



**HAL**  
open science

## Studying the seasonality of scrapie transmission in an experimental flock

Suzanne Touzeau, Margo E. Chase-Topping, Louise Matthews, Daniel Lajous, Jean Michel J. M. Elsen, Mark E. J. Woolhouse

### ► To cite this version:

Suzanne Touzeau, Margo E. Chase-Topping, Louise Matthews, Daniel Lajous, Jean Michel J. M. Elsen, et al.. Studying the seasonality of scrapie transmission in an experimental flock. International conference on transmissible spongiform encephalopathies, Sep 2002, Edinburgh, United Kingdom. 1 p., 2002. hal-02832968

**HAL Id: hal-02832968**

**<https://hal.inrae.fr/hal-02832968v1>**

Submitted on 7 Aug 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

# Studying the seasonality of scrapie transmission in an experimental flock

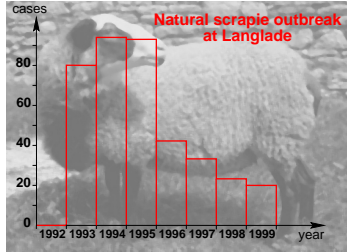
S. Touzeau<sup>1</sup>, M.E. Chase-Topping<sup>2</sup>, L. Matthews<sup>2</sup>, D. Lajous<sup>3</sup>, J.-M. Elsen<sup>3</sup>, M.E.J Woolhouse<sup>2</sup>

Institut National de la Recherche Agronomique: <sup>1</sup>Jouy-en-Josas, <sup>3</sup>Toulouse, France – <sup>2</sup>Centre for Tropical Veterinary Medicine, Edinburgh, Scotland

## I. INTRODUCTION/OBJECTIVES

Presence of scrapie prions in the placenta suggests the possibility of **increased transmission during lambings**, an hypothesis we explore with a mathematical model focused on the disease transmission. The initial model was developed by Woolhouse's group [1] for several outbreaks in British sheep (e.g. [2]). We apply it here to the Langlade experimental flock in which a natural scrapie outbreak started in 1993 [3].

## II. METHODS



### II.1. DATA

- Experimental flock, INRA Toulouse; created 1971, closed 1979-96.
- Mostly Romanov breed (prolificity: 1-6, mean 3.1), size ca. 900.
- ➔ **Study flock:** Romanov, > 8 months, cohorts 83-95.

**Data available:** birth & death/removal, pedigree, scrapie histopathological diagnosis, PrP genotypes (10 from 4 alleles: VRQ, ARQ, AHQ, ARR).

### II.2. MODEL

**Dynamic system:** time  $t \geq 0$ , age  $0 \leq a \leq \Lambda$ , infection load  $0 \leq \theta \leq 1$ .

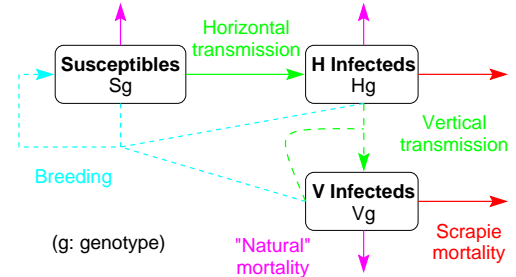
**Seasonal birth:** rate  $b(t, a') = b(t)$  if dam  $a'$  mature, = control / flock size  $\approx$  constant; + genetics: random mating  $G_{gg'}$ (t).

**Natural mortality:** truncated Weibull  $\mu(a)$ ,  $a < \Lambda$  (survival).

**Horizontal transmission  $g' \rightarrow g$ :** rate  $\beta_{gg'}(t, \theta') = k_h \sigma_g \theta' s(t)$ , genetic susceptibility  $\sigma_g$ , infectiousness  $\propto \theta'$ , season  $s(t)$ ; + variable initial load  $\theta_0$ : gamma distribution  $\Theta$ .

