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PATHOLOGICAL LESIONS IN SWINE AT SLAUGHTER

V. PATHOLOGICAL LESIONS IN RELATION TO SOME ENVIRONMENTAL FACTORS IN THE HERDS*

By

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FLESJÅ, KJELL I., INGE B. FORUS and INGVAR SOLBERG: *Pathological lesions in swine at slaughter. V. Pathological lesions in relation to some environmental factors in the herds.* Acta vet. scand. 1982, *23*, 169—183. — The influence of environment on animal health was studied in 40 bacon herds. These herds delivered approx. 11,000 baconers annually to the slaughter-house. The data from the meat inspection was studied in connection with the environmental recordings, and the relationship between 18 lesions and 20 environmental factors were estimated by statistical methods. The data was collected in the period 1975—1977.

The influence of environmental factors upon the prevalence of different lesions showed considerable variation. Ten environmental factors were significantly associated with pleurisy and tail lesions (cannibalism). On the other hand none of the environmental factors bore any significant relation to atrophic rhinitis, pericarditis, peritonitis, perihepatitis, polyarthritis, arthritis and claw lesions. Eight environmental factors influenced the proportion of healthy animals.

The recorded environmental factors influenced the overall health situation to a varying degree. For example, design of pen walls, insulation of pen floors, occasional use of supplementary feed and free access to drinking water were related to 5—7 lesions, while the nature of the concentrate (meal/pellets) had no significant influence.

The study indicated that many details in environment and management could be of importance to the health of bacon pigs. However, statistical analysis also showed that production systems had a considerably stronger influence upon the health situation than any of the "pure" environmental factors — even when these factors were added.

disease recording; slaughter-house; bacon pigs; lesions; environmental factors; relations.

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Pig farming has undergone a considerable change in the last decades. The pig itself has become a more efficient producer of meat, and rearing has become intensified and rationalized. Herd size has increased, and labour- and time-saving equipment has been introduced. In bacon pigs there has been a concomitant increase in several diseases, especially chronic ones, which may be related to changes in environment (*Bäckstrøm & Larsson* 1971, *Lindqvist* 1974, *Aalund et al.* 1976, *Bäckstrøm & Bremer* 1976, 1978, *Penny* 1977, *Martinsson* 1979). One convenient way of obtaining information on such diseases is at the post mortem control performed by the meat inspection (*Penny & Hill* 1973, *Bäckström & Bremer* 1976).

This paper presents the results of an investigation in which the relationship between selected environmental factors and lesions recorded at slaughter were studied.

MATERIAL AND METHODS

The previously described disease recording system (*Flesjå & Ulvesæter* 1979) yielded the data concerning pathological lesions. From 1,100—1,200 herds about 40 (producing approx. 11,000 baconers a year) were chosen for environmental studies. The main criteria of selection were uniform environment and equipment throughout the pig house. The method of recording of environmental factors was a modification of that used in Sweden by *Lindqvist* (1974). About 55 factors having up to 8 levels of variation were recorded. Twenty were selected for further study. There were 2 main reasons for this selection: the recordings were considered relatively reliable and exact, and they were supposed to be of special interest in relation to the lesions in question (Table 1). In addition to the listed relations we also checked for possible influence of meal versus pellets upon the disease picture, and for environmental influence upon the occurrence of abscesses, atrophic rhinitis, pericarditis, tuberculous lesions in the cervical lymph nodes, peritonitis, moderate number of "white liver spots", other liver lesions — mainly perihepatitis, polyarthitis, arthritis and claw lesions.

The chi-square test was used for evaluating differences in frequencies*. Each year was analysed separately. Only statistical

* The analyses have been performed by the Agricultural Research Council's Centre for Experimental Design and Data Processing, Ås, Norway.

significances of $P \leq 0.01$ have been taken into account, and only factors/lesions showing statistical significance all 3 years (1975—1977) were considered.

Environmental factors influencing a given lesion were combined with production system (combined production, production in batches, continuous production) and herd size in stepwise least square analyses (*Searle* 1971). These tests are weighted, i.e. the herds count in accordance with their size.

