Modelling animal movement patterns for disease impact assessment - rationale and implications of the FLI/DTU EuFMD-FAR project

FMD

- Risk of introduction
- Different control options
- Decisions must be taken: Recommendations?

=> Simulation models
Different prevention and control strategies

- Culling
- Vaccination
- Stand still
- Movement restrictions

Reduced social acceptance of massive culling of animals
FMD - simulation models

-Davis Animal Disease Simulation (DADS) model - University of California, Davis

-North American Animal Disease Spread Model (NAADSM) - Center of Epidemiology and Animal Health and United States Department of Agriculture

-InterSpreadPlus (ISP) model - Massey University, New Zealand
FMD simulation model

- **DADS selected** (Bates et al., 2003; Halasa et al., 2014)

- Simulation of transmission
  - intra- and inter-herd

- Spatial, stochastic, state-transition model

- Deterministic on animal-level

- Time steps of 1 day


Halasa et al., 2014, PLOS ONE. 9 (3): e92521
Spread mechanisms

Local spread in 3 km
Animal Movements

- Crucial for spreading the disease
- For simulation: number of individual animals moved on farm level (network of movements between farms)
- Not available in all situations
  - Due to data protection issues => data on administrative unit only available
  - Or not available at all village (= epidemiological unit)
Animal Movements

- Aggregation of movements on administrative unit or village level possible, but farm level data still used for precise modelling of the disease and flexibility (if farm level data are available)

=> Hybrid approach

- Individual infected farm within a source village
- Randomly chosen movement from this village
- Leads to target village
- Randomly chosen individual farm within the target village will be infected
Animal movements evaluation

In degree

Movements into municipalities accumulated over 4 years
- 0 - 37
- 38 - 155
- 156 - 437
- 438 - 1435
- 1436 - 70607

Cumulative affected

No. outbreaks without control accumulated over 100 iterations
- 0 - 9
- 10 - 33
- 34 - 88
- 89 - 237
- 238 - 4101
Simulation model - disease control (basic)

Day first detection

Tracing of contacts

Surveillance in zones

3 km Protection zone

Cull detected

10 km Surveillance zone

Movement restrictions

Transport vehicle

Abattoir

Simulating model of disease control (basic)
• Comparison of different scenarios
  - **Basic** - no resource limits
  - **Basic** - *with resource limits*
  - Depopulation within 1 km zone
  - Vaccination 'to live' of *cattle* in 3 km/10 km zone
  - Vaccination 'to live' of *cattle and pigs* in 3 km/10 km zone
  - Vaccination 'to cull' of *detected farms* in 3 km zone
  - Vaccination 'to cull' of *all farms* in 1km/3 km zone
• Preliminary running of scenarios
  - 100 simulations per scenario

- Stop criteria
  • If more than 1000 herds are infected (excluding the culled herds)
  • AND time >90 days

- Duration of epidemic and number of infected herds
Preliminary results - duration of epidemic

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic no limits</td>
<td>1</td>
</tr>
<tr>
<td>Basic with limits</td>
<td>8</td>
</tr>
<tr>
<td>Depop.</td>
<td>1</td>
</tr>
<tr>
<td>Vacc live cattle 3km</td>
<td>7</td>
</tr>
<tr>
<td>Vacc live cattle/pigs 3km</td>
<td>5</td>
</tr>
<tr>
<td>Vacc live cattle 10km</td>
<td>4</td>
</tr>
<tr>
<td>Vacc live cattle/pigs 10km</td>
<td>3</td>
</tr>
<tr>
<td>Vacc cull det. farms 1km</td>
<td>8</td>
</tr>
<tr>
<td>Vacc cull det. farms 3km</td>
<td>5</td>
</tr>
<tr>
<td>Vacc cull all farms 1km</td>
<td>2</td>
</tr>
<tr>
<td>Vacc cull all farms 3km</td>
<td>2</td>
</tr>
</tbody>
</table>
Preliminary results - infected herds
Sensitivity analysis - high risk period - basic scenario duration
Sensitivity analysis - high risk period - depopulation duration
Preliminary results

- Output similar, except for the number of extreme runs (stop criteria)

- High-risk-period sensitivity analysis shows influence of this parameter, but more detailed investigation necessary (daily modification)
Summary

- Model is suitable for simulating movements on administrative unit and village level as well as farm level depending on the availability of data ➔ more widely applicable for countries and regions

- Provides a tool for management and decision makers
Further work needed to optimise this tool for policy makers and epidemiologists

- Sensitivity analysis of different parameters
- Implementation of additional control options
- Different combinations of control tools (e.g. vaccination and culling)
Further work needed to optimise this tool

- Conditions that favour vaccination-to-live
  • With and without large export of animals or products

- Investigate resource limits
  • staff, vaccines, culling capacities

- Economic effects of different control options

- Input-data-files for easier use
Thank you very much

State veterinary service
Veterinary association
Meat processing industry
Milk processing industry
Inseminator organisations
Rendering industry