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Influence of emergency vaccination on the course of classical swine fever epidemics

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Introduction

In the past, several classical swine fever (CSF) outbreaks occured in Germany. In 1996 to 1998 a CSF epidemic started in Germany and spread to the Netherlands, Belgium, Spain and Italy. During these years a few other independent outbreaks besides the epidemic were detected in other parts of Germany. In total occurred 59 outbreaks and more than 6,500 animals were infected. The politic at that time was no-vaccination, stamping-out and movement restrictions so that a total number of over 120,000 animals were slaughtered, although most of them were not infected (OIE, 2005). In the following years the number of CSF outbreaks decreased and since 2004 no CSF virus was found in domestic pigs in Germany.

As the proportion of pre-emptive culled pigs to the total culled pigs is high, it may be possible to take the emergency vaccination into account as a control measure. To analyse the effect of emergency vaccination a Monte Carlo simulation model was developed to represent CSF epidemics and to compare different control strategies.

Facts about emergency vaccination

Since 1992 the vaccination is prohibited in Europe (Anonymous, 2001). However in the case

of an outbreak it is possible to get a permission for an emergency vaccination. If the CSF is confirmed and there is a great risk for further outbreaks, e.g. in densely populated areas or if many large pig farms are in the neighbourhood of an infected farm. The member state submits an emergency vaccination plan to the EU commission which includes a detailed description of the emergency vaccination campaign. The geographical area in which the emergency vaccination is to be carried out and the number of pig farms and pigs on each farm, as well as the kind of vaccine to be used and the expected duration of the campaign have to be described. The handling of the application lasts 24 days in the best case. The vaccination can therefore not start before the 24th day after the first detection and confirmation of CSF.

The vaccination is carried out through teams consisting out of four people, including one veterinarian. The team vaccinates all pigs and marks them with an ear tag.

There are movement restrictions established for all pigs in the vaccinated region, except when they go to the slaughter house, and the restrictions last during the campaign and 6 months after its end. It is even prohibited to collect semen, ova and embryos from vaccinated pigs, because they are seropositive like an infected pig and can not be distinguished.

Simulation model

In the simulation model a single farm is regarded as a modelling unit. If one animal on a farm is infected the whole farm is regarded as infected and can now spread the virus to other farms. The virus can be transmitted through local spread, animal contact, vehicle contact, personal contact and semen.

The region assumed in this calculation is a simulated area with 1.3 farms/km^2 and a total of 2986 pig farms. For every farm like the geographical location and the number of animals per category on the farm (sows, piglets, fattening pigs, boars) are stored in a database. These farms can be classified into categories depending on their kind of pigs: farrowing farm (sows and piglets), fattening farm (fattening pigs), farrow-to-finishing farm (sows, piglets, fattening pigs) and artificial insemination centre (boars).

The primary outbreak as well as the control measures can be set by the user. Implemented measures in the model are culling of infected herds, movement restrictions in special areas (protection and surveillance zone), contact tracing, pre-emptive culling of all farms in special defined zones (e.g. 1 km around an infected farm) or of farms which had animal contacts with an infected farm, and emergency vaccination around the farm first detected.

A detailed description of the model is given by Karsten, Rave and Krieter, 2005a,b.

For the implementation of the emergency vaccination different parameters have to be defined

by the user to describe the vaccination campaign in detail. In this analysis the geographical region to vaccinate was assumed to be 3-10 km around the primary outbreak. The vaccination campaign should not last longer than 5 days and one vaccination team consisted out of 4 people, of which one must be a veterinarian. One team could vaccinate and mark on average 1,000 animals per day. The success of the vaccination was assumed to be 98 % and time until immunity 3 to 6 days which corresponds to live vaccines (Moennig, 2000). For this analysis the date when the vaccination campaign starts was varied from day 24 (best case), over 47 to 69 (worst case) to represent the time for the application procedure with the EU commission. As a control it was even simulated that the emergency vaccination campaign can start immediately after the first detection to see what would happen if the procedure with the emergency vaccination plan were not necessary and there were always enough vaccines doses available. To answer the initial question about the influence of emergency vaccination on the course of CSF it was focused to quantify the effectiveness of emergency vaccination strategies in contrast to pre-emptive culling.

Results

To compare different control options 1000 simulation runs were performed per alternative and the mean numbers of infected, culled, banned and vaccinated farms were analysed.
The control option movement restrictions in the protection and surveillance zone plus culling of contact farms was chosen as the basic alternative.