RESULTS

The environmental influence on the lesions showed a considerable variation (Table 1). Factors such as insulation of pen floors, supplementary feeding and accessibility to drinking water seemed to affect the development of many lesions, while others such as dry/wet feeding and through length per pig only influenced 1 lesion each. The consistency of feed (meal/pellets) did not affect any of the lesions or the proportion of healthy animals (not included in the tables).

Some lesions — atrophic rhinitis, pericarditis, peritonitis, perihepatitis, polyarthritis, arthritis, and claw lesions — did not show statistically significant relations to any of the environmental factors studied. Three lesions were influenced by 1 factor. Abscesses occurred at a lower frequency in herds without air evacuation fans than in those having such fans. Tuberculous lesions in the cervival lymph nodes were more common in herds kept on well insulated floors with a heat transmission coefficient (U) less than 1 than when the floors had a higher U. A moderate number of "white liver spots" were recorded at a lower frequency in herds with access to zig-zag dunging passage than in herds using other types of dunging passages.

Pyaemia had a statistically significant relation to 5 of the listed environmental factors. A short floor-to-ceiling distance ($\leq$ 2.4 m), an air exchange rate/h/pig of more than 60 m^3 and free access to water tended to reduce the frequency, while a poorly insulated floor ($U > 2$) and occasional use of supplementary feed had the opposite effect.

Environmental factors seemed to have a considerable influence upon the development of severe pneumonia. It appears that an uncovered dunging passage, air intakes from loft via ceiling and air exchange rate of more than 60 m^3/h/pig would reduce the frequency,while poorly insulated pen floors ($U > 2$), a high

Table 1. Some environmental factors and their relations to pathological lesions recorded in swine at slaughter*.

Environmental factor	Number of herds	Number of pigs slaughtered annually	Lesions								
			06	11	12	13	31	60	62	80	00
Pen walls											
Tubular constructions	14	5000				—			—		
Solid walls	8	1600			+			+			+
„ „ but tubular constr. in dung. passage	18	4400									
Dunging passage											
Absent	4	1150							+		
Straight passage	24	6350									
Zig-zag	4	950					+				+
Both straight and zig-zag	8	2550									
Open/covered dunging passage											
Open	20	3150		+							
Slatted flooring	13	5350									—
Connection to manure cellar											
Open	8	3600				—			—	—	
Water trap	20	5000									
Leakly trap door	12	2400									
U (= *heat transmission coefficient) of floor*											
< 1	26	6300									
> 2	7	2500	—	—		—		+	—	—	
1—2	7	2200									
Bedding											
Not used	17	5000									
Used	22	4900							+		
Floor-to-ceiling distance											
2—2.4 m	23	5750	+			+			+		
> 2.4 m	17	5250									
Volume/pig											
< 2.8 m^3	15	7450									
> 3.5 m^3	8	1150				+					
2.8—3.5 m^3	17	2400									
Air intakes											
Open windows	18	5900									
Separate intakes in walls	7	2050									
From loft via ceiling	7	1000		+				+			+
Air evacuation fan											
None	4	950							+		+
Wall	19	3500				+					
Chimney; chimney & wall	15	3850									

Table 1 (cont.)

Environmental factor	Number of herds	Number of pigs slaughtered annually	Lesions								
			06	11	12	13	31	60	62	80	00
Fan regulation											
On/off	16	5500						+			
Stepless	20	3900				+					
Air exchange rate/h/pig											
< 60 m³	12	4100									
> 60 m³	10	2400	+	+	+						
No. of pigs/pen											
< 8	3	850									
> 12	13	4550		—		—					—
8—12	24	5600									
Lying area/pig											
< 0.47 m²	9	3550									
> 0.60 m²	14	2650									
0.47—0.60 m²	17	4800							—		
Through length/pig											
< 0.30 m	18	5600		—							
> 0.33 m	5	1300									
0.30—0.33 m	17	4100									
Feeding (consistency)											
Dry	20	4500									
Wet	20	6500						+			
Feeding (amount)											
"By rule of thumb"	17	4550						+			
According to age	22	6250									
Supplementary feed											
None	15	4250									
Grass silage	10	2450									
Straw (cut/uncut)	11	2600									
Occasionally (potatoes, grass, bread etc.)	4	1700	—	—		—	+		—	—	—
Drinking water											
Free access	28	6500	+		+	+			+	+	+
Restricted	12	4500									

The lesions are: 06-pyaemia, 11-severe, 12-moderate pneumonia, 13-pleurisy, 31-numerous "white liver spots", 60-scabies, 62-tail lesions, 80-anaemia, 00-sound animals.

