ASSESSMENT BY SIMULATION OF THE EFFICIENCY OF STRATEGIES TO CONTROL BVDV SPREAD WITHIN A DAIRY HERD

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Introduction

The bovine viral-diarrhoea virus (BVDV) is widespread in many countries and induces production losses in infected herds[4]. Different strategies to control infection by the BVDV within a herd are available to farmers: either protection by vaccination, or strategies combining monitoring, screening and elimination of Persistently Infected (PI) animals with biosecurity actions (prevention of virus introduction into the herd and of transmission between animals in the herd). Strategies without vaccination (zoo-sanitary schemes) are generally preferred in areas where the risk of new introduction of the virus in a herd is lowered by collective programmes. The efficiency of control measures can be assessed ex-ante using epidemiological models. In the criteria of interest to evaluate the efficiency of a strategy, the ability to eliminate the virus in infected herds can be measured by the probability of and the time to clearance, and the extent of infection. Among the previously published models aiming at studying the BVDV spread[2,4,6,7,9], two[2,7] studied BVDV control by elimination of PI animals. Both were deterministic model and could not represent variability of expected results. One estimated that maximum age at which PI new-born calves should be detected and removed to obtain clearance was below 11 days of age[2]. This is not applicable in field conditions with existing tests. The second concluded that elimination of PI animals was economically unattractive[7]. Screening for PI animals was based on individual testing of all animals, and did not consider the availability in dairy herds of bulk-milk testing for antibodies or virus in cows.

The objective of the present study was to investigate, by simulation, the expected effect of applicable zoo-sanitary schemes in a dairy herd on duration and extent of BVDV infection, in a context of low risk of new infection.

Material and Methods

A stochastic simulation model was used[10]. It consisted of two processes: one modelling the herd dynamics (demography, structure and management) assuming the dairy herd as a multigroup population (semi-Markov process) and the other modelling the transitions between BVDV statuses (Markov process). An individual-based approach was used to take into account individual characteristics influencing the occurrence of events (movements between groups, 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 group whereas the PI animals were assumed to transmit the virus to susceptible animals both within their group and in other groups.

In the modelled herd, actions to avoid virus transmission from herd's neighbourhood were assumed to be in place. PI animals were assumed to be detected before any movement between herds and not to be sold. In such a context, the most probable remaining origin of virus introduction is the purchase of an immune dam carrying a PI foetus which cannot be detected by available tests. The virus introduction was simulated as the purchase of an immune heifer carrying a PI foetus, 20 days before calving. No virus reintroduction over time was simulated. Four scenarios representing four strategies were studied: (1) no other action, (2) prevention of contacts between animals of different groups of age, (3) test-and-cull of PI animals, and (4) combination of (2) and (3). The prevention of contacts between animals was modelled by setting transmission rates between different groups to zero. The test-and-cull consisted of monitoring the herd, and, in case of a positive result, screening for detecting and eliminating PI animals. Every 6 months, the antibody level in the bulk-milk was measured by an ELISA test. If the percentage inhibition was higher than 60% (corresponding to a prevalence of immune cows higher than 30%[1]), a virus spread was assumed. Then, screening for PI animals was based on consecutive combined tests for antibody and virus detection, defined per category of animals, in order to mimic existing zoo-sanitary schemes. Specificity of antibody ELISA, antigen ELISA and PCR were set to 0.978, 0.99 and 0.99, and sensibilities to 0.969, 0.97 and 1, respectively[1, 3, 8].

The initial herd consisted of 38 cows, 13 bred heifers, 18 heifers before breeding and 3 calves, all of which were susceptible. The virus spread was simulated over 10 years. For each strategy, 600 replications were run.

Effects of strategies on virus elimination considered three categories of criteria:

- *The interval between virus introduction in the herd and detection of infection from bulk-milk antibodies*
- *The occurrence of and time to virus clearance*

Clearance was defined as absence in the herd of any shedding animal or dam carrying a PI foetus. The probabilities of virus persistence within the herd (as opposed to clearance) were represented by Kaplan-Meier curves. The distributions of time to clearance were compared between scenarios, stratifying by time of bulk-milk antibody detection (or level allowing detection in case of strategies with no monitoring). Herds already cleared at time of bulk-milk antibody detection were excluded from this latter analysis.

- *The extent of the infection in the herd*

The total number of contaminated animals in the herd during 10 years was calculated for each replication.

Results

Monitoring bulk-milk antibodies every 6 months allowed the detection of BVDV infection within one year after virus introduction in most cases when there were contacts between groups of animals of different ages, but could also result in very late detection (Table 1). In the latter case, the herd was often already cleared from the virus when seroconversion was evidenced.

