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The prevalence of some economically important swine diseases in farrowing units in southwestern Finland

Veikko K. Tuovinen*\textsuperscript{a,b}, Katri H. Levonen\textsuperscript{c}, Yrjö T. Gröhn\textsuperscript{d}, Barbara E. Straw\textsuperscript{e}

\textsuperscript{a}LSO, PL 50, SF-20521 Turku, Finland
\textsuperscript{b}Department of Animal Hygiene, College of Veterinary Medicine, P.O. Box 6, SF-00581 Helsinki, Finland
\textsuperscript{c}National Veterinary Institute, PL 368, 00101 Helsinki, Finland
\textsuperscript{d}Section of Epidemiology, Department of Clinical Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853, USA
\textsuperscript{e}111 VBS, East Campus, University of Nebraska, Lincoln, NE 68583-0905, USA

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Abstract

The prevalence and geographical distribution of some economically important swine diseases were surveyed in 114 randomly selected farrowing units which had a contract with Southwestern Finland's Cooperative Slaughterhouse (LSO) for producing feeder pigs to be delivered to the all in–all out finishing units.

The focus was on infectious diseases which could be transmitted to the finishing units with delivered growers, and which might have some influence on partial carcass condemnations (PCC) in meat inspection. Farm visits were done by a veterinarian (senior author) assisted by a technician. Colostrum samples (average 22 per herd) were taken in 100 herds, and analyzed for \textit{Actinobacillus pleuropneumoniae} (A.pleur) and \textit{Mycoplasma hyopneumoniae} (M.hyo) antibodies by enzyme-linked immunosorbent assays (ELISAs).

Only nine of 114 herds were judged to be free of mange. It was concluded that all finishing units received mange-infected feeder pigs each time the unit was filled. One or more acute erysipelas outbreaks had occurred in every fifth herd during the previous year. The risk of a finishing unit receiving feeder pigs carrying erysipelas was considered to be high.

\textit{Swine dysentery} (\textit{Serpulina hyodysenteriae}) was not found to be a problem in the LSO area.

\textit{Clostridium perfringens} type C enteritis was found in eight (7%) herds. Seven of these herds were located in those supply areas where the PCC percentage of feeder pigs

* Corresponding author.
was high. In spite of statistical connection no causality between this disease and PCC was presumed.

There were no previous diagnoses of respiratory diseases but spontaneous coughing was observed in 5% of the herds. Provocation testing induced coughing in 22% of herds but not serious coughing in any herd. Managers had observed coughing in 15% of herds. Ninety-one herds were positive in a colostrum ELISA for A.pleur antibodies, and eight herds were positive for M.hyo antibodies. A.pleur-positive herds had several positive or samples suspected of being positive in each herd but M.hyo-positive herds had only one or two positive or suspected samples per herd. Six of the M.hyo herds were located in the high PCC area, two in the average PCC area and none in the low PCC area. M.hyo was suggested to be one of the possible explanations for geographical variation of PCC. Atrophic rhinitis was not considered to be of importance in LSO.

1. Introduction

In a study of feeder unit environmental factors and their associations with partial carcass condemnations (PCC) in market swine (Tuovinen et al., 1992), a large geographical variation in PCC percentage of all in–all out feeder pig finishing units was found. Geographical variation remained after controlling for the housing and management factors in the finishing units. It was proposed that variation in the health quality of the feeder pigs at the time of their delivery to the finishing unit might explain some of the geographical differences noticed in condemnation percentages.

Southwestern Finland's Cooperative Slaughterhouse (LSO) buys the market pigs from the finishing units. Transportation of growers from farrowing units to the all in–all out finishing units is also managed by LSO. Growers are gathered from several farrowing units to fill one finishing barn. Also, feeder pigs from one farrowing unit end up in several finishing units. Transportation distances between farrowing units and finishing units are kept as short as possible to reduce costs. It can be speculated that the proportion of infected herds (e.g. dysentery, enzootic pneumonia, mange, erysipelas and atrophic rhinitis) in farrowing units of certain supply districts of LSO is greater than that of other areas. The transported feeder pigs may be asymptomatic disease carriers.

Some idea of the possible diseases transmitted by delivered feeder pigs could be obtained from three different sources: disease statistics published by the Veterinary Department of the Ministry of Agriculture and Forestry (e.g. see Anonymous, 1991), reports of the health control program for pigs published yearly by the Finnish Animal Breeding Association (e.g. see Anonymous, 1990) and LSO's own abattoir findings. Reviewing these data, it seemed evident that erysipelas and mange were common in the LSO area. Clinical cases of swine dysentery, swine enzootic pneumonia caused by Mycoplasma hyopneumoniae (M.hyo) and pleuropneumonia caused by Actinobacillus pleuropneumoniae (A.pleur) seemed to be rare. A few dozen outbreaks of these diseases were reported annually but there
was no information as to whether these cases had been diagnosed in farrowing or in finishing units. Only two cases of atrophic rhinitis (AR) were reported in southwestern Finland in 1990 (Anonymous, 1991). No detailed information of prophylactic treatments (medications or vaccinations) was available.

The breeding herds belonging to the Finnish Pig Health Scheme were recently surveyed for respiratory diseases by the National Veterinary Institute (Levonen et al., 1992). In that study, seven out of 200 breeding units were found to be positive for M.hyo antibodies. M.hyo is more likely to be found in the commercial farrowing units which produce feeder pigs for distribution to the finishing units. However, no published surveys of respiratory or other relevant swine diseases in commercial farrowing units in Finland were found. Any foci of transmissible diseases which could explain the geographical variation in condemnation figures, could not be detected from the available data.

