RISK ANALYSIS AND LOCAL SPREAD MECHANISMS OF CLASSICAL SWINE FEVER

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La peste porcine classique a été une importante maladie animale en Europe. Une politique de contrôle restrictive a été établie par la commission européenne (EC). Suivant les recommandations de cette commission pour les situations exceptionnelles, tous les porcs devaient être éliminés dans une zone de 1 Km de rayon autour du premier foyer épizootique. Aucune preuve scientifique n'a été établie pour cette zone d'abattage, mais les pertes économiques sont considérables, en particulier dans les régions à densité porcine élevée.

Dans le but de mettre en évidence une distance en-dessous de laquelle existe un risque potentiel, plus de 100 épizooties ont été étudiées. En utilisant les données géographiques et celles concernant la transmission de la maladie, il est possible de satisfaire les hypothèses nécessaires afin de modéliser la 1ère épizootie comme étant le point source du « rayonnement ». Pour manipuler les positions géographiques et les données recueillies sur des milliers de fermes, le programme GIS ArcView et son programme de langage orienté est utilisé. La fonction de risque dépendant de la distance, pour la zone entourant la 1ère épizootie, a été calculée par l'estimation de la densité de Kernel pour différentes catégories. Toutes les fonctions de risque obtenues montrent une réduction du risque relatif avec la distance par rapport au point source et atteignant 1 dans un rayon de 500 m. Par ailleurs, une analyse de groupe a été effectuée afin d'écarter les facteurs de confusion spécifiques. Finalement, nous suggérons une modification de la directive 80/217 EEC pour réduire la zone d'abattage recommandée. L'application des modules de statistique spatiale du programme GIS sera discutée.

INTRODUCTION

In the last few years Classical Swine Fever (CSF) has been an important animal disease in Germany and recently also in other countries of the European Union. An outbreak of the disease can lead to huge direct and indirect financial losses for the affected farms and regions. For instance, nearly two million pigs were purchased and killed over a period of three years in Germany since July 1993. The sum exclusively required for compensation amounted to almost 400 million DM. When the costs for piggeries that had to remain empty, culled breeding herds, disinfection and extensive surveillance measures are included, the total economic losses were in the range of 1.3 to 1.5 billion DM (Kramer et al., 1995; Teuffert et al., 1995; Davies, 1996).

Since the aim of the CSF control policy is eradiction and not prevention, the vaccination of pigs against CSF-virus is prohibited since 1990. A restrictive control policy on the disease was established by the European Commission and implemented by the German government (Roberts, 1995). Following a recommendation of the EC for special situations, all pigs were culled in a circle around the primary outbreak with a radius of at least one kilometer. The size of the culling zone is not based on scientific data, but leads to enormous economic losses, particularly in regions of high pig density (Table I). Since the square of the radius determines the area covered by a circular culling zone, a reduction of the radius may have drastic consequences on the economic impact of the disease.

Table I
Relation between radius of the culling zone and losses due to pig culling

Radius [m]	Area [km²]	Savings [%]	Pigs culled[1]	Losses [DM][1]
1000	3.14		2722	805,000
800	2.01	36	1742	515,000
500	0.78	75	676	200,000
400	0.50	84	433	128,000
300	0.28	91	242	72,000

[1] pigs/km^2 = 867; avg. pig price = 295 DM; found in a pig industrial region in Germany

On this background we investigated, whether the recommended culling zone of 1000 m around the primary outbreaks is necessary.

MATERIAL AND METHODS

The culling policy is based on the assumption that the possibility of a continuous spread of CSF-virus exists in the surrounding of an outbreak. This hypothesis implies that a primary outbreak can be modelled as a "radiating" point source.

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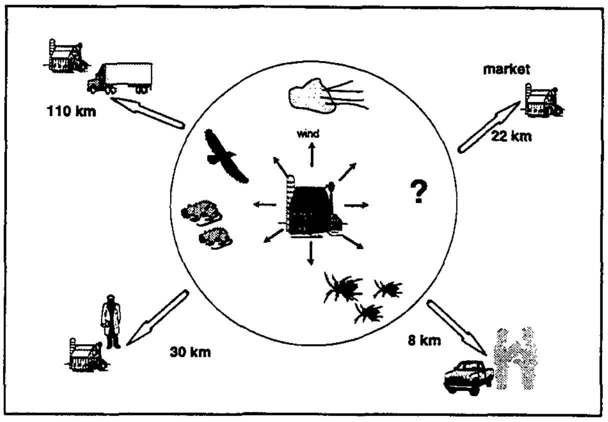
The potential modes of transmission and their relative importance are not known for each individual outbreak. CSF-virus can passively spread to places far away from the original outbreak. Therefore, routes of transmission exist which can be defined as distance-independent, i.e. when the infection potential does not decrease by distance (transport of pigs, farmworkers, supply vehicles etc.). All remaining secondary outbreaks are assumed to be caused by distance-dependent spreading factors (e.g. air; Figure 1). To exclude tertiary outbreaks, only cases that occured within two minimal incubation periods of the CSF infection (3-4 weeks) were taken into account (Dahle & Liess, 1992; Roberts, 1995; Teuffert et al., 1995).