* Signs indicate statistical significance ($P \leq 0.01$) over a 3 year period.

\+ means positive influence upon health;

-- means negative influence.

number of pigs/pen (> 12), a small through length/pig (< 0.3 m) and occasional supplementary feed increased the risk of contracting this condition.

Moderate pneumonia showed significant relation to 3 factors: solid pen walls (min. 0.6 m), an air exchange rate of more than 60 m^3/h/pig and free access to drinking water seemed to be of preventive value with respect to this lesions.

Pleurisy showed relation to as many as 10 environmental factors. A floor-to-ceiling distance below 2.4 m, a volume/pig exceeding 3.5 m^3, fans in walls, stepless regulation of fans and free access to drinking water might have a preventive effect. Tubular constructions in pen walls, open connection to manure cellar, poorly insulated floors, high number of pigs/pen and occasional appliance of supplementary feed seemed to increase the risk of pleurisy.

Numerous "white liver spots", although a high-frequency lesion, was not strongly affected by environmental factors, but a zig-zag dunging passage and an occasional use of supplementary feed might be of preventive value.

Scabies is the condition most frequently diagnosed at the slaughter-house. The disease is recorded in pigs from all farms from time to time and permanent eradication appears to be difficult. However, some environmental factors might have a limiting effect upon this disease. In our investigation solid pen walls, poor floor insulation, air intakes from loft via ceiling, on/off fan regulation, wet feed and "rule of thumb" feeding tended to reduce the frequency of the disease.

Tail lesions (cannibalism) seemed to be strongly influenced by environmental factors. Absence of dunging passage, use of bedding, short floor-to-ceiling distance, absence of air evacuation fan and free access to drinking water were found to be of preventive value. Tubular pen walls, open connection to manure cellar, poorly insulated pen floors, lying area between 0.47 and 0.60 m^2 and occasional use of supplementary feed seemed to increase the risk of cannibalism.

Anaemia is recorded at a low frequency, therefore special care has been taken when evaluating the data. However, the lesion showed relation to 4 environmental factors. Free access to drinking water might have had a preventive effect, while open connection to manure cellar, poor floor insulation and occasional use of supplementary feed had a negative influence.

Table 1 further shows that solid pen walls, zig-zag dunging passage, air intakes from loft via ceiling, absence of air evacuation fan, and free access to drinking water were health promoting factors. Slatted flooring in dunging passage, high number of pigs/pen and occasional use of supplementary feed seemed to reduce the proportion of healthy animals.

Table 2. Percentage of healthy animals at slaughter under the influence of the 8 environmental factors of statistical significance compared to the average of healthy animals in the total material.

	Year		
Environmental factor	1975	1976	1977
Solid pen walls	63.4	70.6	65.8
Zig-zag dunging passage	61.7	74.3	72.8
Slatted flooring in dunging passage	56.1	56.2	55.7
Air intakes from loft via ceiling	64.2	71.6	63.0
No air evacuation fan	62.4	66.4	67.0
More than 12 pigs/pen	49.8	52.3	53.7
Occasional use of supplementary feed	53.1	50.5	55.7
Free access to drinking water	59.8	63.4	61.1
Overall percentage of healthy animals in the total material	58.2	59.7	59.8

Table 2 shows the percentage (over 3 years) of healthy animals under the influence of the 8 environmental factors of significance (cf. Table 1) compared to the average proportion of healthy animals in the total material. When the factors influencing the percentage of healthy animals and the different lesions were combined with production system and herd size in multiple correlation tests and least square analyses, it was shown that production system in general had a considerably stronger impact upon the health situation than had any of the "pure" environmental factors — even the combination of such factors. Table 3 shows the relations between "diseased" pigs and influential factors. It demonstrates that production system was the dominant factor "explaining" more than 50 % of the variation ($r^2 = 0.56$) in percentage of "diseased" pigs at slaughter.