The goal of this study was to determine the prevalence and geographical variation of some economically important swine diseases in farrowing units in the area of LSO. The focus was on infectious diseases which could be transmitted to the finishing units with delivered growers, and which might have some influence on partial carcass condemnations in meat inspection.

2. Materials and methods

2.1. Herd selection and enrolment

There were 1334 commercial farrowing units in 1990 which had a contract for producing feeder pigs for LSO to be delivered to the all in–all out finishing units. The criteria for farms to be included in the study were as follows.

(1) Production was planned to continue without any major changes in 1991 (same owner, no renovation going on, contract with LSO).
(2) Breeding units belonging to the Finnish Pig Health Scheme were excluded.
(3) Farrow-to-finish units were excluded unless most of the feeder pigs were sold for LSO's delivery.

Random samples were taken in two parts from the 1334 farrowing units. The first random sample (150 farms) was taken in January 1991. Thirty farms did not qualify for the reasons above. Seventy-eight farms of the 120 qualified enrolled in the study. Thirty-one farms did not want to enroll because of the extra work required (23 farms) or a lack of motivation (eight farms). Eleven farms did not respond at all. A comparative analysis of the farms which did not respond or declined to enroll, was performed based on the market data at LSO. In addition, the local LSO personnel were asked if they knew of any particular (especially disease) reason for self-exclusion.

The second random sample (74 farms) was taken in June 1991 to replace the dropouts. Because the analysis of the dropouts of the first sampling did not indicate that farms declined enrolment owing to the presence of disease in their unit, detailed dropout analysis of the second sample was not performed. Thirty-six
farms of the second sample enrolled in the study. In total, 114 randomly sampled farms were included in the study.

2.2. Farm visits

The selected 114 farms were visited by a veterinarian (senior author) assisted by a technician. Seven LSO technicians, all with previous experience, were chosen for this study. They were especially trained to perform the environmental measurements in a similar manner. The questionnaire was completed by the veterinarian.

The questionnaire included animal inventory, recording of production figures and measurements of piggery dimensions and environmental conditions. Detailed questions of housing, management, feeding, disease outbreaks, symptoms, prophylactic treatments and disease prevention were asked. Information regarding diseases diagnosed during the previous year was obtained from the health control records (if available), from the manager and, occasionally, verified by the local veterinarian. If one or more clinical cases had occurred during the previous year, the herd was recorded to be positive for that particular disease.

Clinical signs were described by managers and observed by the veterinarian (senior author). Managers described disease problems encountered during the previous year. Veterinary observations can be seen as a point prevalence of signs. Diarrhea, coughing, sneezing, deviated snouts, joint infections and mange were routinely recorded on a three-category scale (frequent, moderate, none), separately in each age group (piglets 0–1 week, 1–3 weeks, 3 weeks to delivery, sows, boars, other pigs). A herd score was given for each symptom based on the worst recording in any age group. Other symptoms, if any, were described.

Mange was recorded, in addition to visible symptoms in the ears and skin, by using a scratching index. A certain number of pigs were observed (usually ten sows and one litter) for 15 min. The index was calculated by dividing the number of scratching animals by the number of observed animals. Thus, the index could vary from 0 to 1. An index greater than 0.4 is a clear indication of mange (Madsen, 1988).

Coughing was provoked by driving a litter of piglets (7–12 weeks of age) in a circle for 1 min. Coughing was scored on a scale of 0 to 3. The score was 0 if none of the pigs coughed. Coughing by one or two pigs, not very seriously, was given a score of 1. The score 2 was given if three to five pigs were coughing a few times or one or two pigs were coughing seriously. Severe coughing of three or more pigs or mild coughing of six or more pigs was rated as 3.

2.3. Colostrum samples

Managers of the farrowing units were requested to obtain colostrum samples from at least 30 sows or from all the sows if the number of sows was 30 or less. Colostrum samples were frozen on farms and sent for analysis to the Department of Animal Hygiene of the College of Veterinary Medicine, Helsinki. A research
assistant trained for this study in the National Veterinary Institute analyzed all the samples. Colostrum samples were analyzed for the M.hyo antibodies using the method of Bommeli and Nicolet (1983). The ELISA test kit used was Checkit (R) Hyop-test produced by the Laboratory of Dr. Bommeli AG, Switzerland. A.pleur (serotype 2, the only serotype found in Finland) antibodies were analyzed using the A.pleur-ELISA from the Laboratory of Dr. Bommeli AG (Von Ruswil, 1991). Samples were recorded as positive, suspected of being positive or negative (a photometer was used in all readings) according to the methods described in the operating instructions (Anonymous, 1989a,b).

The results were interpreted at the herd level. A herd was designated as positive (possibly infected with M.hyo) if one or more of the samples were either positive or suspected of being positive in the ELISA for M.hyo. If all the samples were negative, it was concluded that the herd was negative (probably free of M.hyo). The results of ELISAs for A.pleur were interpreted similarly.

2.4. Geographical distribution

The LSO area was divided into ten supply areas in 1990 when this study was designed. Since 1990, there has been a continuing process in LSO to merge and reorganize these areas. The number of supply areas was decreased to five supply districts in 1992. The analysis was initially performed using both the old supply areas and the new supply districts. Because the new supply districts did not match the areas used in the study and the number of the old supply areas was too large for proper analysis, new geographical categories were created for further analysis. Each supply area was placed in one of three categories based on the PCC for that area in 1991 (Tuovinen et al., 1994). The high PCC (PCC between 3.7% and 4.3%) category included supply areas of Turku, Huittinen and Laitila. Average PCC (3.4–3.6%) areas were Karjaa, Pori and Kerava. The low PCC (2.7–2.9%) category included the results of Tampere, Hämeenlinna, Lahti and Forssa supply areas.