Figure 1
Routes of transmission of Classical Swine Fever



To establish a distance-dependent risk function, 36 areas with 106 outbreaks which occured between 1993-1997 were analysed. To handle the geographical positions and other data of the farms concerned, the Geographical Information System (GIS) tool ArcView® (ESRI, Redlands, USA) and its object-oriented programming language Avenue® were used.
A technique originally applied to environmental epidemiology was introduced to estimate density functions, showing the distribution of piggeries surrounding a primary outbreak (Silverman, 1986; Bithell, 1992). For each farm the radial distance to the primary outbreak was calculated. A density function of the distribution of the resulting distances was estimated for identified secondary outbreaks or the census, respectively. To separate the underlying risk potential from the influence of urbanisation on the distribution of cases, we calculated the relative risk as the ratio between these two distributions. To minimize the average global error of the estimate we chose the Epanechnikov kernel and the critical smoothing parameter in an almost optimal manner (Silverman, 1986). Furthermore, we carried out a pooled analysis to remove case-specific confounding factors (Hills, 1992).

RESULTS
The following analysis is based on data obtained from 7 districts in 4 Federal States of Germany. 18 primary outbreaks were considered which lead to 37 secondary outbreaks all fulfilling the necessary assumptions. In addition, the 1 km zones contained further 197 CSF-negative farms.

Figure 2
Relative risk and distance from the primary outbreak

Even without a definitive knowledge of the real routes of transmission, it could be shown that the risk for a secondary outbreak decreased by distance. All resulting risk functions showed a decreasing relative risk (approaching 1.0) by distance for radial distances of 475 m maximum (Figure 2). Furthermore, the pooled data analysis demonstrates that the relative risk for a secondary outbreak declines from 2.3 to 1.0 within a radial distance of 250 m from the primary outbreak.

DISCUSSION

The practical experience with CSF outbreaks in the last years shows an higher infection potential for piggeries in the surrounding of a primary outbreak (Roberts, 1995; Teuffert et al., 1995). Therefore, the EC directive 80/217 recommends to depopulate all piggeries within a radius of 1 km in special situations. Such a decision is only useful if there are transmission routes that lose influence with increasing distance to the primary outbreak. Therefore, we divided the spreading mechanisms in two categories based on the sources of infection: (i) modes of transmission that depend on erratic movement over any distance, and (ii) the continuous spread of CSF-virus. The distance-dependence of the second category might be caused by the dilution of the virus concentration in the air with increasing distance from a point source or by the higher probability of the presence of rodents near the place of an outbreak. We are aware of the fact that "unknown" sources of infection and "neighbourhood infections" probably also include distance-independent modes of transmission, but a risk assessment clearly shows a decreasing relative risk which confirms the results of previous empirical studies (Teuffert et al., 1995). These findings underline the need to improve our knowledge on the real modes of transmission and their relative importance.

To reduce case-specific confounding factors such as false-classified sources of infection or wrong determination of the time of infection we conducted a pooled data analysis. The projection of all the farms of the analysis into the surrounding of an imaginary outbreak was achieved with a GIS tool.

The direct use of spatial statistics in Geographical Information Systems is hampered by insufficient or missing integration of statistical routines in most of the available software (Alexander et al., 1991; Goodchild et al., 1992; Paterson, 1995). The available statistical tools are extensions to expensive UNIX-environments (e.g. S-Plus®, Splancs, GAM; Openshaw, 1990; Rowlingson & Diggle, 1993). Alternatively the data can be exported into statistical software packages. Modern GIS tools allow to integrate statistical routines such as density estimations or cluster tests even in a PC environment. In our case we used the object-oriented language Avenue® which is integrated in the GIS tool ArcView® to create, maintain and analyse the spatial database.

As a consequence of our studies, we suggest to depopulate all piggeries within a 250 m radius of an outbreak. The further extension of the culling zone should depend on the date of onset of infection and the geographical distribution of the farms.To improve the predictive value of the results it is necessary to analyse further outbreak areas. A limited culling zone determined on the base of datas obtained from real outbreaks may help to restrict economic losses to a minimum without increasing the risk for the spread of CSF.

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