Table 1. Number of replications per interval from virus introduction to detection of bulk-milk antibodies and % of replications with herd not yet cleared

	Virus introduction to detection - in days					
	190	370	550	730	910	1090
Test-and-cull only						
# detected	120	135	25	4	4	4
% not cleared	98.3	96.3	84.0	25.0	0	0
Prevention of contacts and test-and-cull						
# detected	0	0	0	2	178	8
% not cleared	-	-	-	0	24.7	0

Clearance occurred earlier with test-and-cull than with do-nothing, but persistence was further reduced by prevention of contacts in the herd (Fig. 1). Extent of infection was only slightly reduced by test-and-cull, whereas prevention of contacts resulted in a drop in the number of contaminated animals (Fig. 2). Test-and-cull mainly reduced time to clearance (Fig. 3 and 4), but, in case of prevention of contacts, for only 7% replications.

Figure 1. Probability of virus persistence for four strategies (600 replications by strategy)

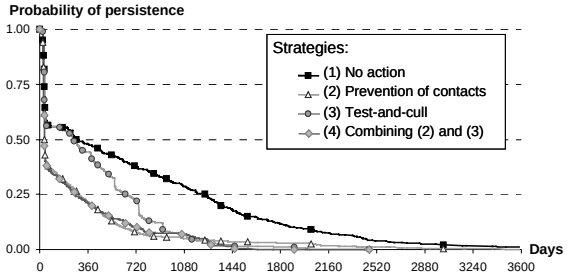
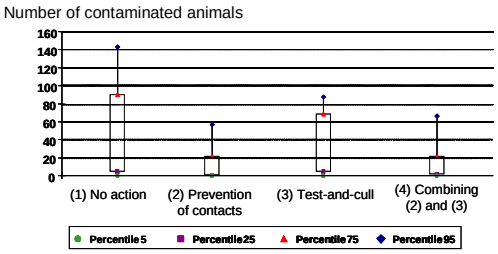


Figure 2. Extent of the infection for four strategies: number of contaminated animals during the simulated 10-year period (600 replications by strategy)



Discussion

After a purchase of a non-PI dam carrying a PI foetus, a zoo-sanitary scheme based on test-and-cull generally reduces persistence of BVDV in a herd, but this effect may be largely delayed due to late detection of infection. If late detected, the herd is likely to be free of PI animals at cows' seroconversion. In Bretagne, PI animals were found in only 28% of seroconverting herds (Joly, unpublished data), suggesting that virus introduction may often have occurred more than one year before. Prevention of contacts between groups appears to be very efficient in limiting both duration and extent of infection, as compared to test-and-cull. Nevertheless, in many commercial herds, total prevention of contacts (assumed here) may not be possible. BVDV infection in herds where virus transmission between groups is only partly prevented could be further investigated.

Figure 3. Time to clearance by time of detection of bulk-milk antibodies for test-and-cull (right) vs. no action (left)

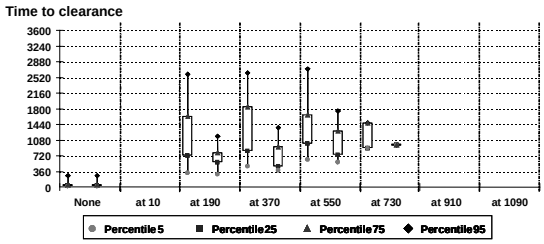
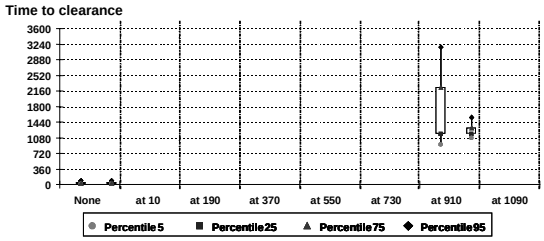


Figure 4. Time to clearance by time of detection of bulk-milk antibodies for prevention of contacts with (right) vs. without (left) test-and-cull



Costs of the test-and-cull strategy can be calculated from the number of laboratory analyses, and losses resulting from BVDV can be estimated from number and category of infected animals depending on the strategy.

Conclusion

Model simulation allows the investigation of how BVDV control strategies interact with herd management and provides relevant data to assess their technical and economic efficiencies in various herd situations. In a context of low risk of virus introduction, zoo-sanitary schemes appear to reduce overall duration of infection, but still have to be evaluated economically.

References

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