3. Results

3.1. Farm visits

The mean number of farrowed sows in the 114 visited farms was 30.6, the median was 27.5 and the range 6–320. The second largest herd had 75 sows. The number of feeder pigs sold to LSO in 1990 ranged from ten to over 4500, and the median was 502.
Diagnosed diseases

Mange and erysipelas were the most common diagnoses reported by the producer during the previous year in the 114 herds (Table 1). Mange was diagnosed in most herds (85.1%) and erysipelas in every fifth herd during the previous year. None of the herds had been diagnosed with any respiratory disease. Swine dysentery was found in two herds. Eight farms (7.0%) had a history of *Clostridium perfringens* type C enteritis, and were using vaccination as a preventative measure. In addition to diseases included in the questionnaire, two farms reported problems with edema disease. Other herd problems reported and discussed during the farm visits (e.g. infertility) were not relevant to the study goals and were not recorded.

Clinical signs

Symptoms noticed by the manager during the previous year and observed by the senior author during the farm visits are listed in Table 2.

Only 11 herds (9.6%) were free of typical mange symptoms. Symptoms were most often seen in sows. Mange in weaners was seldom seen by the managers, although the symptoms were evident to the author in most herds.

The average scratching index was 0.26 (median 0.2, range 0–1). The index was zero for 13 herds (11.4%). An index of 0.4 or greater was given for 29 herds (25.4%). Three herds had the maximum index of 1. The scratching index was, on average, 0.02 for the 11 farms without any mange symptoms noticed by the senior author, 0.26 for the 97 farms with moderate symptoms and 0.65 for the six farms with frequent symptoms.

Most herds (82.6%) had diarrhea during the previous year according to the managers. The proportion of herds with diarrhea signs observed during the farm visits was 25.4%. Diarrhea was seldom seen in adult animals. Arthritis was a common symptom, both in piglets and in adult pigs. Snout deviations were found in one herd in the 1–3 week age group. *Fusiformis necrophorus* was found in the autopsy of two piglets of that herd.

The provocation test for coughing was performed in 107 herds. The coughing

| Diagnosis                          | No. | %  |
|-----------------------------------|-----|----|
| Mange                             | 97  | 85.1|
| Erysipelas                        | 23  | 20.2|
| *Clostridium perfringens* type C enteritis | 8   | 7.0 |
| Swine dysentery                   | 2   | 1.8 |
| Swine enzootic pneumonia          | 0   | 0.0 |
| Pleuropneumonia (*Actinobacillus pleuropneumoniae*) | 0   | 0.0 |
| Atrophic rhinitis                 | 0   | 0.0 |
Table 2
Disease signs noticed earlier by the manager (MAN) or by the senior author (AUT) during farm visits to the 114 randomly selected farrowing units which produced feeder pigs for LSO in 1990

| Symptom          | Occurrence within herd | Piglets (< 3 weeks) | Piglets (3-12 weeks) | Sows, gilts, boars and other pigs | Whole herd |
|------------------|------------------------|---------------------|----------------------|----------------------------------|------------|
|                  |                        | MAN     | AUT     | MAN     | AUT     | MAN     | AUT     | MAN     | AUT     |
| Diarrhea         | Frequent               | 7.0     | 0.0     | 2.6     | 0.0     | 0.0     | 0.0     | 7.9     | -       |
|                  | Moderate               | 46.5    | 13.2    | 50.0    | 18.6    | 4.4     | 0.9     | 73.7    | 25.4    |
|                  | None                   | 46.5    | 86.8    | 47.4    | 81.4    | 95.6    | 99.1    | 18.4    | 74.6    |
| Spontaneous coughing | Frequent             | -       | 0.0     | -       | -       | -       | -       | -       | -       |
|                  | Moderate               | 7.0     | 1.8     | 10.5    | 5.3     | 0.9     | -       | 14.9    | 5.3     |
|                  | None                   | 93.0    | 98.2    | 89.5    | 94.7    | 99.1    | 100.0   | 85.1    | 94.7    |
| Sneezing         | Frequent               | 0.9     | 1.8     | -       | -       | -       | -       | -       | 0.9     |
|                  | Moderate               | 7.9     | 11.4    | 15.8    | 20.4    | 0.9     | 0.9     | 17.5    | 23.7    |
|                  | None                   | 91.2    | 86.8    | 84.2    | 79.6    | 99.1    | 99.1    | 81.6    | 74.6    |
| Deviated snouts  | Frequent               | -       | 0.9     | -       | -       | -       | -       | -       | 0.9     |
|                  | Moderate               | 0.9     | -       | 0.9     | 0.9     | -       | -       | 0.9     | -       |
|                  | None                   | 99.1    | 99.1    | 99.1    | 99.1    | 100.0   | 100.0   | 99.1    | 99.1    |
| Arthritis        | Frequent               | 0.9     | 2.6     | -       | -       | -       | -       | -       | 2.6     |
|                  | Moderate               | 55.3    | 34.2    | 43.0    | 38.9    | 31.6    | 14.9    | 81.6    | 49.1    |
|                  | None                   | 43.9    | 63.2    | 57.0    | 61.1    | 68.4    | 85.1    | 17.5    | 48.2    |
| Mange            | Frequent               | -       | 2.6     | 0.9     | 4.4     | 0.9     | 2.6     | 1.8     | 5.3     |
|                  | Moderate               | 13.2    | 55.3    | 30.7    | 75.2    | 78.1    | 84.2    | 78.1    | 85.1    |
|                  | None                   | 86.8    | 42.1    | 68.4    | 20.4    | 21.1    | 13.2    | 20.2    | 9.6     |

*There were 113 observations (no piglets in this age group in one herd during the farm visit).

by provocation score was 0 in 83 (77.6%) herds. Eighteen (16.8%) herds were given a score of 1, six (5.6%) herds received a score of 2, and no herds received a score of 3. There were 75 herds where coughing was not observed by managers nor by the author, and could not be induced by provocation. Provocative testing induced coughing in seven of the 17 herds where spontaneous coughing had been observed by managers and in five of the six herds where coughing was observed by the author. In addition, the provocation test induced coughing in 16 herds where neither the author nor the manager had observed coughing.

