An attempt at measuring health in nucleus and multiplier pig farms

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ABSTRACT

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A pilot epidemiological inquiry was undertaken in France in a group of 205 nucleus and multiplier pig farms. The aim was to find out a method for a quantitative evaluation of the health level in farms selling young breeders. An exhaustive protocol was prepared for data collection. The sources of information were clinical inspections on the farms, meat inspection data at slaughter and laboratory investigations. Data processing issued in the selection of a profile made of 14 prevailing health indicators. These were then associated so as to set up a health index with an overall score. In a second phase, the relevance of the method with respect to disease transmission was assessed. The principle was a contact challenge within totally controlled facilities between SPF pigs hysterectomy-derived and gilts taken from farms with different health scores as previously checked. The contact lasted for 28 days. Eleven farms were chosen and in every one of them 7 gilts were sampled and 10 SPF pigs were assigned to each of these farms. All the pigs were submitted to a detailed observation. At the end of it the pigs were euthanized at the laboratory and checked to find out any lesions and infectious agents. A wide range of symptoms appeared among the SPF pigs. Mortality rate was 14.6%. Pneumonia affected 23.7% of them. A relationship was found between the germ transfer and the severity of the troubles. The degree of illness in SPF pigs was clearly related to the score obtained previously in the corresponding farms. Consequently, the method was considered as valid with respect to health evaluation.

Keywords: pig farms, epidemiology, health indicators

INTRODUCTION

To measure health standards is a delicate task for an epidemiologist whatever the species concerned. With humans, the problem of selecting accurate and reliable criteria has been underlined many times (Feinstein, 1977, Holland et al. 1979, Wagner et al. 1983). For this purpose, the concept of health

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indicators has been widely used (Hetzel, 1972, Jenicek and Cleroux, 1982). The approach is also available for farm animals and, therefore, health requirements have to be defined and listed (Drummond, 1989). The question of health evaluation is of particular importance in farms selling new replacement stock. As regards pigs, the onset of breeding pyramids with a wide spread of gilts and boars from a limited number of specialized nucleus herds emphasize the need for measuring health in these herds. Descriptions of health statuses of farms have been proposed (Goodwin and Whittlestone, 1983, Muirhead, 1989). The evaluation must not be confined to the microbial agents that can be detected. Nevertheless, these are usually granted great interest in health monitoring (Alexander, 1986, Skovgaard, 1987). Health evaluation methods consist in binary responses for specific health indicators taken one by one rather than in a figure giving an overall quantitative evaluation for the health profile. Furthermore, such measurements can hardly ever be judged as reliable through experimentation. This paper presents a method of scoring health in nucleus and multiplier pig farms obtained from a field study. Then, it describes an experimental trial undertaken as a validating challenge.

MATERIALS AND METHODS

Phase A: The field study and the scoring system

The method used to assess the health level

A pilot study was undertaken to describe the health situation of nucleus and multiplier pig farms: 205 farms were considered. They were scattered all over France respecting the territorial pig farming distribution. Farmers and veterinarian inquirers were volunteers.

Two types of diseases were considered in the protocol:
• those determined by specific microbial agents:
• those resulting from carelessness in herd management and husbandry.

Two sorts of measurements were therefore undertaken:

Indicators of risk of actual disease transmission. In order to obtain information for this, wide laboratory investigations were carried out on different samples of material, with the aim of detecting infectious agents. They have been described in detail elsewhere (Madec et al. 1990). The material used was blood from sows and fatteners, feces and urine from sows, and lungs from slaughtered pigs. Furthermore, 3 ten-week-old-piglets, randomly selected on the farms, were necropsied at the laboratory to be fully examined. The notifiable diseases (swine fever, Aujeszky's disease) were kept aside at the time of data processing because all the farms were non infected. Furthermore, since there is a specific regulation for these, the present work was mainly focused on the other health disorders.

Tendency for a farm to show out signs of enzootic diseases. Visits were planned so to obtain information about the disease history, current clinical signs and production inefficiencies.