Table 3. Relations between environmental factors, including herd size and production system (combined production, production in batches, or continuous production), and "diseased" pigs. The factorial influence was estimated by stepwise least square analysis. In each step of the analysis the factor with the highest P was removed from the test. $P \leq 0.05$ is noted.

	Analytical step									
Environmental factor	1	2	3	4	5	6	7	8	9	10
Drinking water	NS									
Herd size	NS	NS								
Supplementary feed	NS	NS	NS							
Air intakes	NS	NS	NS	NS						
Dunging passage	NS	NS	NS	NS	NS					
Open/covered dunging passage	NS	NS	NS	NS	NS	NS				
Number of pigs/pen	NS	NS	NS	NS	NS	NS	NS			
Air evacuation fan	NS	0.01	0.01	0.02	0.05	0.03	NS	NS		
Pen walls	NS	0.01	0.01	0.02	0.05	0.04	NS	NS	NS	
Production system	NS	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Multiple correlations (r^2)	0.83	0.88	0.87	0.85	0.82	0.78	0.65	0.63	0.58	0.56

NS = not significant

DISCUSSION

Provided there is an unbiased composition of the material, it was assumed that if an environmental factor had any influence upon health, it would be noticeable. Each factor has been checked for bias with regard to production system and herd size. However, the material has not been checked for linkage between "pure" environmental factors. Some of the factors were recorded in such a small number that the χ^2-test is possibly not a proper test. It should also be remembered that when so many factors are tested, there is a high risk of detecting chance relations. To reduce this risk, only relations found to occur all 3 years were considered.

Solid pen walls had a favourable effect upon moderate pneumonia and scabies, while tubular constructions seemed to increase the risks of tail biting and pleurisy. *Lindqvist* (1972) recommended solid pen walls because they reduced draught, anxiety and agressiveness. *Christensen & Nielsen* (1972) hold that solid walls could be important factors in limiting the spread of Mycoplasma suipneumoniae in a pig house. Thus our observations correspond well to their views. These observations also indicate that sarcoptic mites are no great wall climbers.

Why absence of dunging passage should reduce tail biting is unclear, but it could be that pigs allowed to choose a dunging site by themselves will feel more comfortable. However, it should be kept in mind that there are only 4 herds in this group.

In another 4 herd group using zig-zag dunging passages the incidence of "white liver spots" was less than in herds using other dunging systems. This factor was combined with slatted flooring in the dunging passage and mechanical scrapers underneath. A small dunging passage used by relatively many animals may lead to a quick passage of manure through the slats so that few ascarid eggs are embryonated in the pen. However, it should be noted that use of anthelmintics was not evaluated in the present study.

Open connection to manure cellar was found to increase the risk of pleurisy, tail lesions and anaemia. Draught and gases from the manure may irritate eyes and respiratory organs and also act as general stress factors resulting in cannibalism (*Haarbo et al.* 1966).

Concrete was used in all pen floors studied. However, insulation varied considerably. Poor insulation seemed to increase the risk of severe pneumonia and pleurisy, cannibalism, pyaemia and anaemia. Most of these lesions may imply condemnation of the carcass (*Flesjå & Ulvesæter* 1979) and are therefore of considerable economic importance. A strong relation has previously been demonstrated between severe pneumonia and pleurisy, and between tail lesions, pyaemia and anaemia (*Flesjå & Ulvesæter* 1980). It is therefore possible that the prime effect of poor insulation is upon the respiratory tract and psyche, i.e. through greatly varying temperatures in the pigs' closest proximity. However, our observations do not correspond to those of *Aalund et al.* (1976) who found that varying insulation of floors, walls and ceilings had very little effect on lungs and pleura.

Many investigators have dealt with the positive effect of straw bedding upon cannibalism (*Haarbo et al.* 1966, *van Putten* 1968, *Høgsved* 1969, *Madsen et al.* 1978), and most of these investigators consider the dietetic effect the most important. Bedding was used in more than half of the herds studied. In most cases, however, sawdust and wood shavings were applied. Nonetheless, a preventive effect upon tail biting has been recorded. Although partly eaten, woody material probably having a limited dietetic value, it may improve insulation and comfort, i.e. offering the pig an opportunity to partially fulfill its routing instinct.