**Protective measures against infectious diseases**

Boots or disposable boot covers for visitors were provided by nearly half the farms but only ten farms provided protective clothing as well. Fifty-nine (51.8%) farms did not provide either protective clothes or boots for visitors (Table 3).

Both feeder pig and market hog truck drivers were allowed to go into the piggery to transfer pigs to the truck in 81 (71.1%) farms. Thirteen (11.4%) farms denied all truck drivers access to the piggery. Market hog truck drivers were denied access to the piggery in more farms (26.3%) than feeder pig truck drivers (14.0%).

Equipment (cart, panels or other arrangements) for moving growers to the transport truck was furnished by 63 (54.4%) farms. The remainder of the farms...
Table 3
Protective measures taken against infectious diseases in 114 randomly sampled farrowing units which produced feeder pigs for LSO in 1990

| Protective measure                                      | Herds |   |
|--------------------------------------------------------|-------|---|
|                                                        | No.   | % |
| Boots or disposable boot covers for visitors           | 55    | 48.2 |
| Overalls (or other protective clothes) for visitors    | 10    | 8.8 |
| Feeder pig truck drivers allowed in the piggery        | 98    | 86.0 |
| Market hog truck drivers allowed in the piggery        | 84    | 73.7 |
| Own cart or panels for transferring feeder pigs to trucks | 63    | 55.3 |
| Access of birds into piggery hindered                  | 52    | 45.6 |
| Frequent rat and mouse control                         | 75    | 65.8 |
| Access of cats, dogs or other pets into piggery hindered| 64    | 56.1 |
| Replacement pigs are bought                            |       |   |
| Not at all                                             | 13    | 11.4 |
| Only from the Pig Health Scheme breeding units         | 100   | 87.7 |
| Also from other sources                                | 1     | 0.9 |
| Quarantine for replacement pigs                        |       |   |
| Yes                                                    | 6     | 5.3 |
| No                                                     | 95    | 83.3 |
| Not necessary as none are bought                       | 13    | 11.4 |
| Distance to the nearest piggery*                        |       |   |
| ≤0.5 km                                                | 30    | 26.8 |
| 0.5–1 km                                               | 27    | 24.1 |
| 1–3 km                                                 | 28    | 25.0 |
| 3–5 km                                                 | 8     | 7.1 |
| >5 km                                                  | 19    | 17.0 |

*Data of 112 herds.

Did not provide any equipment, and allowed truck drivers to use their panels or cart.

Fifty-two (45.6%) of the farms attempted to limit access of birds to the piggery. Rat and mouse populations were controlled on 75 (65.8%) farms. Cats, dogs or other pets were allowed to go into the piggery on 50 (43.9%) farms.

Distances between piggeries were estimated by the manager on 112 farms. Every second farm was located less than 1 km from another piggery. Three of four farms had another piggery closer than 3 km.

Replacement pigs were usually (87.7%) bought from breeding units belonging to the Finnish Pig Health Scheme, and were home raised in 13 (11.4%) herds. Artificial insemination was used in all but five farms.

A quarantine piggery for replacement animals was present on six (5.3%) farms. In 95 (83.3%) farms, replacement pigs were taken directly to the piggery.

3.2. Prophylactic treatments

Mange was controlled in most herds (75.4%) by medicating all sows and boars simultaneously, either routinely twice a year or only when needed (Table 4). Four
Table 4
Preventive medications and vaccinations given in 114 randomly selected farrowing units which produced feeder pigs for LSO in 1990

| Disease          | Prophylactic treatment                        | Herds |          |
|------------------|-----------------------------------------------|-------|----------|
|                  |                                               | No.   | %        |
| Mange            | Whole herd simultaneously twice a year        | 34    | 29.8     |
|                  | Whole herd simultaneously when needed         | 52    | 45.6     |
|                  | Sows individually before farrowing            | 6     | 5.3      |
|                  | Other medication practice                     | 13    | 11.4     |
|                  | No medication                                 | 9     | 7.9      |
| Internal parasites| Sows before farrowing and piglets at 7 weks    | 16    | 14.0     |
|                  | Sows before farrowing, no piglets             | 22    | 19.3     |
|                  | Other medication practices                    | 34    | 29.8     |
|                  | No medication                                 | 42    | 36.8     |
| Erysipelas       | Vaccination twice a year (sows, gilts and boars) | 9     | 7.9      |
|                  | Vaccination once a year (sows, gilts and boars) | 76    | 66.7     |
|                  | Other vaccination practices                   | 9     | 7.9      |
|                  | No vaccinations                               | 20    | 17.5     |
| Porcine parvovirus | Frequent vaccination (gilts, sows and boars)  | 22    | 19.3     |
|                  | Frequent vaccination (gilts only)             | 29    | 25.4     |
|                  | Other vaccination practices                   | 9     | 7.9      |
|                  | No vaccinations                               | 54    | 47.4     |
| Enteric colibacillosis | Simultaneous vaccination (whole herd)  | 24    | 21.1     |
|                  | Individual vaccination (sows before farrowing)| 21    | 18.4     |
|                  | Other vaccination practices                   | 2     | 1.8      |
|                  | No vaccinations                               | 67    | 58.8     |

of the latter herds were now probably free of mange (no symptoms noticed by manager, by local veterinarian or by senior author). Of the nine non-medicating herds, five were free of symptoms and one had frequent symptoms of mange.