The sources of data were the following:

- on-farm performance records and clinical inspections of the pigs during standardized visits to the farms
- laboratory examinations
- slaughter checks

The combination of health indicators and the scoring system

A general analysis of the data was undertaken in order to rank the farms into clusters (families) according to their similarities regarding health standards. Concurrently, the most relevant parameters for this purpose were determined. The statistical process was performed with the use of descriptive multivariate methods, namely correspondence analysis and a cluster analysis (Lebart et al. 1985, Jambu et al. 1983). At the end of the statistical process, a combination of fourteen variables (health indicators) was retained to classify the farms according to their health status and a typology could be concluded (Madec et al. 1990). Some of the health indicators derive from the association of 2 or more criteria. They are listed in Table 1. Furthermore, each of the health indicators was divided into 3 levels respecting the sense of the relationship with health. Then, they were used to establish an ultimate health score. Health indicators with a low, medium or high level were given respectively an elementary score of zero, one or two. Afterwards the elementary scores were added up so as to obtain a global score for health, ranging theorically from zero (the 14 indicators at low level) to 28 (all at the high level).

Phase B: Experimental trial

Scope and schedule

The scoring index obtained in phase A was tested in a second phase in order to find out whether the detected difference between farms based on the index is expressed in the level of disease in SPF pigs. A contact trial was suggested between gilts taken from breeding or multiplier pig farms previously checked for health using the method described above and hysterectomy-derived SPF piglets. The design of the experimental contact trial is demonstrated in Fig. 1. The experimentation was conducted in totally isolated rooms. Each room was equipped with 2 flat decks with perforated floors and sides partially open.

- Feeding: the same pelleted food was provided ad lib. throughout the trial.
- The farms: gilts from 11 farms were tested. These farms did not participate to phase A. The managers of breeding pyramids that accepted to take part in the trial were first asked to give us an initial idea of the profile of the

TABLE 1

The 14 health indicators selected to build an overall classification of the farms on health level

| Health indicator Number of included criteria	Meaning	
• Pneumonia in slaughter pigs	2	Prevalence of Pneumonia Prevalence of severe lesions (Madec et al. 1988)
• Other lung lesions in slaughter pigs	2	Prevalence of pleuresy/ pericarditis Prevalence of abcess
• Atrophic rhinitis in slaughter pigs	2	Prevalence of A.R. Prevalence of severe lesions (Madec et al. 1988)
• Respiratory tract lesions in three ten-week- old piglets	3	Pneumonia Pleuresy, abcess, pericarditis Atrophic rhinitis
• Isolation of P. multocida from the piglets	1	nasal cavity, tonsils, lungs

• Level of hygiene in the farm	5	Skin and internal parasites in the
		    sows
		Whitlows in the breeding sows
		Prevalence of umphalitis in
		    nursing piglets
		Prevalence of arthritis in nursing
		    piglets
		Prevalence of white scour in
		    nursing piglets

• Sudden death of breeding sows	1	Annual percentage

• Urinary tract infections in the breeding
    sows
	1	Prevalence, through urine
		    examination

• Locomotor disorders in the breeding sows	1	Prevalence, through clinical examination

• Reproductive disturbances in the herd	2	Prevalence of returns in heat
		Prevalence of small litters (less
		    than 5 piglets born, alive
		    and/or dead)

• Post-weaning disturbances	2	diarrhoea losses
• Digestive problems in growing–fattening pigs	1	troubles including dysentery

• Vulnerability of the farm regarding
    external contamination
	6	fence around the buildings
		protection against birds
		shower
		other breeding or breeding-
		    finishing herds less than 2
		    km distant
		Specialized fattening units less
		    than 2 km distant
		Porcine Coronavirus infection
		    in finishing pigs