Floor-to-ceiling distance has been divided into low and high. Why low ceiling (< 2.4 m) should appear advantageous compared to high ceiling is unclear. However, it should be noted that the figures are averages for each house. It the high ceiling group there are many houses with a ridge roof and no loft. Therefore there may be considerable variation of height within the house and this may imply an unfavourable combination with, for example, air intakes/evacuation. Further, a high ceiling does not always imply a large volume/pig, since it may be combined with high density of animals.

Lindqvist (1974) found a lower frequency of pneumonia in herds with more than 3 m^3/pig, than in houses with less space, but did not see statistically significant difference regarding pleurisy. *Bäckstrøm & Bremer* (1978) noticed no relations between volume/pig and respiratory lesions. However, our results and those of *Lindqvist* favour the generally recommended minimum volume of 3 m^3/pig.

Many investigators have considered respiratory disease/ventilation relations in pigs. *Jerico et al.* (1975) observed more severe pneumonias in mechanically ventilated houses than in houses applying a "natural" ventilation. *Aalund et al.* (1976) concluded that forceful ventilation was associated with increased risk of respiratory diseases. *Haaring et al.* (1978) and *Truijen & Tielen* (1980) noticed a favourable effect of indirect air intakes upon the respiratory system. These observations correspond well to ours, which indicate that compared to on/off fans a stepless regulation reduced the frequency of pleurisy and that air intakes from loft via ceiling tended to reduce the frequency of severe pneumonia. Absence of fan had a positive influence upon tail biting. Some of the old types of fans produce considerable noise which may be regarded as a stress factor and accordingly may provoke cannibalism. However, caution should be taken in evaluating the results as there are only 4 herds in the absence-of-fan group.

The data dealing with air exchange/h/pig are based on the fan specifications given by the producers. Recommended ventilation rate is about 80 m^3/h/pig (*Lindqvist* 1972, *Lilleng* 1975). Only a few of the studied herds reached that level, the average being about 60 m^3. However, higher frequencies of pneumonia were recorded in herds with an air exchange rate below this level than in those above.

Large pens are supposed to increase the risks of infectious diseases and to represent a general stress factor provoking cannibalism (*Haaring et al.* 1978, *Feenstra* 1976). *Nielsen & Madsen* (1973) recorded a higher frequency of tail lesions in pens containing 32 pigs than in those having 8 or 16. *Bryant & Ewbank* (1972) reported fewer agonistic encounters in pens with 6 than in those with 12 or 18. In our investigation no relation was found between number of pigs/pen and tail lesions, but a high number of pigs/pen (> 12) seemed to increase the risk of severe pneumonia and pleurisy and to reduce the proportion of healthy animals. This contrasts with the observations of *Lindqvist* (1974) and *Bäckstrøm & Bremer* (1978) who found no relations between number of pigs/pen and health.

Neither *Bäckstrøm & Larsson* (1971) nor *Lindqvist* (1974) saw significant relations between lying area/pig and recorded lesions in their studies. *Bäckstrøm & Bremer* (1978), however, observed a higher frequency of pneumonia in houses with less than 0.5 m^2 lying area than in those with a larger area, and *Tielen* (1974) found that a decrease in area/pig increased the number of affected lungs. *Kelley et al.* (1980) did not record any significant influence upon tail biting or aggression when pen size was reduced from 0.7 to 0.4 m^2/pig, as long as the pigs were fed ad libitum. Our results indicate that tail biting was more frequent in the groups with the medium sized lying area (0.54 ± 0.06 m^2) than in those with a lying area above or below this figure. This observation is puzzling and could possibly be a "nonsense relation", i.e. the data are in some way connected to some unfavourable factors.

A through length of 0.3 m/pig is generally recommended. A too narrow eating place is supposed to provoke cannibalism, especially if food is restricted. None of our farms used ad libitum feeding, but no relation between a narrow through place and cannibalism was noted. However, there tended to be a biased distribution of herds with various production systems in the groups, which probably influenced the results.

