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Veterinary epidemiology – a key to sustainable pig production in Switzerland

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Abstract

Sustainable animal production requires a healthy production system including healthy animals producing wholesome products. Epidemiology as a discipline is concerned with the occurrence of disease or disease indicators in populations as well as with factors influencing disease occurrence. By providing this information, epidemiology contributes significantly to the development and maintenance of healthy livestock. This is illustrated with the example of the enzootic pneumonia (EP) eradication programme of Switzerland.

A series of observational studies were conducted in order to obtain the necessary knowledge to implement an area-wide EP eradication programme. The issues of economical eradication strategies at the herd level and the risk of re-infections were addressed. Simulation modelling and economical analysis were also applied. These research projects led to the successful start of a national eradication programme.

The example of the EP eradication programme illustrates that applied epidemiological research provides critical information for the planning, implementation and evaluation of disease control programmes and is thus a key tool in developing sustainable animal production.

Key words: respiratory diseases – swine – specific pathogen free – animal health

Veterinärepidemiologie – ein Schlüssel zur nachhaltigen Schweineproduktion in der Schweiz

Ein tiergerechtes Produktionssystem mit gesunden Tieren, welche gesundheitlich unbedenkliche Produkte hervorbringen ist die Grundlage für eine nachhaltige Tierproduktion. Die Epidemiologie versteht sich als die Disziplin, welche sich mit dem Auftreten von Krankheiten in Populationen befasst sowie mit den Risikofaktoren, welche dieses Auftreten beeinflussen. Durch diese Information trägt die Epidemiologie signifikant zum Aufbau und Erhalt von gesunden Nutztierbeständen bei. Dies wird anhand des Beispiels der Flächensanierung von Schweinebeständen bezüglich enzootischer Pneumonie (EP) in der Schweiz illustriert.

Um die notwendigen Kenntnisse für ein flächenhaftes EP-Sanierungsprogramm zu erarbeiten, wurde eine Reihe von Beobachtungsstudien durchgeführt. Den Themen der wirtschaftlichen Sanierung auf Betriebsebene und des Reinfektionsrisikos kam besondere Bedeutung zu. Es wurden auch Simulationsmodelle und Kosten-Analysen durchgeführt. Dank dieser Projekte konnte ein flächenhaftes Sanierungsprogramm in der Schweiz erfolgreich gestartet werden.

Das Beispiel der flächenhaften EP-Sanierung illustriert, wie dank epidemiologischer Forschung wichtige Erkenntnisse bezüglich der Planung, Umsetzung und Evaluation von Kontrollprogrammen gewonnen werden können. Die Epidemiologie stellt deshalb ein Schlüsselwerkzeug für den Aufbau einer nachhaltigen Tierhaltung dar.

Schlüsselwörter: Respirationskrankheiten – Schwein – spezifisch-pathogen-frei – Tiergesundheit

Introduction

Sustainable animal production requires a healthy production system including safe feed and feed production, healthy animals producing wholesome products and considerate treatment of waste water and slurry. The majority of diseases in pigs housed in intensive production systems are of infectious nature. Subclinically or clinically infected livestock are a risk for consumers either through direct transmission of zoonotic agents or indirectly if they are improperly treated with antimicrobial substances that can create residue and/or resistance problems. Epidemiology as a discipline is concerned with the occurrence of disease or disease indicators in populations as well as with factors influencing disease occurrence (Thrusfield, 1995). The knowledge of these risk factors forms the basis for preventive interventions and disease eradication programmes. By providing this information, epidemiology contributes significantly to the development and maintenance of healthy livestock.

The accumulation of epidemiological knowledge and the development of minimal-disease production systems are a continuing process where the output of research projects feeds into the implementation of disease control programmes. This process is illustrated in the following using the example of national disease eradication programmes in pigs in Switzerland. These programmes include at present the eradication of enzootic pneumonia, actinobacillosis and mange. In this article, only the example of enzootic pneumonia will be discussed in detail. Furthermore, it should be noted that the Swiss pig population is of high health standard with a documented absence of diseases such as Aujeszky's disease, porcine respiratory and reproductive syndrome (PRRS) and classical swine fever (Anonymous, 2000).