• Parvovirus infection	1	Parvovirus activity in pigs
		    during finishing phase (90–
		    100 kg LW)
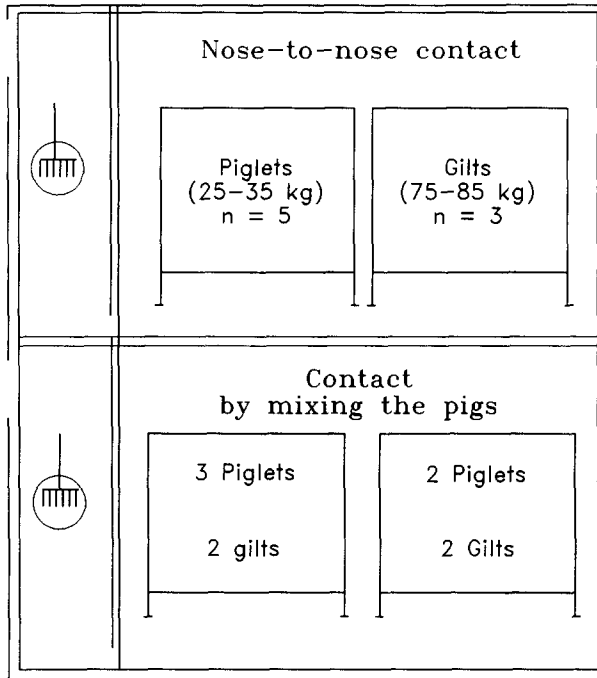
Fig. 1. Design of the experimental contact trial.

farms candidates. All the pigs from these farms had to be individually and systematically identified at birth on routine basis (Tattoo). Provisional groups of farms were made with respect to health. Then a random selection was undertaken within these groups. The selected farms were widely scattered all over the North-West of France. Their health was checked up just before the contact trial started.

• The gilts: On the farms, batches of pigs weighing around 75–85 kg live weight were considered for the choice of the individuals that were to be transferred to the research station. Pigs showing obvious signs of illness or those with a low liveweight were eliminated. Among the others, gilts estimated to be fit for sale were submitted to random selection. They were weighed, and transferred to the experimental facilities in a perfectly clean and disinfected lorry. On average, they were 141 days old (SD: 19 days) at a liveweight of 79.4 kg (SD: 4.5 kg).

• The piglets: The piglets used in this trial came from the SPF herd at the "Station de Pathologie Porcine" in Ploufragan. At the beginning of the challenge, they weighed 30.3 kg, on average, at 60 days of age SD: 6 days).

• Duration of the challenge: For each farm, the contact period lasted 28 days.

• Statistical procedures: The data, concerning the prevalences obtained in the

TABLE 2

Laboratory investigatious: infections agents concerned and corresponding diagnosis methods

Microbial agent	Method
Aujesky's disease virus	Serology ELISA (OIE manual, 1991)
Swine Influenza virus	Serology HI test (Palmer et al. 1975)
TGE/Porcine Respiratory Coronavirus	Serology SN (OIE Manual, 1989)
P.E.D. Virus	Serology ELISA (Callebaut et al. 1982) Call
Porcine Parvovirus	Serology H.I. test (Mengeling, 1992)
Mycoplasma hyopneumoniae	Serology ELISA (Nicolet and Paroz, 1980)
Pasteurella multocida	Culture (Avril, 1989)
P. multodica toxin	ELISA (Foged et al. 1988)
Bordetella bronchiseptica	Culture (Michel-Briand, 1989)
Haemophilus parasuis	Culture (Dabernet and Sanson-Le-Pors, 1989
Actinobacillus pleuropneumoniae	Culture (Avril, 1989)
Streptococcus suis	Culture (Hommez et al. 1986)
Salmonellae	Culture (Ellis et al. 1976)
Internal parasites	Coproscopy (Coles, 1974)

different groups of piglets, were compared by chi-square. The weight gains were compared by the t test.

• Clinical observations and laboratory examinations: rectal temperature, fecal consistency, respiratory signs (sneezing, coughing, etc.), locomotor disorders and any other particular anomalies were recorded day by day. Weekly food intake was recorded for each flat-deck. Blood samples were taken from every pig on the first day, and then, every 7 days. The sera were tested against pseudorabies, swine Influenza, Porcine respiratory coronavirus, Transmissible gastroenteritis, Porcine Epidemic Diarrohea, porcine parvorirus and Mycoplasma hyopneumoniae. At the beginning of the trial, nasal swabs were taken for bacteriology and faeces were examined for parasites and salmonellae. At the end of the period (28 days), all the pigs were euthanasied and then, according to a standard protocol, necropsied and sampled for further laboratory testing (bacteriology and parasitology, Table 2).
Respiratory tract lesions were scored at necropsy, on scales according to Madec et al. 1988. Pigs dying in the course of the trial were weighed and a similar procedure was carried out in a thorough examination for lesions plus appropriate microbiology.

