Dynamics of the spread of the Bovine Viral Diarrhoea Virus (BVDV) within a dairy herd according to the separation of animals into subgroups

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Summary
The spread of the BVDV within a dairy herd can be influenced by management. An heterogeneity in the probability of virus transmission is induced by the separation of animals into subgroups. The influence of the level of separation between such subgroups was studied using a simulation model. The spread was simulated assuming 3 levels (no, intermediate, high) in contacts between subgroups. These levels were modeled by different transmission rates. The persistence and the extent of infection in the herd were found influenced by the level of contacts. Thus, separation into subgroups has to be considered in BVDV spread models.

Introduction

The BVDV is widespread in many countries and induces production losses for infected herds [2]. Different control strategies are available and their efficiency can be assessed ex-ante using models. In dairy herds, animals are often separated into subgroups according to their age and reproductive status. Animals in different subgroups may stay in the same or in different barns. According to the direct and indirect transmission risks between animals belonging to different subgroups, the dynamics of the BVDV spread may vary. The separation into subgroups can be assumed to influence the probability of and the time to clearance in a herd (disappearance of all animals which excrete the virus or carry a Persistently Infected (PI) fetus). Among the previously published models aiming at studying the BVDV spread[1, 3, 4, 5], none investigated the influence of the separation into subgroups.

Objective

The objective of this study was to assess the influence of the level of separation of the animals into subgroups on the BVDV spread within a dairy herd.

Materials and methods

A stochastic simulation model was developed [8, 9]. It consists in two processes : one modeling the herd dynamics (demography, structure and management) assuming the herd as a multigroup population (semi-Markov process) and the other modeling the transitions between BVDV statuses (Markov process). An individual-based approach was used to take into account the individual characteristics influencing the occurrence of events (movements between subgroups, transitions between BVDV statuses, vertical virus transmission). The transiently infective animals were assumed to be able to transmit the virus to susceptible animals only in the same subgroup whereas

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the PI animals were assumed to transmit the virus to susceptible animals both within their subgroup and in other subgroups.

The BVDV spread was simulated assuming 3 different levels of contacts between subgroups: no; intermediate; and high contact level. The influence of the level of contacts between subgroups on the probability of BVDV transmission was considered by defining different transmission rates. The initial herd consisted of 38 dairy cows, 13 bred heifers, 18 heifers before breeding and 3 calves, all of which were susceptible. A PI heifer was assumed to be purchased 20 days before its calving. The virus spread was simulated over 10 years. For each contact level (no, intermediate high contacts), 600 replications were done.

The probabilities of persistence within the herd according to the levels of contacts were represented by a Kaplan-Meier curve and compared using the log-rank test. The extent of the infection was represented by the proportion of susceptible animals in the herd over time. SAS software (SAS Institute, Cary, NC USA) was used to perform the statistical analyses.

Results

The persistence of the virus showed a large heterogeneity in each situation (Fig 1). The probability of persistence differed slightly but significantly according to the levels of contacts simulated (P=0.005). The probabilities of persistence were significantly different two by two under no and high contacts and under no and intermediate contacts. In the three levels of contacts, time to clearance was distributed across the whole simulation period. Clearance occurred significantly earlier in the case of no contact between subgroups than in other levels.

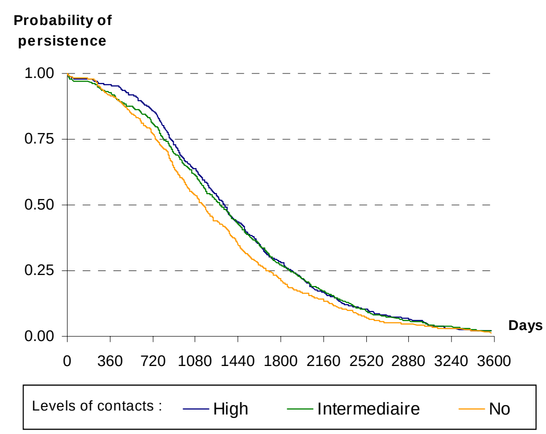

Fig. 1. Probability of persistence of the virus for three levels of contacts after the introduction of a freshening PI heifer.

No contact

High contacts

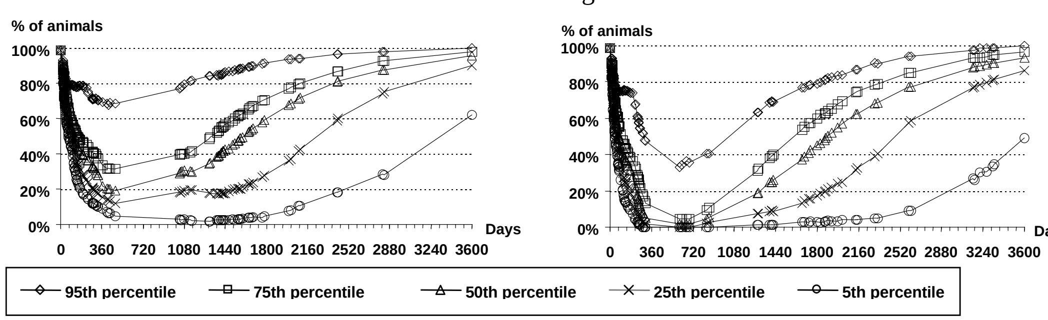

Fig 2. Percentiles over time of the total percentage of susceptible animals for two levels of contacts (No and High) after the introduction of a freshening PI heifer.

Without any contact, the number of replications where all susceptible animals were infected are less frequent than with high contacts (5% *vs.* 50% of replications) (Fig 2). Infection occurred earlier in the situation of high contact than without contact. The variability of the dynamics of virus spread differed according to the level of contacts.

Discussion

For other infectious agents, some simulation models took into account the separation of animals into subgroups and the movements of animals between subgroups[6, 7]. The influence of the levels of contacts between subgroups on a bacteria spread in a cattle herd was demonstrated[7]. For the BVDV spread, the persistence of the virus and the variability of the dynamics of virus spread differed according to the level of contacts. Thus, the level of contacts between subgroups and the heterogeneity of the probability of virus transmission induces by the separation into subgroups has to be taken into account to study the BVDV spread.

In this study, only a constant level of contacts between subgroups was used, whatever the subgroups. In dairy herds, animals of different subgroups can live in the same barn, only separated by a fence (high contact) or can also stay in different barns (no contact). This herd management was not studied here, but can be represented using the model by parameterising different BVDV transmission rates between the subgroups.

Conclusion

Our results demonstrated that different behaviors of the BVDV spread are induced by the level of contacts between the subgroups within a herd. For an ex-ante assessment of control actions, separation into subgroups has thus to be taken into account.

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