Stochastic Agent-Based Modelling of Jaagsiekte Transmission in a Typical Scottish Sheep Flock

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What is Jaagsiekte?

Jaagsiekte, also known as Ovine Pulmonary Adenocarcinoma (OPA), is a contagious lung cancer of sheep.

- It is caused by the Jaagsiekte Sheep Retrovirus (JSRV).
- It is a particular problem in Scotland but is found in many countries around the world.
- Clinical symptoms often include production of copious lung fluid (see photo, right).
- The prevalence in Scotland is currently unknown.
- Transmission is believed to occur mainly via respiratory route but indirect transmission via the environment cannot be ruled out.

Why is modelling useful?

Modelling is useful for many reasons…

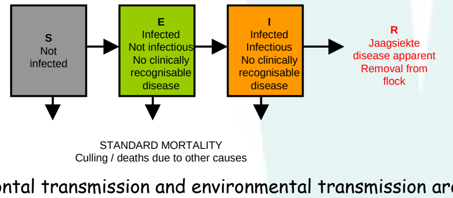
- to assess potential Jaagsiekte control measures.
- to provide further insight into the relative importance of different Jaagsiekte transmission routes.
- to integrate sheep management strategies & knowledge of disease into a single structure.

Stochastic modelling is required as the number of clinically affected sheep in a typical affected flock is very low.

Stochastic ***agent-based*** modelling is used in order to facilitate straightforward modelling of the vertical transmission that may occur between the ewe and lamb and to model certain control measures.

How can Jaagsiekte infection be modelled?

- Progression of infection is modelled using an SEIR compartmental model:



- Horizontal transmission and environmental transmission are modelled by calculating a cumulative hazard value for each sheep, initially set to zero. At each timestep (of one week), the hazard is incremented by a term

$$\beta_{direct}(I+R)+\beta_{indirect}\int_{t_{n-1}}^{t_n} f(c(t))dt.$$

Here the two β parameters describe *direct* transmission between sheep and *indirect* transmission via the environment. The function $c(t)$ models environmental contamination, while $f(c(t))$ represents the force of infection corresponding to $c(t)$. Transmission occurs when the cumulative hazard passes the random threshold specified for a specific animal.

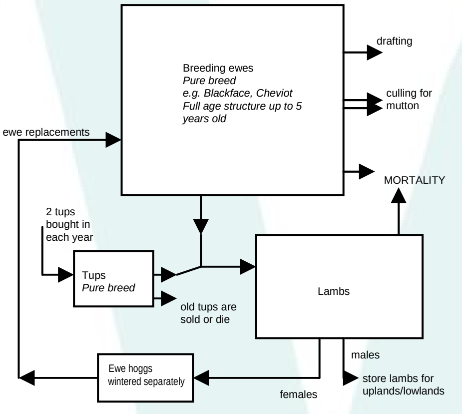
- Vertical transmission between the ewe and lamb is modelled via p, the probability that a lamb is infected given an infectious dam.

What is a typical Scottish sheep flock?

There is no such thing. However, the geography of Scotland has strongly influenced the type of sheep management practiced in different regions. Generally speaking, there are three types of flock:

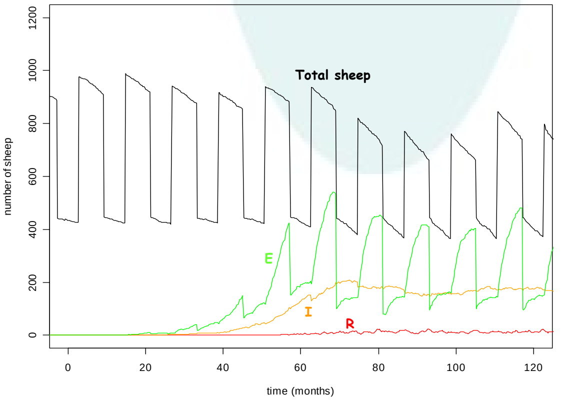
- Hill (see diagram below)
- Upland
- Lowland.

Each flock type has been modelled separately in this project. Most real farms broadly resemble one of the above three types.



What qualitative dynamics can we expect?

The figure below summarises a simulation of a lowland farm, using hypothetical but plausible infection parameters. A single infected sheep is introduced at time zero. The total number of sheep is plotted, together with the numbers in each compartment E, I, and R. The model is currently being parameterised using survey data and further results will follow.



Acknowledgements

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