**Vertical transmission  $g' \rightarrow g$ :** rate  $\gamma_{gg'}(t, \theta') = k_v \sigma_g \theta'$ .

**Scrapie:** during incubation  $\frac{d\theta}{dt} = c_g \theta \rightarrow \theta = 1$ : clinical signs & death.



$$\left(\frac{\partial}{\partial t} + \frac{\partial}{\partial a}\right) S_g(t, a) = -S_g \sum_{g'} \int_0^1 \beta_{gg'} [H_{g'} + V_{g'}] d\theta' da' - \mu S_g$$

$$S_g(t, 0) = \sum_{g'} G_{gg'} \int b \left( S_{g'} + \int (1 - \gamma_{gg'}) [H_{g'} + V_{g'}] d\theta' \right) da'$$

$$\left(\frac{\partial}{\partial t} + \frac{\partial}{\partial a} + \frac{\partial c_g \theta}{\partial \theta}\right) H_g = \Theta S_g \sum_{g'} \int \beta_{gg'} [H_{g'} + V_{g'}] d\theta' da' - \mu H_g$$

$$H_g(t, 0, \theta) = 0 \quad H_g(t, a, 0) = 0$$

$$\left(\frac{\partial}{\partial t} + \frac{\partial}{\partial a} + \frac{\partial c_g \theta}{\partial \theta}\right) V_g(t, a, \theta) = -\mu V_g$$

$$V_g(t, 0, \theta) = \Theta \sum_{g'} G_{gg'} \int \gamma_{gg'} [H_{g'} + V_{g'}] d\theta' da' \quad V_g(t, a, 0) = 0$$

## III. RESULTS

Outbreak simulation

### 1. Parameters

**From data:** lambing/transmission season, random mating  $G_{gg'}$ , natural mortality  $\mu$ , genetic susceptibility  $\sigma_g$  (VRQ-VRQ=0.78, VRQ-ARQ=0.57, ARQ-ARQ=0.48).

**Fitted:** transmission  $k_h, k_v$  and incubation  $\Theta, c_g$  (mean = 2 yrs).

**Outputs:** **incidence** = scrapie case distribution **with** seasonal transmission (= during lambings) or **without**; **prevalence** = proportion of infecteds **with** seasonal transmission.

### 2. Initial condition

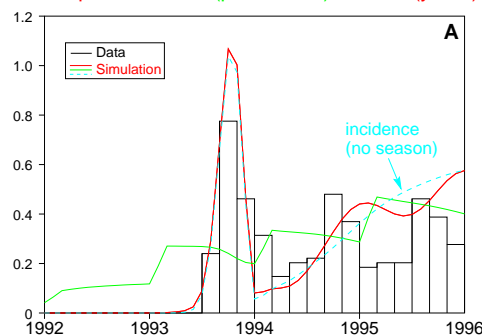
**From data:** susceptibles  $S_g(0, a)$  + scrapie infecteds  $H_g(0, a, \theta)$  from experimental\* batch, born end 1991 and 1st showing signs.

➔ **Horizon:** 1992-96 (same breeding practices).

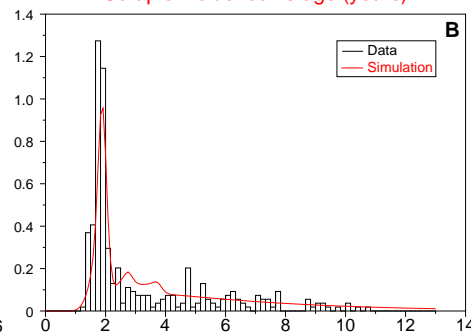
\* Experiment: genetic susceptibility to *Teladorsagia*, cf. [3].

### 3. Numerical method: Lax-Wendroff; Fortran code.

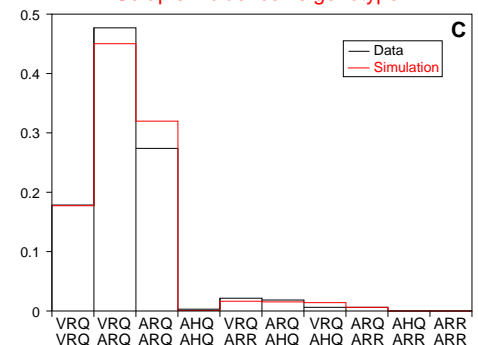
Scrapie incidence (prevalence) vs time (years)



Scrapie incidence vs age (years)



Scrapie incidence vs genotype



## IV. DISCUSSION

**A.** Oscillations appear with seasonal transmission, closer to data. 1st peak from initial condition.

**B.** No age dependent susceptibility implemented, still peak around 2 years because of exposure.

**B&C.** Both case distributions quite in accordance with the data.

## V. CONCLUSIONS

The seasonal transmission hypothesis seems consistent with the patterns we observe with our model.

**Further work:** • better fit for transmission;

• vertical → perinatal transmission.

### REFERENCES

- [1] Stringer et al. 1998, Math. Biosci. 153(2):79-98.  
[2] Matthews et al. 2001, Arch. Virol. 146(6):1173-1186.  
[3] Elsen et al. 1999, Arch. Virol. 155(3):431-445.