RESULTS

The health score of the 11 tested farms

Out of the eleven farms selected and having their health standards checked, 5 were breeding farms and 6 were multipliers. Ten breeding pyramids were

TABLE 3

The score obtained by the 11 farms checked for health

Farms	1	2	3	4	5	6	7	8	9	10	11
Score	12	12	17	18	10	15	15	18	15	18	22

involved. Table 3 shows the score which these farms obtained. The average score was 15.6 (min = 10, max = 22).

The response of the SPF Pigs: Overall results

The overall results concerning the SPF pigs are listed in Table 4. Mortality rate was 14.8%. Glasser's disease and streptococcal septicemia due to were the main causes of death. Clinical signs of coughing and sneezing were recorded in respectively 25.2 and 47.7% of the piglets. Fever (rectal temperature $\geqslant 40.5°C$) was detected in 53.3%, and diarrhoea affected 22.4% of the piglets. Daily liveweight gain varied a lot: 13 piglets lost weight while alive; 10 gained at least 900 g daily.

TABLE 4

Overall results from the SPF piglets: clinical signs, lesions and microbiology at necropsy after contact with gilts from nucleus and multiplier farms ($n = 107$ piglets)

	Number of piglets affected	%
Fever: rectal T° $\geqslant 40.5°C$	57	53.3
Sneezing	51	47.7
Coughing	27	25.2
Diarrhoea	24	22.4
Mortality	16	14.8
Average daily gain ≤ 0	13	12.1
Average daily gain $\geqslant 900$ g	10	9.3
Pneumonia	25	23.7
Turbinate atrophy (mild)	13	12.2
Pleuritis and/or Polyserositis	10	9.3
Isolation P. multocida	20	18.7
Isolation B. bronchiseptica	30	28
Isolation H. parasuis	21	19.6
Isolation S. suis II	8	7.4
Seroconversion Mycoplasma hyopneumoniae.	22	20
Seroconversion Porcine parvovirus	3	2.9

Necropsy showed pneumonia in 23.7% of the piglets and turbinate atrophy in 12.2%, the latter being mild. Many specific pathogens were transferred from the gilts to the corresponding piglets. These were mainly pneumotropic agents, but, neither swine influenza nor porcine coronavirus were concerned. But surprisingly a seroconcersion against porcine parvovirus was found out in a group of piglets. All the fecal samples proved negative as regards salmonellae.

Consequences of the type of contact (nose to nose or mixing)

When the gilts and the piglets were put together on the same flat-deck, the challenge was more severe (Table 5). Signs of illness attested by rectal temperature (Fig. 2) were also detected earlier in this case. Furthermone the piglets had a significantly lower weight gain. The mortality rate was higher and fever more largely prevalent. The general trend was also for more severe lesions together with a higher frequency of isolation of P. multocida. On the other hand, the figures obtained for the seroconversion against M. hyopneumoniae were similar. In both cases rectal temperature became normal after 20 days.

Relation between the farm health standards and the response of the corresponding matched piglets.

The farms fell into 3 groups according to the figures obtained for the score on health. The response of the piglets is listed in Table 6. There is a clear difference between the extreme groups ($\leqslant 12$ vs. $\geqslant 18$) for all the criteria. When the score reached 18 or more, prevalence of illness indicated in the table by rectal temperature was low and none of the piglets died. The pathogen transfer rate was lower. Nevertheless, P. multocida was isolated from 4

TABLE 5

Results from the SPF piglets according to the type contact with the gilts

| | Type of contact | |
| | --- | --- |
	Mixing (same pen)	Nose-to-nose (adjacent pens)
Number of piglets	54	53
Mortality rate	22.2	7.5*
Average daily gain (g)	351	750**
Pneumonia score	1.2	0.3
Atrophic rhinitis score	0.7	0.5
Prevalence of severe fever	16.1	3.9***
T° $\geqslant 41$°C)		
Isolation of P. multocida (%)	25	13
Seroconversion M. hyopneumoniae (%)	17	25

