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Development of methods for simulation of disease surveillance

- Case study Surveillance of paratuberculosis in cattle

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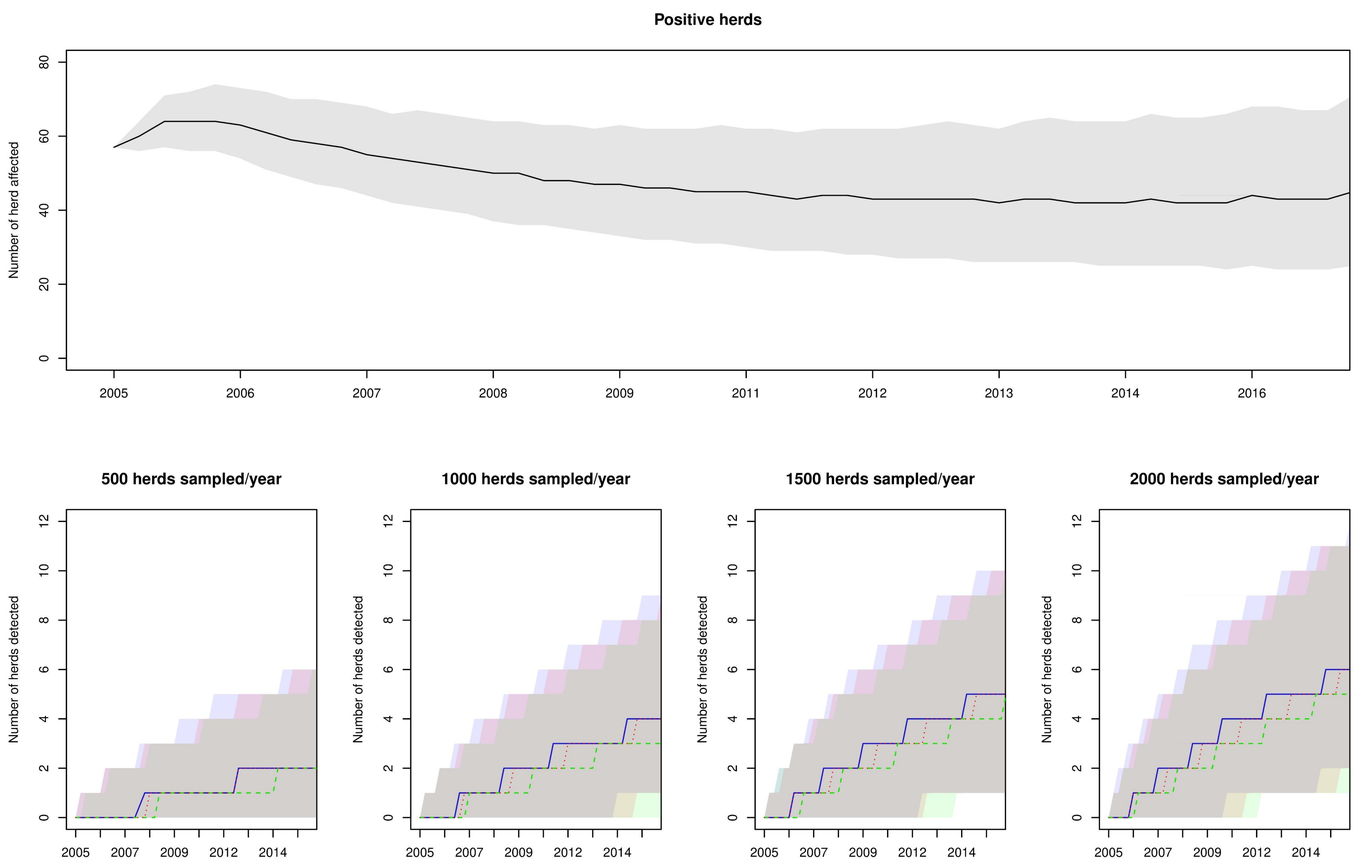
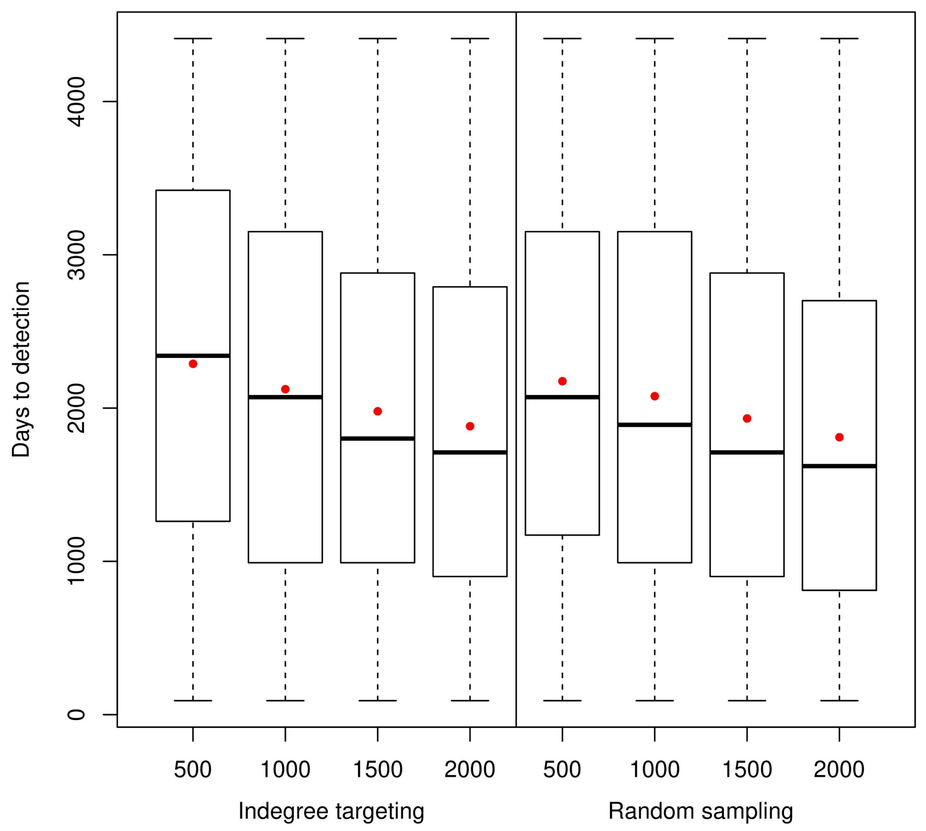
Assessing the performance of surveillance has been limited to methods that do not account for spread and network dynamics in the population. The aim of the current work is to define a method for simulation of imperfect testing of individuals or groups in a compartmental disease-spread model for the purpose of assessing surveillance system performance.