Medication for internal parasites was not given in 42 (36.8%) herds. Sows were medicated individually 2–3 weeks before farrowing in 38 (33.3%) herds. In addition to sow medication, weaned piglets were medicated in 16 (14.0%) herds. Thirty-four (29.8%) farms had some other medication practice (all animals simultaneously, piglets only, when remembered etc.).

All sows, gilts and boars were vaccinated for erysipelas twice a year in nine (7.9%) farms and once a year in 76 (66.7%) farms. No erysipelas vaccinations were given in 20 (17.5%) herds.

Porcine parvovirus vaccinations were frequently given for all sows and gilts in 22 (19.3%) herds. Only gilts were vaccinated in 29 (25.4%) herds. Parvo vaccines were not used at all in 54 (47.4%) herds.

Frequent vaccinations against enteric colibacillosis were performed in 45 (39.5%) herds. Of these, 24 herds vaccinated all sows and gilts simultaneously, usually at 5 month intervals. Vaccines were given individually about 3 weeks before farrowing in 21 herds. Vaccines for colibacillosis were not used at all in 67 (58.8%) herds.
3.3. Colostrum samples

Colostrum samples were received from 100 of the randomly selected 114 farms (87.7%). The total number of received and analyzed samples was 2222. The farm average was 22.2 samples and ranges from 5 to 51. The 14 farms which did not send any samples were smaller (average 21 sows) than those which did (32 sows).

Nine of the analyzed 2222 samples (0.4%) gave a positive test result in ELISA for M.hyo antibodies (Table 5). Five (0.2%) samples were suspected of being positive and 2208 (99.4%) were negative. Ninety-two herds were negative and eight herds were positive. Positive herds were larger than negative herds. The proportion of positive and suspected positive samples was under 10% in all positive herds.

Of the 2222 colostrum samples tested by ELISA for A.pleur antibodies, 454 (20.4%) were positive, 443 (19.9%) were suspected positive and 1325 (59.6%) were negative (Table 5). Nine herds were negative and 91 herds were positive. Negative herds were smaller (18.2 sows on average) than positive herds (33.3 sows on average). Four of the positive herds had no positive and only one suspected sample. The proportion of positive or suspected samples was, on average, 43% in positive herds. Six of the positive herds had less than 10% of positive or suspected samples.

Table 5
Mycoplasma hyopneumoniae and Actinobacillus pleuropneumoniae antibodies detected by ELISA. Colostrum samples (n=2222) from 100 farrowing units which produced feeder pigs for LSO in 1990

|                   | Mycoplasma                  | Actinobacillus             |
|-------------------|-----------------------------|----------------------------|
|                   | Neg. herds | Pos. herds | All herds | Neg. herds | Pos. herds | All herds |
| No. of herds      | 92         | 8          | 100       | 9          | 91         | 100       |
| No. of sows       | 2610       | 582        | 3192      | 164        | 3028       | 3192      |
| Sows per herd     | 28.4       | 72.8       | 31.9      | 18.2       | 33.3       | 31.9      |
| Proportion of all sows (%) | 81.8 | 18.2 | 100 | 5.1 | 94.9 | 100.0 |
| Total no. of samples | 1957 | 265 | 2222 | 137 | 2085 | 2222 |
| No. of samples per herd | 21.3 | 33.1 | 22.2 | 15.2 | 22.9 | 22.2 |
| No. of positive samples | - | 9 | 9 | - | 454 | 454 |
| No. of positive samples per herd | - | 1.1 | 0.09 | - | 5.0 | 4.5 |
| No. of suspicious samples | - | 5 | 5 | - | 443 | 443 |
| No. of suspicious samples per herd | - | 0.8 | 0.05 | - | 4.9 | 4.4 |
| No. of negative samples | 1957 | 251 | 2208 | 137 | 1188 | 1325 |
| No. of negative samples per herd | 21.3 | 31.4 | 22.1 | 15.2 | 13.1 | 13.3 |
| Proportion of negative samples in a group (%) | 100.0 | 94.7 | 99.4 | 100.0 | 57.0 | 59.6 |

*Results excluding the largest farm with 320 sows.
3.4. The geographical distribution of diseases

*Clostridium perfringens* type C enteritis was the only one of the previously diagnosed diseases which differed significantly ($P<0.05$) between the three area categories (Table 6); seven of the eight herds affected were in the high PCC area. Mange symptoms in weaners were most common in the average PCC group. Arthritis, diarrhea and sneezing were most often seen in high PCC area herds but the differences were not significant ($P>0.05$).

Six herds with positive results for *M. hyo* antibodies were located in high PCC.

