Evaluation of the effectiveness of control measures for prevention of calf infection by *Mycobacterium avium paratuberculosis*: a modelling approach

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Introduction & Objective

Johne's disease is a chronic and progressive intestinal inflammatory disease in cattle and other ruminants caused by *Mycobacterium avium* subsp. *paratuberculosis* (*Map*). Worldwide, Johne's disease has great economic importance for dairy producers. In affected herds, economic losses attributable to Johne's disease are a result of mortality or premature culling of sick animals, reduced milk production and lower slaughter value of clinically infected cows. Several countries have attempted for several years to eradicate the disease with organized control programs. Experience suggests that these programs are of limited effectiveness in relation to removing infection from farms and are very costly to the whole industry. There is therefore a need for developing effective and economically attractive control programs against Johne's disease and programs based on epidemiological criteria (other than eradication) and economical criteria are now considered.

In that context, the objective of the current project is to model intra-herd transmission of paratuberculosis in infected dairy herds in order to examine the effect of available control measures depending on the importance of different transmission routes. The model developed for the project will take into account new knowledge on the pathobiology of the disease such as in relation to calf-to-calf transmission.

Transmission assumptions

The infection with *Map* occurs mainly in newborn calves (Doyle, 1953; Larsen *et al.*, 1975). It is generally acknowledged that calves can get infected until one year of age, especially during the first hours after birth. Subsequently, calves seem to become resistant to the infection. If infected, clinical signs will occur only after a latency period (2 to 12 years) during which the animal is subclinically infected and is able to shed the bacteria.

Main routes of transmission are **in utero** transmission (Whittington and Windsor, 2008) and **ingestion of the bacteria** (Chiodini, 1984).

Ingestion of the bacteria can occur:
- ✓ Via ingestion of infected colostrum or milk (naturally infected products or suckling of udders soiled by faeces)
- ✓ Via ingestion of faeces (in the environment or through contact with infected animals)

It has recently been shown that calves can also shed the bacteria and transmit the infection to other calves (Van Roermund *et al.*, 2007). It is then not only important to consider dam-to-calf and adult-to-calf transmission but also calf-to-calf transmission.

Relevant transmission pathways

- Direct transmission *in utero*
- Indirect transmission by ingestion of the bacteria
  - In faeces
  - In colostrum
  - In milk

  → In the environment
  → Contacts
    - Calf-to-calf transmission
    - Dam-to-calf transmission
    - Adult-to-calf transmission

We will focus on closed infected herds.

The initial model will aim:

- To represent detailed transmission mechanisms of *Map* in calves
- To consider the influence of housing facilities on *Map* transmission
- To take into account calf-to-calf transmission and the role of environment

Model description

A **compartmental dynamic deterministic model** will be developed in order to model the transmission of *Map* within a dairy herd structured into groups. The model will incorporate demographic dynamics and herd management.

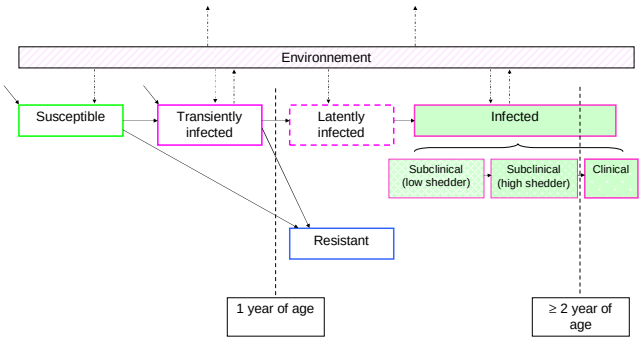

Figure 1: State variables and transmission routes
→ Transition between groups (Death not represented)
⇢ Movement of the bacteria

1. State variables

Our unit of interest is the dairy animal within a farm

Five states are considered. Animals can be Susceptible, Resistant, Transiently infected (shedding the bacteria). Latently infected (not shedding the bacteria) or Infected (shedding the bacteria).

If an infectious contact occurs, susceptible animals become transiently infected before becoming latently infected and then infected. When infected, animals are first subclinically infected and can shed the bacteria before becoming clinically infected if not culled before. If not infected after 1 year of age, animals are considered resistant.

Age structure, housing facilities and environment will be taken into account.

2. Control measures

- Colostrum and milk management
- Housing facilities management
- Test and cull and management of the descendents of positive tested cow
- Hygiene measures

Discussion & outlook

Three different steps are scheduled

✓ Development of a model for studying *Map* transmission within a herd under different hypotheses in relation to potential transmission routes
✓ *Ex-ante* evaluation by simulation of the epidemiological effectiveness of *Map* infection control programmes in a dairy herd
✓ *Ex-ante* evaluation of the profitability of control measures towards *Map* infection within a farm

French dairy production system characteristics will initially be used in this model before adapting it to other countries' systems.

References:
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Larsen AB *et al*. 1975. AM J Vet Res.
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