Steps towards the eradication of enzootic pneumonia in Switzerland

Enzootic pneumonia (EP) caused by *Mycoplasma (M.) hyopneumoniae* is a disease of world-wide economical significance in swine production (Ross, 1999). Early on, enzootic pneumonia was described as a multifactorial disease the consequences of which are greatly influenced by management factors (Kalich, 1970a,b; Whittlestone, 1976; Stärk, 2000). Therefore, it is possible for a well-managed farm to be EP-infected without major disease symptoms (Keller, 1976). However, if a problem in the management occurs, clinical signs will occur. In such an outbreak situation, antibiotic treatment is typically applied (Ross, 1999). Medication against EP and secondary infections is also used in continuous production systems to protect newly-added animals from clinical infection. It has been shown that the probability of pigs being treated is higher among animals with respiratory disease (Elbers et al., 1992; Singer, 1993, Blaha et al., 1994). Blaha et al. (1994) postulated that the detection rate of antimicrobial residues is also expected to be higher in carcasses with lung lesions, as compared with others without pathological abnormalities. As a consequence of EP infection, a reduced production efficiency was observed in infected herds (Braude and Plonka, 1976; Christensen, 1995). This disadvantageous effect and the limited effect of antibiotic treatment, initiated the development of minimal disease herds that are EP-free. One such programme is the SPF programme as it is applied in many countries of the world (Twiehaus and Underdahl, 1975; Kuiper et al., 1994). A comparable system was developed in Switzerland in 1961 on a voluntary basis (Keller, 1993). Apart from EP, SPF farms in Switzerland are also free from a number of other infectious diseases (Keller, 1980). From 1970 to 1990, the SPF programme was increasingly popular among Swiss farmers. However, a constant number of herds was re-infected with EP each year (Zimmermann et al., 1989). In these herds, an expensive re-population strategy had to be applied to re-establish the SPF status. Later, a simpler technique was developed that only required a partial re-population (Zimmermann et al., 1989). This technique is based on the observation of Waldmann and Raatke (1937, cited by Zimmermann et al., 1989) that EP does not appear to be transmitted from older sows to their litter. A partial re-population includes two elements: 1) the creation of an interval of at least 10–14 d during which only clinically-healthy animals >10 months of age are present on the farm, and 2) antibiotic treatment of all pigs during these 10–14 d. Using this method, 16 of 17 herds were shown to be free of EP after a follow-up of over one year in a field intervention study and later confirmed on further farms (Zimmermann, 1990). Partial depopulation was subsequently used regularly and became widely known as the "Swiss Method" for EP eradication (Frey et al., 1997; Bækbo, 1999). However, each re-infection remained a set-back, particularly for the affected farmers.

As the risk factors for re-infection were not fully understood, epidemiological methods were applied to investigate possible reasons. A case-control study was conducted and provided evidence supporting the hypothesis of airborne transmission (Stärk et al., 1992). This hypothesis had earlier been postulated in the UK and in Denmark (Goodwin, 1985; Jorsal and Thomsen, 1988). A survival analysis conducted with data collected in Denmark quantified the relationship between the probability of infection and purchase patterns as well as the distance to neighbouring farms (Thomsen et al., 1992). Thomsen et al. (1992) concluded that this model was consistent with airborne transmission of *M. hyopneumoniae*. Later, it was also shown that *M. hyopneumoniae* could be detected in air samples collected in infected farms (Stärk et al., 1998), and there is at present little doubt that EP is an airborne disease. The consequence of this observation was, that the only promising approach for high-risk areas with dense pig populations would be an area-wide eradication of EP (Stärk et al., 1992). This was an ambitious idea and no expertise was available to indicate whether such a project would be feasible. Too much was at stake to experiment in the field. Alternatively, a spatial simulation model was developed to explore the feasibility of area-wide eradication (Laube et al., 1997). It was shown that it was sufficient to eradicate EP from the largest farms in an area to bring down the infection pressure sufficiently for the other farms. Many other logistical questions were explored with this model until there was enough evidence encouraging practical implementation. However, before the area-wide eradication project could be started, the legal basis for compulsory eradication had to be provided. This was necessary because it was likely that not all producers would join an area-wide eradication on a voluntary basis. The legal basis was provided in the Ordinance on Animal Epizootics (TSV). Articles 246–247 state that compulsory eradication of EP and *Actinobacillus pleuropneumoniae* can be ordered by the cantonal veterinarian in specific areas.