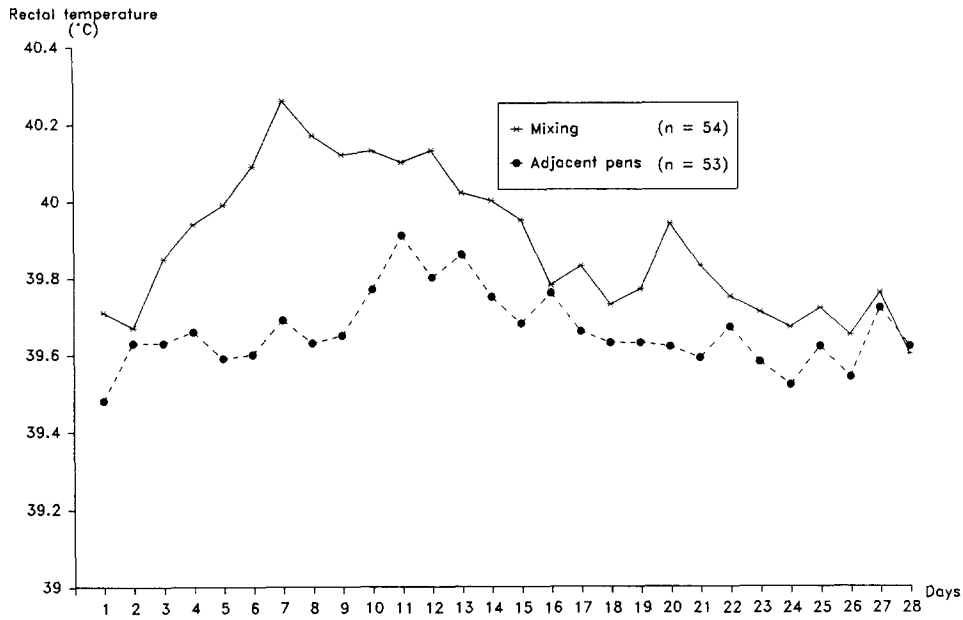*, **, ***: respectively $P < 0.05, 0.01$ and 0.001.

Fig. 2. Rectal temperature in the SPF pigs according to the type of contact with the gilts.

TABLE 6

Relationship between the score obtained for health and the response of the piglets

	Health score of the farms		
	≤ 12	13–17	≥ 18
Mean score obtained	11.3	15.5	19
Total piglets involved	28	39	40
Mortality rate (%)	21.4	25.6	0 *
Average daily gain (g)	559	346	733 **
Prevalence of severe fever (1)	10.6	8.5	1.5 **
Prevalence of diarrhoea (2)	3.2	5	1.5
Prevalence of pneumonia (%)	28.2	23.1	7 *
Transfer P. multocida (%)	21.5	25.5	10
Transfer H. parasuis (%)	50	10	7 *
Transfer S. suis II (%)	21.4	5.1	0 *
Seroconversion M. hyopneumoniae (%)	60	2.5	5

*, **: respectively P <0.05 and 0.01.
(1) days X pigs with t° ≥ 41°C, %.
(2) days X pigs, %

piglets (10% in group ≥ 18). However, in the piglets matched to the 3 farms getting a poor score, the microbial transfer rate was high and some agents like *H. parasuis* and *M. hyopneumoniae* were found in at least half of the piglets. The response of the piglets concerned by the medium scores was more irregular but considering the whole sample of farms, as regards many criteria, a gradual trend could be detected between the severity of the response of the piglets and the score on health.

DISCUSSION

Transmission of disease to a recipient farm through the replacement breeding stock accounts for the transfer of specific pathogens. However, diseases cannot develop unless these pathogens find certain specific conditions in the recipent farm. The immunity status of the herd is believed to play an important role in determining this. At first sight the general process looks simple in the case of highly infectious viral diseases like TGE or swine influenza. In a non-immune herd, viral shedding from newly-purchased pigs will undoubtedly lead to disease. These diseases usually show a marked wave pattern according to the level of protection of the swine population.

Unfortunately, the situation is much more complex with respect to other health disorders like enzootic respiratory diseases or streptococcosis. In such cases, microbial transfer is also necessary for a disease to break out but in most situations there is the need for many other additional conditions before disease does actually occur. This kind of multifactorial disease has a major economic impact on the pig industry. The problem is that most of the pathogens involved in such diseases are widely spread in the breeding pyramids and it is assumed that the diseases can be transmitted by pigs from herds harbouring the pathogens even though subclinical troubles only are present in the selling farms (Backström and Hoefling, 1986, De Jong and Nielsen, 1990). On the other hand, it has been demonstrated earlier that, at least for the respiratory tract, the frequency of germ carriage is related to the severity of the lesions (Morrison et al. 1985, Cowart et al. 1989).