Why wet feed and "rule of thumb" feeding should have a preventive effect upon scabies is unclear. However, it appears that poorly insulated pen floors and on/off fan regulation have an inhibitory effect upon scabies. This could mean that the mites do not thrive under these conditions, or perhaps more likely, that these factors cause some stress in the pigs and thus reduce the hypersensitivity reaction which is recorded as scabies at slaughter

(*Cargill & Dobson* 1979, *Flesjå & Ulvesæter* 1979). The question of whether wet feed and "rule of thumb" feeding also can be regarded as stress factors remains to be settled.

Occasional use of supplementary feed and restricted access to drinkring water both had negative influence upon the health of the animals. *Lindqvist* (1974) studied the relation between restricted water access and pneumonia, pleurisy, pericarditis, "white liver spots", and abscesses, without noticing any conclusive influences, while *Bäckstrøm & Bremer* (1978) found higher frequencies of pleurisy, pneumonia, and "white liver spots" when drinking was restricted. In our study, the results indicated that both occasional appliance of supplementary feed and restricted access to water not only increased the risk of chest lesions, but also indicated general stress as expressed by a higher frequency of tail lesions and related lesions such as pyaemia and anaemia. The reason why occasional use of supplementary feed should be more detrimental to the health of the animals than no use of supplements is not clear, but it could reflect the animals' addiction to habits or possibly also reflect a generally rather low standard of animal husbandry in these herds.

When considering the lesions which showed no associations to environmental factors, it might be noteworthy that atrophic rhinitis, contrary to common opinion, was among these, and that pericarditis and arthritis also occurred in these groups. Regarding the latter 2, *Lindqvist* (1974) made corresponding observations. Similarly, claw lesions were not related to any of the analysed environmental factors. This lesion is supposed to be strongly related to the nature of pen floors— stretch metal mats are considered especially risky (*Nielsen & Madsen* 1977). However, in our study only concrete floors were recorded and thus the material is not relevant in this respect.

The present investigation indicates that variation in design of pig houses and management will influence the health situation to a certain degree (Tables 1 and 2). The relative importance of influential factors was estimated by stepwise least square analyses. As expected, these tests showed that production system was by far the most influential factor. It did, for instance, "explain" more than 50 % of the variation in "diseased" pigs (Table 3). Previously published results *(Flesjå & Solberg* 1981) showed that combined production gave a significantly higher proportion of healthy animals at slaughter than those production systems rearing purchased piglets.

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SAMMENDRAG

Patologiske funn på gris ved slakting. V. Sammenheng mellom patologiske funn og en del miljøfaktorer.

I 40 svinebesetninger med en årlig leveranse på ca. 11.000 slakt har en studert samspillet mellom miljø og helsetilstand. Som uttrykk for helsetilstanden ble brukt registreringene utført av kjøttkontrollen ved slakteriet. Dataene fra slakteriet ble koblet sammen med miljøregistreringene og sammenhengen mellom 18 ulike patologiske funn og 20 miljøfaktorer ble vurdert v. h. a. statistiske metoder. Dataene ble samlet inn i årene 1975—1977. Tre ulike produksjonssystemer (kombinert, alt inn/alt ut, kontinuerlig) og besetningsstørrelser inngår i materialet.

Undersøkelsen viste en betydelig variasjon i miljømessig innflytelse på utviklingen av de ulike sjukdomer. Atrofisk rhinitt, pericarditt, perihepatitt, peritonitt, polyartritt, artritt og klauskader var ikke relatert til noen av de behandlede miljøfaktorer, mens pleuritt og halesår (kannibalisme) viste sammenheng med 10 og „friske" dyr med 8 faktorer.

Det var også stor forskjell på utslaget av de forskjellige miljøfaktorene. Utforming av bingeskiller, isolasjon av gulv, tilfeldig bruk av tilleggsfôr (grovfôr) og fri tilgang på drikkevann så ut til å influere på 5—7 ulike sjukelige tilstander, mens kraftfôrstrukturen (mjøl/pellets) viste ingen relasjoner til patologiske funn.

Undersøkelsen indikerte at mange detaljer angående miljøet kan ha betydning for grisens helse. Men den statistiske analyse viste at produksjonssystemet hadde en betydelig sterkere innflytelse på helsesituasjonen enn noen av de „reine" miljøfaktorene — også sterkere enn disse faktorer sammenlagt.

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