### Table 6

Farm visit and colostrum test findings classified by geographical area. Area categories were based on partial carcass condemnation (PCC) percentages in 1991

| | High PCC | Avg. PCC | Low PCC | $P^d$ |
|---|---|---|---|---|
| Proportion of LSO’s pig slaughter in 1991 (%) | 50.4 | 24.7 | 25.0 |  |
| PCC of market pigs in 1991 (%) | 4.1 | 3.5 | 2.8 |  |
| No. of visited herds | 49 | 32 | 33 |  |
| Proportion of visited herds (%) | 43.0 | 28.1 | 28.9 |  |
| Diagnosed diseases (% of visited herds) |  |  |  |  |
| Respiratory diseases $^e$ | 0.0 | 0.0 | 0.0 |  |
| Mange | 81.6 | 90.6 | 84.8 | 0.62 |
| Erysipelas | 16.3 | 25.0 | 21.2 | 0.54 |
| Dysentery | 2.0 | 3.1 | 0.0 | 0.63 |
| *Clostridium perfringens*, type C enteritis | 14.3 | 0.0 | 3.0 | 0.03 |
| Symptoms $^f$ (% of visited herds) |  |  |  |  |
| Diarrhea | 26.5 | 15.6 | 9.1 | 0.13 |
| Spontaneous coughing | 6.1 | 0.0 | 9.1 | 0.25 |
| Sneezing | 26.5 | 6.3 | 24.2 | 0.08 |
| Deviated snouts | 2.0 | 0.0 | 0.0 | 0.52 |
| Arthritis | 49.0 | 25.0 | 36.4 | 0.11 |
| Mange | 75.5 | 90.6 | 72.7 | 0.07 |
| Colostrum samples (no. of herds) | 47 | 27 | 26 |  |
| Colostrum samples (no. of samples) | 1129 | 567 | 526 |  |
| *M. hyo* pos. herds (% of sampled herds) | 12.8 | 7.4 | 0.0 | 0.16 |
| *M. hyo* pos. or susp. samples (% of samples) | 0.9 | 0.7 | 0.0 | 0.10 |
| A.pleur $^h$ pos. herds (% of sampled herds) | 97.8 | 74.1 | 96.2 | 0.00 |
| A.pleur pos. or susp. samples (% of samples) | 43.6 | 28.2 | 46.6 | 0.00 |

$^a$Turku, Huittinen and Laitila, (PCC 3.7–4.3%).

$^b$Karjaa, Pori and Kerava, (PCC 3.4–3.6%).

$^c$Tamperé, Hämeenlinna, Lahti and Forssa, (PCC 2.7–2.9%).

$^d$P-value of $\chi^2$ test of independence.

$^e$Swine enzootic pneumonia, pleuropneumonia, atrophic rhinites.

$^f$Symptoms observed by the senior author in the age group 3–12 weeks, combining herds with frequent and moderate occurrence of symptoms.

$^g$Herd was scored positive if one or more samples were positive or suspected of being positive in ELISA for *Mycoplasma hyopneumoniae*.

$^h$Herd was scored positive if one or more samples were positive or suspected of being positive in ELISA for *Actinobacillus pleuropneumoniae*. 
areas (three in Turku, two in Huittinen and one in Laitila) and two in the average PCC area (both in Kerava). No positive herds were found in the low PCC area. However, the differences were not statistically significant ($P > 0.05$). Five of the nine herds negative for A. pleur antibodies were located in the Pori supply area. The differences in A. pleur antibody results between area categories were highly significant ($P < 0.01$).

4. Discussion

The probability ($P_1$) that an all in–all out finishing unit will receive feeder pigs from one or more infected farrowing units (source herds) is a function of herd prevalence ($p_1$) of the particular disease and the number ($N$) of source herds

$$P_1 = 1 - (1 - p_1)^N$$

(1)

The probability ($P_2$) that one or more feeder pigs purchased from an infected herd are disease carriers, can be calculated by the same formula ($p_2$ represents prevalence within the herd, and $n$ the number of pigs purchased from that herd)

$$P_2 = 1 - (1 - p_2)^n$$

(2)

The probability ($P$) that one or more of the purchased feeder pigs is infected, is the product of these two probabilities

$$P = P_1 \times P_2$$

(3)

Farrowing units in Finland are small. The average number of feeder pigs sold by a farrowing unit to LSO was about 450 in 1991. The average number of feeder pigs received from one farrowing unit was 17.5 per collection. To fill one finishing barn (typical size about 300), feeder pigs were usually gathered from 10–20 farrowing units (average 17, range 1 to over 30). Because of the large number of source herds, the risk of transmitting infectious diseases to a finishing herd is great.

Only nine herds of 114 were considered to be free of mange. Practically all finishing units receive at least some mange-infected feeder pigs every time pigs are purchased to fill the unit. Mange makes pigs nervous and irritable and may increase the risk of tail biting, which is a main cause of abscesses. Abscesses are the second most common reason for partial carcass condemnations in LSO (Tuovinen et al., 1994). Geographical differences in condemnations cannot, however, be explained by mange because it was common throughout the LSO area.

Every fifth herd had suffered from at least one acute erysipelas outbreak during the previous year. Vaccination programs against erysipelas were insufficient in most herds. Clinical outbreaks of erysipelas in Finnish finishing units are known to be common. The risk of a finishing unit receiving feeder pigs from an erysipelas-infected farrowing unit is high.

According to the literature review by Wood (1992), erysipelas is of economic
importance worldwide, especially in its chronic form (arthritis). Healthy carriers (30–50% of pigs) are the most important reservoir of erysipelas. The causal agent can survive in swine feces for 1–6 months. Thus, the risk of finishing units becoming permanently infected with erysipelas is high. Erysipelas has been reported to be the major infectious agent in non-suppurative arthritis in pigs (Johnston et al., 1987). Erysipelas poses a risk for human health because arthritis is not necessarily detected in meat inspection (Cross and Edwards, 1981). Arthritis is the most important reason for partial carcass condemnations in LSO (Tuovinen et al., 1994). Erysipelas might explain a relatively high percentage of arthritis in LSO. However, it cannot explain the geographical variation in condemnations owing to its common appearance throughout the LSO area.

Dysentery was rarely diagnosed in farrowing units. Both herds in which it was found had previous outbreaks of dysentery recorded by the LSO Animal Health Service. Delivery of the feeder pigs from those herds was controlled to avoid the disease being spread to several finishing units. Dysentery has been successfully controlled in LSO by earlier projects and is no longer considered to be of economic importance in this area (Tuovinen, 1992). The present study was in agreement with earlier findings.

