.23/4.00/216	2/11/241
1996	Ruminant feed ban	0/0/63	0.05/0.28/75	1/2 /89
1997-1999	+Rendering req.	0/0/339	0.26/1.41/364	2/4 /390
2000	+Exclusion of SRM	0/0/151	0.10/0.40/168	1/2 /188
2001-2006	+Total feed ban	0/0/1129	0.33/1.05/1159	2/4 /1193

+ = In addition to previous.

(*) Estimated apparent cases / Estimated true cases / All cattle disposed of.

Discussion

The risk management has developed to be more extensive over the years at the same time as the estimated number of imported BSE cases disposed of has declined. Inference including only records with complete data, ignoring partially missing records typically underestimates uncertainty and can induce selection biases. An assessment should correctly account for any partially missing factors. The EMD-model is generally applicable to any import RA where partially missing data present a problem. The PCO is dependent on the validity of the assumption that the upper level of true prevalence for each CO is set equal to the AP for UK. In assessing the risk we used information on risk management practice in Finland in combination with YB and YD which in the case of BSE is more relevant than the YI alone.

References

1. Report on the monitoring and testing of ruminants for the presence of TSE. European Commission, (2003-2005).

2. P Congdon: Bayesian Statistical Modelling. Wiley, Chichester, (2001).