The purpose of this work was to test the value of a method used to estimate quantitatively the health standards on farms in order to measure the level of "microbe pressure" as evidenced by disease transmission. The idea put forward being that disease is all the more likely to be transmitted as the amount of microbes transferred is high. According to the authors, the health level can be assessed through the measurement of direct health indicators (mortality rate, clinical signs, etc.) but also indirectly through the evaluation of the degree of exposure to particular circumstances that have been proved to be linked to a given disease (Jenicek and Cleroux, 1982). Most of the parameters here included in the index are direct health indicators. To elaborate a parameter in order to find out how vulnerable the farms are to viral epidemics is also –

though indirectly – a health indicator in itself and this is in accordance with the above definition. Collectively, the different criteria selected in the index have a descriptive value for the whole farm health situation but they do not have an individual direct causative value with respect to a specific disease (Evans, 1978) or to disease transmission per se by the concerned pigs since for example none of the criteria gives a measure of viral shedding. Thus the health indicators are meant to describe the trend and/or to find out the factors which make that a farm is more or less liable to show such or such diseases. The relative economic impact of the different diseases of swine was not directly taken into account when selecting the health indicators. Since the target farms were farms selling young replacement stock, the objective was not to assess the relation between health and financial income. Such attempts have been undertaken elsewhere (Ellis and James, 1979, Dijkhuisen, 1989, Madec et al. 1992). Nevertheless, it can be noticed in the list of the health indicators that respiratory and reproductive problems, which are very detrimental in financial terms, hold a place of choice in the profile.

The experiment reported in this paper which consists of using young gilts for a standard challenge was carried out in order to assess infection pressure more objectively on their original farm. The results obtained showed great discrepancies between the groups of piglets according to the farms the gilts came from. When the farms offered top health standards, the response of the piglets was either nil or mild regarding both clinical signs and lesions or microbial transfer. This might indicate a low infection pressure. Whereas, when most of the health indicators were at a bad level, the response of the piglets was severe. Nevertheless a new issue might be raised: were the gilts selected truly representative of the real health status of the farms. It has not been possible to solve this problem completely. However, the retrospective comparative observation of the respiratory tract of the gilts at the end of the trial and the viscera of the slaughtered pigs from the farms concerned gave substantial results (Madec et al. 1991).

Besides, one might question a 28-day challenge, why 28? This might not be long enough for certain diseases to have time to develop properly. However, the curves indicating the daily prevalences of the clinical signs showed a slight decrease from day 12 post-contact onwards, and in most of the groups of pigs, the signs of disease vanished during the last days of the trial. Since the signs of illness (and therefore contamination) occurred within the first 12 days, at least 16 days remained for antibody detection.

The rapidity and the severity of the response were higher in the case of close contact between the piglets and the gilts than when the pigs had limited contact with one another. This is not without practical consequences in commercial farms where young high health-status breeders are bought-in. A progressive contact with the local microflora is recommended whenever the two herds show great discrepancies regarding their own health standards.

Furthermore the introduction of high health-status animals into a given commercial farm with a poor health level could also argued: will this not create a booster effect on disorders in the whole herd through an acute response in the replacement pigs? Our experimental model could not confirm this hypothesis since no significant recrudescence in the clinical signs could be observed in the gilts even when their own piglets were severely affected.

The results of the present study show that it is possible to estimate the health level of breeding farms through a rational epidemiological approach. To do so, it is necessary to combine as many different health indicators as possible and these have to provide data as hard as possible (Feinstein, 1977) to avoid subjective deviation by the inquirer (Heard, 1981). The method described above requires certain investigations which have practical constraints, for example laboratory investigations and the sacrifice of 3 ten-week-old-piglets per herd. New diagnosing methods might also appear for current diseases and new syndromes might occur. Therefore, actualization and further research are made necessary in order to find out new, refined or more accurate criteria just as relevant but more practical to use than some of the health indicators mentioned in this study.

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RESUME

Madec, F., Kobisch, M. et Leforban, Y., 1993. Un essai a estimée le santee dans élevages de sélection et de multiplication. *Livest Prod. Sci.*, 34: 281–294 (en anglais).