The geographical distribution of \textit{C. perfringens} type C enteritis was in agreement with an earlier study by Mäkelä (1988). Seven of the eight positive farrowing units were in the high PCC area. In the LSO area, clostridial enteritis has been recognized as an increasing problem for farrowing units but it has not been considered to be of any consequence for finishing units. Jestin et al. (1985) reported a diarrheic syndrome linked to \textit{Clostridium perfringens} type A in fattening pigs but no reports of disease problems linked to type C were found. Diarrhea of any kind has not been considered to be an important problem by the LSO finishing pig producers (Tuovinen, 1992), and a statistical association does not prove causality. Clostridial enteritis must, however, be recognized by the animal delivery people to avoid it being transmitted from one farrowing unit to another.

The results of the colostrum antibody tests were inconsistent with farm visit findings. There were no previous diagnoses of respiratory diseases but M.hyo antibodies were found in eight and A.pleur antibodies in 91 of 100 sampled herds. Spontaneous coughing or induced coughing by provocation testing did not correlate with either M.hyo or A.pleur antibody test results. Seven of the eight M.hyo positive farms were given a score of 0 in coughing by the provocation test and did not cough spontaneously during the farm visit. Coughing by provocation was scored 1 in two herds which were negative in both M.hyo and A.pleur antibody tests. Coughing was not a good predictor of M.hyo in a herd. Straw et al. (1990) did not find coughing to be a good indicator of the severity of pneumonia on an individual level either.

A.pleur-positive herds had several positive or suspected samples in each herd but M.hyo-positive herds had only one or two positive or suspected samples per herd. Because of a low prevalence of M.hyo-positive samples it is possible that some herds were misclassified because of false positive or false negative test results. Exact figures of sensitivity or specificity of the ELISA for M.hyo are not
available because there is no gold standard for the test. Bommeli (1986) assumed a very high sensitivity and specificity for the test. In his trials, the sera of pigs kept under specific pathogen free conditions were always negative, and all sera tested 3–50 weeks after inoculation by M. hyopneumoniae were always positive. Sorensen et al. (1992) reported 93% sensitivity, 96% specificity, 99.8% negative and 39% positive herd predictive value for the ELISA (not by the same laboratory as the test used here). They, however, were not quite sure if the pigs, assumed to be free of M.hyo, really were free of it (no gold standard). A specificity of 96% would be expected to produce 89 false positives out of 2222 samples, suggesting that the test used in this study had a higher specificity. If any of the positive or suspected samples in this study were true positives (as opposed to false positives) the specificity of the test would have been over 99.4%. The sensitivity and specificity on the herd level depend on the prevalence of the disease within the herd and the sample size taken in each herd. The sample size per herd (22.2 on average) in the present study was relatively large. We assume that on the herd level, false positive results were more probable than false negative.

Veterinarian and manager observations as well as provocation testing are rather rough diagnostic tools, of unknown specificity and sensitivity. Sneezing, observed in several herds, is the least specific symptom because it can be induced by straw and other bedding materials. Subjective observations (including veterinary clinical diagnoses) are always questionable.

In spite of the diagnostic problems described above, some conclusions or at least hypotheses of respiratory diseases in LSO could be drawn. Atrophic rhinitis was not of great importance in the LSO area. A.pleur serotype 2 antibodies were very common. Only a few small herds in the northern LSO area were free of A.pleur antibodies. A.pleur seems to be subclinical in farrowing units as no clinical outbreaks were seen. Clinical cases of A.pleur in finishing units are often reported to the Animal Health Service of LSO, most reports coming in late winter to spring. Practically all finishing herds receive feeder pigs from at least one A.pleur-infected farrowing unit with every batch. Eradication of A.pleur from farrowing units is hardly economical because of its high prevalence and because of problems in its eradication (Hunneman, 1986; Agger, 1989; Baekbo et al., 1992).

It has earlier been proposed that swine dysentery and mange should be totally eradicated from the Finnish swine population (Tuovinen, 1991). The results of this study and the study by Levonen et al. (1992) support the idea that enzootic pneumonia could be included in the total eradication list. Low prevalence of M.hyo among the farrowing units, M.hyo-free breeding units, successful eradication management and a sensitive diagnostic tool (ELISA) to find infected herds are the foundations of that strategy.

Six of the eight positive herds for M.hyo were situated in the high PCC area, two in the average PCC area and none in the low PCC area. If a finishing unit receives feeder pigs from 10 to 20 farrowing units, its risk ($P_i$ in Eq. (1)) of obtaining feeder pigs from at least one M.hyo-positive herd is 75–94% in the high PCC area (12.8% of herds positive), 54–79% in the average PCC area (7.4% of
herds positive) and undefined but considerably lower in the low PCC area (no positive herds). Although this does not prove any causality between M.hyo and PCC, an indirect causality could, however, be theorized because M.hyo is an immunosuppressive disease (Ross, 1992). Secondary pathogens could infect a feeder pig predisposed by M.hyo, and result in PCC.

The risk of receiving infected feeder pigs might be decreased by modifying the feeder pig delivery system to consider the health status of the farrowing units producing feeder pigs.

LSO's share of farrowing units in its area is about 60%. There were no data available to compare the disease prevalence among LSO's customers with those among the customers of the other slaughterhouses in southwestern Finland.

The diseases considered in this study were known to exist in Finland. The Finnish swine population is free of many infectious diseases which are of great importance elsewhere, such as Aujeszky's disease, swine fever, porcine respiratory and reproductive syndrome (PRRS), transmissible gastroenteritis (TGE) and even respiratory corona virus.