On this legal ground, two pilot areas of – in total – 230 km^2 were selected to conduct a field intervention study. The pilot areas were well separated from the surrounding areas by natural boundaries (mountains, forest) which were known to hinder airborne transmission. The areas were also selected such that they represented areas of high pig density by Swiss standards (150–200 pigs per km^2). The two areas included 360 and 345 pig farms, respectively (Masserey-Wullschleger and Maurer, 1998). The majority of breeding farms in these areas had an SPF status. A procedure to co-ordinate the partial depopulation of swine herds in the areas was developed. The administrative responsibility for the project was with the Cantonal Veterinarians of Bern and Lucerne. One key element was the control of trade to prevent re-infection through purchase of infected animals. This project was scientifically accompanied to collect further epidemiological knowledge and to identify critical factors before implementing the programme in other areas (Masserey-Wullschleger and Maurer, 1998). In total, 80 breeding farms were partially depopulated and 11 breeding farms were completely depopulated due to additional infection with *Actinobacillus pleuropneumoniae.* All fattening farms with clinical signs of EP were emptied and re-stocked after cleaning and disinfecting. After one year, 11 fattening and 8 breeding farms were diagnosed to be infected with EP (re-infection rate of 3.1% per year). Regarding risk factors for re-infection, the purchase of clinically healthy animals from EP-infected farms in the incubation period inside and outside the project area accounted for the majority of cases (53%). Secondary aerosol infections from neighbouring herds and from herds outside the project area were also observed (4 cases). The fact that the majority of infected farms were secondary infections underlined the potential risk of transmission through animal trade and the problem of how to protect farms along the border of EP-free areas. This project also included a cost-benefit analysis of EP eradication (Masserey-Wullschleger and Maurer, 1998). The authors showed that the costs can be highly variable depending on the individual characteristics of a farm. In a case without further complications, losses were estimated to be neutralised by increased productivity and higher prices for

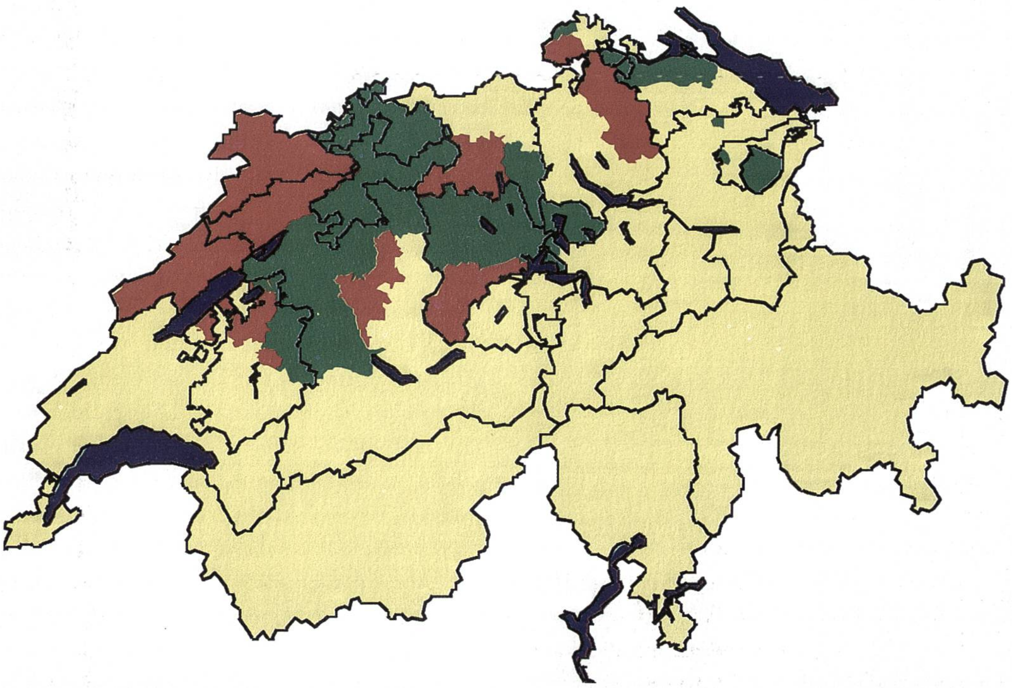

Figure 1: Map of Switzerland indicating the planned gradual eradication of actinobacillosis and enzootic pneumonia from pig farms (green areas = eradication complete, red areas = eradication planned for 2001, yellow areas = eradication planned for 2002–2004, blue areas = lakes).

