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A GIS-BASED COMPUTER PROGRAM FOR THE REGION-WIDE ERADICATION OF ENZOOTIC PNEUMONIA (EP)

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La pneumonie enzootique (PE) est présente dans au moins 64% des élevages porcins en Suisse. Cette maladie engendre des pertes économiques considérables dans la filière porcine. Depuis la dernière décennie, il est évident que cette maladie à transmission aérienne, nécessite la coordination de l'ensemble des éleveurs de la même région pour un plan de lutte efficace.
Un programme informatique « GIS » a été mis au point afin d'aider à identifier les fermes à haut risque et pour lesquelles l'éradication est prioritaire. La classification du risque est basée sur quelques facteurs de risque (localisation de la ferme, taille du troupeau, distance des fermes voisines). Ce système classe les élevages en tenant compte de la pression de l'infection dans la région. Les élevages à haut risque sont ainsi sélectionnés et leur statut modifié. De cette manière, la situation sanitaire dans une région peut être mise à jour en permanence, et de nouveaux élevages peuvent être sélectionnés. Ce programme permet aussi la production d'une cartographie sur les statuts des élevages. La liste des élevages et leur cheptels peut également être imprimée.
Cependant, l'intérêt et l'utilisation de ce système dépend de la validité des données recueillies (cheptel, coordinateur). Malheureusement, la structure complexe de la base de données et les informations géographiques ont retardé la mise en œuvre d'un modèle de simulation pour la pneumonie enzootique en Suisse.

INTRODUCTION

Enzootic pneumonia (EP) is prevalent in at least 64% of conventional pig farms producing slaughter pigs in Switzerland (Grest, 1995) and the disease causes remarkable economic losses for the pork sector. Since the 1960s, a voluntary eradication program for *Mycoplasma* (M.) *hyopneumoniae*, the major causative agent of EP, has been offered to pig farmers. This program was very popular but suffered from a yearly re-infection rate of up to 3%. Over the last decade it became obvious that EP was an airborne disease and therefore an attempt to control the problem could only be successful if it was a co-ordinated effort of all pig farmers in an entire region (Stärk et al., 1992).
However, there was a lack of experience with large-scale eradication programs in the pig industry. Rather than experimenting with an eradication protocol in the field with a considerable risk of failure, a simulation program was developed to evaluate different control options. Because the location of a farm and the distances between farms are important risk factors for calculating the risk of re-infection (Thomsen et al., 1992), the simulation was bound to have a significant spatial component. Additionally, during the eradication, status maps of farms would be needed. Both these requirements can be met by using a geographic information system (GIS). GIS have been included in decision support systems for the control of other infectious diseases before (Sanson, 1994). This paper describes the features of a GIS-based decision-support system for region-wide EP eradication, discusses its practicability and potential use in the field.

DESCRIPTION OF PROGRAM

The simulation is run in ArcInfo (Version 7.0). The GIS uses farm data (ownership, address, livestock inventory, farm ID number) and farm co-ordinates. In Switzerland, farm data can be obtained from the federal livestock census database, but farm co-ordinates have to be extracted from a number of different federal and municipal databases using the farm address as a key. Matching of records has to be performed manually, if the join of fields is unclear.
Data from a test region consisting of 17 municipalities and covering a surface of approximately 94 km^2 was used in the program for demonstration purposes. In this region there were 202 conventional (26 breeding, 131 fattening, 45 mixed farms) and 50 EP-free (22 breeding, 9 fattening, 19 mixed) pig farms with a total number of 2,100 sows and room for 11,400 fattening pigs. A detailed livestock inventory was obtained for each farm from the 1994 federal farm census.
Between-farm airborne transmission of *M. hyopneumoniae* is simulated using two earlier developed risk indices, one for estimating agent emission (RE) and one for calculating agent pressure from outside the farm (RI) on a regional basis. The indices are largely dependent on the distance between farms, the herd size of the farm under consideration and the herd size of the other farms in the region. Two herd size figures (herd $size_1$ and her $size_2$) are calculated as not all age groups are equally important for agent emission. For more details see Laube et al. (1996).

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$$RE = \text{herd size}_1 \times \sum_{i=1}^{n} \text{herd size}_{2i} \times \frac{1}{\text{distance}_i^2 [\text{km}]}; RI = \text{herd size}_2 \times \sum_{i=1}^{n} \text{herd size}_{1i} \times \frac{1}{\text{distance}_i^2 [\text{km}]}$$

In a first step, the GIS calculates the risk of potential disease transmission from each farm to all other farms in the test region using RE. The program ranks farms by risk index and identifies farms causing the highest infection pressure. These farms are given priority for cleaning up. Herds are selected for EP-eradication according to user-defined rules. The health status of selected farms is then changed to EP-free. In a second step, the total infection pressure remaining in the region is calculated. The change in risk is recorded. If necessary, the first step is then repeated. The iterations are stopped when all farms are EP-free or when the risk index of all EP-free farms falls under a threshold value for RI. Threshold values for acceptable risk levels can for example be calculated from 'safe' farms that remained EP-free in the region for a defined number of years. For example in the test region, farms with a RI<0.8 remained free for >2 years.
During the simulation the change of RI in the region can be graphically monitored. At any stage of the simulation, thematic maps displaying the status or the risk category of farms can be plotted.
Additionally, lists with high-risk farms and their livestock inventory can be printed to plan eradication in the field. Descriptive statistics of these farms can be produced, for example to estimated needed replacement stock for re-population (Table I).

Table I
Descriptive statistics of high-risk and low-risk farms for EP-transmission within a defined geographical region as identified by a simulation program

	High-risk farms			Low-risk farms		
	n	%	Mean herd size	N	%	Mean herd size
Fattening	39	63	121.1*	92	65	33.9*
Breeding	4	7	31.5**	22	16	8.0**
Mixed	18	30	21.3**; 84.3*	27	19	12.9**; 48.7*
Total	61	100		141	100	

* number of fattening pig units (measure of space available for fattening pigs)
** number of breeding sows

DISCUSSION

Adequate decision making during a disease eradication process can be difficult, as a large amount of information will need to be taken into consideration. Various risk factors may be involved and their interaction may be complex. The use of computer-supported tools facilitates the quantification of risk factors and enhances evidence-based interventions. Because EP is an airborne disease, spatial analysis of the situation in a region is a prerequisite for the assessment of the next steps in an eradication process. For example, in regions with a high pig density, it may not be possible to clean all farms at a time. Then, selection of the right farms is crucial, because farms that are already EP-free are under constant risk of re-infection. A GIS-based simulation model like the one described in this paper is a powerful tool in such a situation.
Additionally, a GIS-based system can facilitate the management of an eradication program very efficiently as has been shown in the context of foot-and-mouth disease (Sanson, 1994). Maps displaying the updated situation in a region together with farm information are important tools for field personnel and can also be incorporated in reports to producers, administrators and the media.
However, it has not yet been possible to use the GIS-based system in Switzerland, although region-wide EP eradication was started in 1996. Currently, EP is eradicated on all farms simultaneously. Obtaining completely geo-referenced data for all farms is at the moment the most limiting part of the simulation as a managerial tool. Missing or inconsistent use of keys such as property ID numbers in the different databases make it difficult to match information from different sources. Also, data ownership may be difficult to resolve in a federal system.
The full potential of GIS-based decision support systems in the field of animal health will - to a large extent - depend on improvements of the accessibility and compatibility of national farm databases.

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