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References

Agger, N., 1989. Haemophilus (Actinobacillus) pleuropneumoniae: Epidemiologig elimineringsforsoeg. Dansk VetTidsskr., 72: 51–65.
Anonymous, 1989a. Operating instruction (no. 0059/1/89) of the enzyme immunoassay kit for diagnosing enzootic pneumonia in pigs (EPP). Dr. Bommeli AG, Liebefeld-Bern, Switzerland, 3 pp.
Anonymous, 1989b. Operating instruction (7/89) for the enzyme immunoassay (EIA) kit to detect antibodies against A.pleur. Dr. Bommeli AG, Liebefeld-Bern, Switzerland, 3 pp.
Anonymous, 1990. Animal health control in Finland 1989. The Finnish Animal Breeding Association, Vantaa, 16 pp.
Anonymous, 1991. Eläinlääkintötiedote 2/91. Maa-ja metsätalousministeriön eläinlääkintöosasto, Helsinki, 21 pp.
Baekbo, P., Szancer, J. and Hansen, B., 1992. Attempts to eradicate Actinobacillus pleuropneumoniae from infected herds by strategic medication. Proc. of the 1992-IPVS Congress, Den Haag, the Netherlands, Vol. I, p. 228. (Abstr.)
Bommeli, W.R., 1986. Mycoplasma hyopneumoniae antibodies. In: H.V. Bergmeyer (Editor), Methods of Enzymatic Analysis. II. Antigens and Antibodies 2, 3rd edn. VCH, Weinheim, pp. 189–200.
Bommeli, W.R. and Nicolet, J.A., 1983. A method for the evaluation of enzyme-linked immunoassay results for diagnosing enzootic pneumonia in pig herds. Proc. 3rd Int. Symp. of the World Association of Veterinary Laboratory Diagnosticians, Vol. 2, pp. 439–442. (Abstr.)
Cross, G.M. and Edwards, M.J., 1981. The detection of arthritis in pigs in an abattoir and its public health significance. Aust. Vet. J., 57: 153–158.

Hunneman, W.A., 1986. Incidence, economic effects, and control of Haemophilus pleuropneumoniae infections in pigs. Vet. Q., 8: 83–87.

Jestin, A., Popoff, M.R. and Mahe, S., 1985. Epizootiologic investigations of a diarrheic syndrome in fattening pigs. Am. J. Vet. Res., 46 (10): 2149–2151.

Johnston, K.M., Doige, C.E. and Osborne, A.D., 1987. An evaluation of nonsuppurative joint disease in slaughter pigs. Can. Vet. J., 28 (4): 174–180.

Levonen, K., Schulman, A. and Neuvonen, E., 1992. Antibody assay from colostrum in Mycoplasma hyopneumoniae diagnosis and disease control. Proc. of the 1992-IPVS Congress, Den Haag, the Netherlands, p. 309. (Abstr.)

Madsen, S.-A., 1988. Udryddelse af skab i svinebesætninger. Behandlingsforsøg med phoxim i pour-on form. Dansk VetTidsskr., 71 (22): 1159–1167.

Mäkelä, O., 1988. Porsaan kuoloinen suolitulehdukseen esiintyminen Suomessa, Eläinlääketieteellinen korkeakoulu, Helsinki, 27 pp.

Ross, R.F., 1992. Mycoplasmal diseases. In: A.D. Leman, B.E. Straw, W.L. Mengeling, S. D’Allaire and D.J. Taylor (Editors), Diseases of Swine, 7th edn. Iowa State University Press, Ames, pp. 537–551.

Sorensen, V., Barford, K. and Feld, N.C., 1992. Evaluation of a monoclonal blocking ELISA and IHA for antibodies to Mycoplasma hyopneumoniae in SPF-pig herds. Vet. Rec., 130 (22): 488–490.

Straw, B.E., Shin, S.J. and Yeager, A.M., 1990. Effect of pneumonia on growth rate and feed efficiency of minimal disease pigs exposed to Actinobacillus pleuropneumoniae and Mycoplasma hyopneumoniae. Prev. Vet. Med., 9: 287–294.

Tuovinen, V.K., 1991. Terveydenhuollon kohteet sianlihan tuotannossa. Suomen Eläinlääkäriliiton luentokokoelma, eläinlääkärinpäivät 1991, pp. 273–285. (Abstr.)

Tuovinen, V.K., 1992. Ripulitautien epidemiologia, chkäisy ja hoito lihaskallassa Suomen Eläinlääkäripäivät 1992, pp. 337–352. (Abstr.)

Tuovinen, V.K., Gröhn, Y.T., Straw, B.E. and Boyd, R.D., 1992. Feeder unit environmental factors associated with carcass condemnations in market swine, Prev. Vet. Med., 12: 175–195.

Tuovinen, V.K., Gröhn, Y.T. and Straw, B.E., 1994. Partial condemnations of swine carcasses — a descriptive study of meat inspection findings at Southwestern Finland’s Cooperative Slaughterhouse. Prev. Vet. Med., 19: 69–84.

Von Ruswil, S.M., 1991. Zur seroprevalenz von Actinobacillus pleuropneumoniae in Schweizer schweinezuchtbestaendenden. Thesis, Der Klinik für Nutztiere und Pferde der Universität Bern, Bern, 66 pp.

Wood, R.L., 1992. Erysipelas. In: A.D. Leman, B.E. Straw, W.L. Mengeling, S. D’Allaire and D.J. Taylor (Editors), Diseases of Swine, 7th edn. Iowa State University Press, Ames, pp. 475–486.