SPF-pigs after one (partial depopulation) to two (total depopulation) years. After the promising results of the pilot areas, producers and authorities were highly motivated to continue with more areas. The eradication regions were broadened. As more and larger areas were included, the logistics of the project became more challenging. Therefore, a strategy for the entire country was developed with the goal to terminate the eradication by the year 2005 (Anonymous, 1999; Fig. 1).

Although the project is in full swing at the moment, it is not without problems. Again, re-infections in the EP-free regions are occurring. These re-infections are jeopardising the success of the entire project as undetected re-infected farms in the incubation period and infected farms before the re-eradication are a risk for their neighbours. To identify risk factors for this new type of re-infections, again an epidemiological study is used. A case-control study is being conducted where all cases of re-infection of the year 2000 occurring in the Pig Health Service areas of Bern and Lucerne are compared with farms without re-infection in the same regions. A questionnaire is used to collect information on possible risk factors, particularly neighbouring farms and animal trade. The risk originating from improperly cleaned transport vehicles will be specifically addressed. This project is expected to provide practical guidelines on how to prevent re-infections and – if they occur – on how to best deal with them. An additional problem that recently emerged is not related to enzootic pneumonia but to actinobacillosis (*Actinobacillus pleuroneumoniae,* APP). It was observed that although APP infections are comparatively rare in most regions of Switzerland, the prevalence is much higher in some regions, particularly in the north-east of the country. Additionally, farms in these areas tend to be larger so that total depopulation – the standard procedure used to eradicate APP – is economically hard to defend, particularly if there are only individual reactors. In order to shed more light on this issue and also in order to come up with possible alternative eradication strategies (e.g. serological and/or bacteriological testing followed by removal of positive reactors), an observational study was started recently. This is another example of how epidemiological research can support eradication programmes in a practical fashion.

Table 1. Input provided by research projects to develop an area-wide enzootic pneumonia (EP) eradication programme in Switzerland

Epidemiological project aim	Study type	Implementation in the field
Reliable EP eradication method avoiding total depopulation	Field intervention study	Standard technique used in the Swiss Pig Health Service
Identification of risk factors for EP re-infection of breeding farms	Case-control study	Risk indicator to estimate re-infection risk, decision support for farmers who wish to eradicate EP
Feasibility study for area-wide EP eradication	Simulation model	Decision to declare EP as a disease to be eradicated from certain areas (legal basis)
EP eradication in a pilot area	Field intervention study	Development of a guide to plan and co-ordinate practical eradication in an area
Economic feasibility of EP eradication	Cost-benefit analysis	Communication with and motivation of producers
Identification of risk factors for EP re-infection in eradicated areas	Case-control study	Development of preventive measures and guidelines

Discussion and Conclusion

As summarised in Table 1, a series of epidemiological research projects provided (and continue to provide) input to the stepwise development of EP-free pig production in Switzerland. The results of these studies were directly implemented in the work of the Swiss Pig Health Service (Keller, 1993). Most study designs were of observational nature, but theoretical models and economic analyses were also applied. This underlines the practical relevance of epidemiological research. Compared with experimental studies, observational studies are often challenged due to uncontrolled environment with various factors present simultaneously and various sources of bias (Thrusfield, 1995). Nevertheless, advantages such as more realistic conditions outweigh the limitations in the majority of cases. The most serious argument against epidemiology is the difficulty to proof causal relationships. However, it has been argued that with the objective of taking preventive measures, the final proof of causality may not be an absolute necessity (Stärk, 2000). In addition, it has been suggested that the joint effects of factors are probably the most important ones in the case of respiratory diseases in pigs (Lindqvist, 1974). A more management-related issue, where epidemiological methods can also be used, concerns the monitoring of the progress of eradication programmes. In a situation of limited resources it is crucial to demonstrate the success of eradication efforts and to apply tools for early detection of delayed progress. The concept of using performance indicators for controlling is not new and has been used in large programmes such as the global Rinderpest eradication scheme (M. Jeggo, IAEA, personal communication). It is now planned to identify a few epidemiological indicators within the respiratory disease eradication programme in