Table 1: Mean number of infected, culled, banned and vaccinated farms during one epidemic depending on different control options

control option	***mean number of herds***			
	infected	***culled***	***banned***	***vaccinated***
basic	13.75 a	13.99 a	820.51 a,c	-
basic + 1 km pre-emptive culling	11.76 b	27.76 b	787.57 a,b	-
basic + 3-10 km vaccination	14.30 a	14.50 a	843.10 c	300.50 a
basic + 3-10 km vaccination + 1 km pre-emptive culling	11.88 b	27.63 b	779.46 b	152.70 b

- basic: movement restrictions in protection and surveillance zone + culling of contact herds
- vaccination starts on day 24 after first detection
- a, b, c: means with differing letters differ ($P<0.05$)

In table 1 different control options are compared by the mean number of infected, culled, banned and vaccinated herds.

The vaccination started on day 24 after the first detection of a CSF outbreak.

Adding the pre-emptive culling of all farms within 1 km around every infected farm significantly reduces the mean number of infected farms, while the number of culled farms nearly doubles from 13.99 to 27.76 (75 % of the culled farms are pre-emptively slaughtered). The mean number of banned farms is not significantly influenced. The mean number of infected, culled and banned herds does not differ between the basic alternative and the one with 3-10 km vaccination around the farm first detected, but additionally 300.50 farms are vaccinated on average.

Combining the two alternatives with vaccination and pre-emptive culling does not result in a significant change of the mean number of infected, culled and banned herds compared to the alternative with only pre-emptive culling.

Table 2: Different start dates for the emergency vaccination, day 24 as the best and 69 as the worst case, day 1 as a theoretical case

vaccination start	***mean number of herds***			
	infected	***culled***	***banned***	***vaccinated***
day 1	10.29 a	21.14 a	683.73 a	341.18 a
day 24	11.88 b	27.63 b	779.46 b	152.70 b
day 47	11.66 b	27.47 b	784.80 b	47.83 c
day 69	11.42 b	26.88 b	775.93 b	14.75 d

- all alternatives: basic + 1 km pre-emptive culling + 3-10 km vaccination
- a, b, c, d: means with differing letters differ ($P<0.05$)

The start date of the vaccination depends on the time it takes to submit the emergency plan to the EU. This procedure can take 24 days in the best case but up to 69 days in the worst case. As shown in table 2 this has no effect on the course of the CSF epidemic. The mean number of infected, culled and banned farms is not significantly different. But if the emergency vaccination started immediately (day 1), the mean number of infected, culled and banned herds would be significantly lower.

Assuming that the vaccination starts immediately after the first detection of an outbreak the same control options as in table 1 were simulated and the results are presented in table 3.

Table 3: Mean number of infected, culled, banned and vaccinated farms during one epidemic depending on on different control options

control option	*mean number of herds*			
	infected	***culled***	***banned***	***vaccinated***
basic	13.75 a	13.99 a	820.51 a	-
basic + 1 km pre-emptive culling	11.76 b	27.76 b	787.57 a	-
basic + 3-10 km vaccination	14.09 a	14.21 a	796.28 a	372.97 a
basic + 3-10 km vaccination + 1 km pre-emptive culling	10.29 c	21.14 c	683.73 b	341.18 b

- basic: movement restrictions in protection and surveillance zone + culling of contact herds
- vaccination starts immediately after first detection
- a, b, c: means with differing letters differ ($P<0.05$)

The mean number of infected, culled and banned herds is significantly lower in the alternative with 1 km pre-emptive culling and 3-10 km vaccination than in the alternative with only pre-emptive slaughter. However, the control option with only 3-10 km vaccination as addition to the basic does not change.

Conclusion and Outlook

In sparsely populated areas the emergency vaccination with starting on day 24 after the first detection does not give any additional profit in improving the course of a CSF epidemic. The control option with 1 km pre-emptive culling indeed reduces the number of infected farms but significantly increases the number of culled farms while the major part of these farms are culled pre-emptively.

The control measures of the basic alternative might therefore be sufficient for this region. By establishing movement restriction areas in the region an outbreak is confirmed and by reducing the probability of virus transmission over longer distances by pre-emptively culling of contact farms of infected herds a CSF epidemic can be eradicated.

Under the given laws of the EU the emergency vaccination has no additional benefit in sparsely populated areas regardless of how long the permission procedure takes. If the vaccination could start immediately after the first the control option 1 km pre-emptive culling plus 3-10 km vaccination is significantly better than the alternative with only pre-emptive culling.

In further simulations the herd density has to be varied to consider a more densely populated area and to analyse whether the emergency vaccination is more effective in densely populated areas. Furthermore marker vaccines can be used for the vaccination instead of the live

vaccines. This results in a longer time until immunity, which might degrade the effectiveness of the emergency vaccination, but vaccinated animals could be distinguished from infected animals.

Literature

Anonymous, 2001. Council Directive 2001/89/EC of 23 October 2001 on Community measures for the control of classical swine fever

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