Detection in an endemic state. Model predicted outcome over 12,000 iterations (1,000 per surveillance scenario) with a seed of 0.2 % of herds in the population infected at a within-herd prevalence of 2 %, evenly distributed over calves, heifers and cows. The top graph indicates the median, low and high potential herd prevalence, the bottom graphs show the cumulative number of herds detected by bulk milk screening. The blue lines indicate herds sampled by random, the red dashed line herd sampled weighted by *log(indegree)* and the green dashed lines sampled weighted by indegree.



Detection of a new introduction. The difference in the number of days from the beginning of an outbreak it is detected with the various surveillance schedules. The red dots are the average days to detection for each surveillance schedule. This graph only includes those outbreaks that did not die out during the study period and were detected by the surveillance. Result is based on 228,016 iterations (28,510 per each of 8 surveillance scenarios) with a seed of a single herd in the population infected at a within-herd prevalence of 2 %, evenly distributed over calves, heifers and cows.

In this study, we use the compartmental disease-spread model as a tool, not only to model the change in disease states of animals in the herds, but also to keep track of the states of testing herds in the model. This method proved to be very useful since it allows the surveillance to be modelled in real-time alongside the disease spread and be pre-scheduled in a manner similar to the way surveillance is designed in practise. Currently, single samples were tested in each herd, but the approach can also be generalised to multiple samples per herd in the case of modelling individual-animal tests. The findings from the surveillance are only recorded as observations from the model. Future development will make it possible to use surveillance results as feedback to the disease spread model in order to test intervention strategies to reduce the prevalence of disease, not just detect it.

- Paratuberculosis spreads slowly and most often dies out in the Swedish cattle population.
- Detection of an outbreak by bulk-milk sampling is possible but takes several years
- Targeting sampling by purchasing behavior of herd (indegree) does not improve surveillance performance in this population and for this rare and slow spreading disease.

Sensitivity of surveillance. The proportion of persistent outbreaks detected by the surveillance system over the study period given an introduction in 1 random herd at the beginning of the study period. The outbreaks were considered to be persistent if herds were positive on the last time step of the simulation. Outbreaks were persistent in 34.5 % of 228,016 simulations.

Number of sampled herds per year	Targeting	
	Indegree	Random
500	0.1031	0.1008
1000	0.1593	0.1630
1500	0.1965	0.2061
2000	0.2219	0.2322

SimInf

STATENS VETERINÄRMEDICINSKA ANSTALT