Switzerland and to use them as performance indicators. One indicator may for example be the incidence of re-infections within eradicated areas. In order to provide the basis for good data, cases of EP and APP are suggested to become notifiable in the revised Ordinance of Animal Epizootics (Anonymous, 2000). A respiratory-disease-free pig population will produce more efficiently and with a reduced use of antimicrobial drugs. This is desirable from both an economical and food safety point of view. Minimal-disease herds support sustainable production by reducing adverse impact on human and ecosystem health. The example of EP eradication illustrates that applied epidemiological research supplements disease control programmes with critical technical and management information and is thus a key tool in developing sustainable animal production.

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Epidemiologia veterinaria – la chiave per una produzione di maiali durevole nel tempo in Svizzera

La base di una produzione durevole nel tempo di animali è un sistema di produzione con condizioni soddisfacenti per gli animali, con animali in buona salute che portino a prodotti non pericolosi per la salute. Animali da produzione clinicamente o subclinicamente ammalati possono rappresentare un rischio per il consumatore. L'epidemiologia è la disciplina che si occupa dell'apparizione di malattie in una popolazione e dei fattori a rischio che possono influenzarne l'apparizione. La conoscenza dei fattori a rischio è la base della prevenzione e del controllo. L'epidemiologia contribuisce in maniera significativa all'organizzazione ed alla conservazione di animali da produzione in buona salute. Questo aspetto viene illustrato con l'esempio del risanamento dei pavimenti dei porcili per quel che concerne la polmonite enzootica (PE) in Svizzera. Per acquisire le conoscenze necessarie per un programma di risanamento su vasta scala per combattere la PE sono stati eseguiti studi d'osservazione. Importanza particolare è stata data alle tematiche del risanamento economico a livello aziendale ed al rischio di reinfezione. Sono stati eseguiti pure dei modelli di simulazione ed analisi economiche. Grazie a questi progetti è stato avviato con successo in Svizzera un programma di risanamento su vasta scala.

L'esempio del risanamento su vasta scala della PE illustra che grazie alla ricerca epidemiologica si possono ricavare nuove conoscenze riguardanti la pianificazione, la realizzazione e l'evaluazione di programmi di controllo. L'epidemiologia rappresenta quindi uno strumento chiave per la realizzazione di sistemi di produzione animale durevoli nel tempo.

Epidémiologie vétérinaire – une clé pour une production porcine efficace en Suisse

Un système de production respectueux des animaux, avec des animaux sains et qui permet de mettre sur le marché des produits de bonne qualité hygiénique est le fondement d'une production animale efficace. Des animaux de rentes malades avec des symptômes cliniques ou subcliniques représentent un risque pour le consommateur et la consommatrice. L'épidémiologie est une discipline qui s'occupe de l'apparition d'une maladie dans une population ainsi que des facteurs de risque qui influcencent cette apparition. La connaissance des facteurs de risque est la base de la prévention et du contrôle. Ainsi l'épidémiologie est une contribution importante à l'édification et au maintien de troupeaux sains. Ceci est illustré en ce qui concerne la pneumonie enzootique (PE) en Suisse par l'exemple de l'assainissement d'exploitations de porcs. Une série d'études basée sur des observations a été conduite afin d'accumuler les connaissances nécessaires pour un programme d'assainissement de la PE. L'assainissement économique au niveau de l'exploitation et le risque de réinfection ont été particulièrement considérés. Des modèles de simulation et des analyses économiques ont été effectués. A l'aide de ces projets, des programmes d'assainissement ont été initiés avec succès en Suisse.

L'exemple de l'assainissement de l'EP illustre comment à l'aide de recherche en épidémiologie des connaissances importantes peuvent être acquises concernant la planification, la réalisation et l'évaluation de programmes de contrôle. L'épidémiologie est par conséquent un outil clé pour l'édification de systèmes de production efficaces.

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