Une enquête épidémiologique pilote est conduite en France dans un groupe de 205 élevages de sélection et de multiplication. Le but est de contribuer à la mise au point d'une méthode permettant une évaluation quantitative du niveau sanitaire des élevages. Le protocole appliqué permet une collecte exhaustive d'informations à partir d'examens cliniques réalisés en élevage, d'examens de lésions sur porcs en abattoir et à partir de recherches de laboratoire. Le traitement statistique des données a permis de sélectionner 14 indicateurs de santé prépondérants. Ces derniers sont ensuite combinés pour former un index de santé. Un score peut alors tre attribué à chaque élevage. Au cours d'une seconde phase, la pertinence de la méthode en regard du risque de transmission de maladies par les jeunes reproducteurs dans un élevage d'accueil a été testée dans des conditions expérimentales standardisées et totalement contrôlées. Le principe est un "contact" entre des porcs SPF et des cochettes prélevées dans des élevages ayant obtenu des scores différents pour leur état de santé. Le contact dure 28 jours. Onze élevages ont été choisis. Dans chacun d'eux 7 cochettes sont prélevées et mises au contact de 10 porcs SPF. Tous les animaux sont soumis en station expérimentale à une observation détaillée. Au terme de la période, tous les porcs sont euthanasiés et des recherches complètes sont entreprises. Des symptômes variés sont apparus sur les porcs SPF. Le taux de mortalité en cours d'essai a été de 14.6%. Des lésions de pneumonie ont été décelées sur 23.7% des porcs. Une relation est apparue entre le transfert des contaminants et la sévérité des signes cliniques. La sévérité du challenge chez les porcs SPF était bien corrélée au niveau sanitaire global des élevages fournisseurs des cochettes. La méthode d'évaluation du niveau sanitaire est donc considérée comme satisfaisante en regard des objectifs fixés.

La signification de l'outil épidémiologique pour estimer la pression d'infection dans les élevages est discutée.

KURZFASSUNG

Madec, F., Kobisch, M. und Leforban, Y., 1993. Ein Versuch zur Messung der Gesundheit in Nukleus- und Vermehrungsbetrieben für Schweine. *Livest. Prod. Sci.*, 34: 281–294 (auf englisch).

In 205 Nukleus- und Vermehrungsbetrieben für Schweine in Frankreich wurde eine epidemiologische Umfrage durchgeführt. Das Ziel war die Erarbeitung einer Methode zur quantitativen Bewertung des Gesundheitsstatus in Betrieben, die Jungtiere zur Zucht verkaufen. Für die Datensammlung wurde ein umfangreiches Protokoll vorbereitet. Als Informationsquellen dienten klinische Untersuchungen der Bestände, Fleischbeschaudaten am Schlachthof und Labortest. Für 14 wichtigere Gesundheitsindikatoren wurden aus den Daten Profile berechnet. Diese wurden dann zu einem Gesundheitsindex als "overall score" zusammengeführt.

In der zweiten Phase wurde die Bedeutung der Methode für die Krankheitsübertragung bewertet. Das Prinzip war eine Kontaktinfektion der Jungsauen von Earmen mit verschiedenen Gesundheitsindices in einer total kontrollierten Anlage mit SPF-Primär-Schweinen. Der Kontakt wurde für 28 Tage gegeben. Aus 11 ausgewählten Betrieben wurden je 7 Jungsauen genommen und 10 SPF-Schweine wurden jeder dieser Gruppen zugeordnet. Alle Schweine wurden genau beobachtet, am Ende geschfitet und im Labor auf Läsionen und Infektionsagencien untersucht. Bei den SPF-Schweinen wurde eine breite Palette von Symptomen registriert. Die Mortalitätsrate war 14.6% und 23.7% waren mit Pneumonie infiziert. Zwischen Keimtransfer und Schwere der Erkrankungen wurde eine Beziehung gefunden. Der Grad der Erkrankung der SPF-Tiere war deutlich mit dem vorher ermittelten Gesundheitsindex des Korrespondierenden Betriebes korreliert. Deshalb wurde die Methode als geeignety eingestuft, den Gesundheitszustand zu bewerten.