Acta vet. scand. 1991, *32*, 107–114.

Epidemiological and Genetical Studies in Norwegian Pig Herds

IV. Breed Effects, Recurrence of Disease, and Relationship between Disease and some Performance Traits

By *Frode Lingaas*

Department of Animal Genetics, Norwegian College of Veterinary Medicine, Oslo, Norway.

Lingaas, F.: Epidemiological and genetical studies in Norwegian pig herds. IV. Breed effects, recurrence of disease, and relationship between disease and some performance traits. Acta vet. scand. 1991, 32, 107–114. – Individual health records collected from 1984 to 1986 in 70 swine-herds in the south-eastern part of Norway were analysed by epidemiological methods. The incidence rate for most of the reported diseases was less than 1 % per farrowing, and a majority of disease recordings concerned 6 frequently-occurring conditions. The incidence of several diseases was lower in crossbred sows compared to purebred Norwegian landrace sows. The risk of most diseases increased in sows that had been ill previously, and also in litters from sows that had previously had diseased litters. Disease risk in piglets also increased if the sow became ill during the first few days after farrowing. The reduced performance associated with most of the common diseases impacts adversely on economic returns.

disease recording; health cards; swine; MMA-syndrome; mastitis; metritis; neonatal diarrhoea; arthritis; scrotal hernia.

Introduction

According to official statistics (*Central Bureau of Statistics in Norway*) the number of veterinary treatments per pig has shown a steady increase in recent years. This may be due to adverse changes in environmental factors or decreased genetic disease resistance, or both. Information on the heritability of disease resistance is lacking for most animal species, mostly because of the lack of satisfactory disease recording schemes. Disease recording by means of health cards is an efficient collection method for use in routine disease control or research (*Solbu* 1983, *Lingaas & Rønningen* 1990). Differences in disease frequencies between breeds may indicate that resistance to diseases has a genetic basis. Significant recurrence of disease, such as when the same sow suffers the same disease in several successive lactations, or when a sow has several successive litters affected by the same disease, may also indicate that disease resistance is heritable in nature.

The present epidemiological study was concerned with breed differences in the frequency of certain important diseases in pigs, as well as the recurrence of disease in different litters, and the influence of disease on some performance traits.

Material and methods

Material

Disease recording was performed in 70 pig herds in a three-year period from 1984 to 1986 (*Lingaas & Rønningen* 1990). The material included both herds with combined production, i.e. feeding their piglets until

slaughter, breeding herds (herds registered for providing breeding stock for the Norwegian Pig Breeders' Association, and which are also combined production herds) and weaner herds only producing weaners for sale. The only inclusion criterion was that the herds should practice herd performance recording (*Landsrådet for husdyrkontrollen*), this being a necessary prerequisite for the study of epidemiological and genetical aspects of disease. Traditionally, the Norwegian landrace (NL) has accounted for the major proportion of pigs kept in Norway, the number of crossbred pigs being low. During the last 5–10 years, however, crosses between NL and Yorkshire (Y) have become increasingly more popular. The majority (84.5 %) of the sows included in this study were NL, while 9.6 % were crosses between NL and Y. Breed information were lacking for the remaining 5.9 % of sows. Though the proportion of hybrid sows in the material (9.6 %) is below the present national mean, there has been a gradual increase from 2 % in 1984 to 13.1 % in 1986.

Statistical methods

The basis data set comprised a total of 8350 observations. However, only 7858 observations, for which associated breed information was available, could be used in the analyses. The risk of the most important diseases in the 2 breeds and the tendency for recurrence was estimated as relative risk (RR) according to *Mantel & Haenszel* (1959), using the "freq procedure" in the SAS system (*SAS Institute Inc.* 1985). Adjustment for the effects of year and herd was performed.

Several linear methods were used to describe the influence of diseases on the production level:

Model 1: This model was used for the total number of piglets born. Disease variables were therefore not considered because all the registered diseases occurred in the preweaning period.

$Y_{ijklmno} = \mu + A_i + S_j + B_{jk} + R_l + G_m + M_{in} + e_{ijklmno}$ where

$Y_{ijklmno}$ = the total number of piglets born in the litter

μ = least squares mean

A_i = effect of i'th year

S_j = effect of j'th herd status, and "j" has the following values; 1 = weaner herd, 2 = breeding herd, 3 = combined herd

B_{jk} = effect of k'th herd within j'th herd category

R_l = effect of breed "l"

G_m = effect of litter number "m"

M_{in} = effect of n'th month within i'th year

$e_{ijklmno}$ = random error

Model 2 was used for measuring the effect of environmental factors on the number of piglets born alive or dead. The model was mainly used to test the significance of dystocia and the MMA-syndrome because these diseases were expected to influence farrowing duration (*Jorsal* 1983). The model was similar to model 1 with the addition of the following effects:

F_o = effect of the MMA-syndrome

H_p = effect of dystocia

Model 3 was used for description of the number of piglets at 3 weeks after weaning, the number of piglets dying from farrowing until 3 weeks, and the total loss (still-born + deaths during the first 3 weeks). Model 3 was based on model 1 with the addition of the following effects:

L_o = effect of "o" number of pigs born alive

F_p = effect of the MMA-syndrome

I_q = effect of metritis

D_r = effect of neonatal diarrhoea

E_s = effect of arthritis in the piglets

Results

Differences between breeds

The 2 breeds were compared with regard to the occurrence of the 6 most frequent diseases. Results are shown in Table 1. There was a lower risk of occurrence of several of the most frequent diseases in hybrid sows as compared to the Norwegian landrace sows. The decreased risks were only significantly different from 1 for the MMA-syndrome, metritis, piglet arthritis and scrotal hernia.

Table 1. Influence of breed on the incidence of the MMA-syndrome, mastitis, metritis, neonatal diarrhoea, arthritis and scrotal hernia. Relative risk and 95 % confidence level.

	Relative risk	
	Hybrids (NL* Y)	Norwegian landrace
MMA-syndrome	1	1.22 (1.03–1.43)
Mastitis	1	1.30 (0.87–1.94)
Metritis	1	4.51 (1.78–11.41)
Neonatal diarrhoea	1	0.69 (0.45–1.04)
Arthritis	1	1.64 (1.13–2.36)
Scrotal hernia	1	1.70 (1.16–2.49)

Recurrence tendency

The recurrence for diseases in sows was estimated as the risk of disease in a given lactation period relative to the situation in the previous lactation period (diseased/non-diseased). As regards diseases in piglets, recurrence was estimated as the risk of a sow producing a diseased litter relative to the disease situation in her previous litter. The relative risks for the 6 most important diseases are shown in Table 2. As can be seen, the risk of the sow being affected by disease generally increased if she had been ill during her previous parturition and suckling period. The estimates varied from RR = 1.1 for mastitis to RR = 2.0 for metritis. However, the increased risk was only significantly different from 1 for the MMA-syndrome and metritis. As regards the 3 frequently occurring diseases in piglets, there was an overall increased risk of the same disease occurring in the next litter. When adjusting for herd these risks were, however, not significantly different from 1.

Table 2. Estimates of recurrence of the MMA-syndrome, mastitis, metritis, neonatal diarrhoea, arthritis and scrotal hernia. Relative risk (RR) and 95 % confidence level.

	Relative risk	
	Healthy at previous farrowing	Diseased at previous farrowing
MMA-syndrome	1	1.29 (1.13–1.48)
Mastitis	1	1.07 (0.70–1.64)
Metritis	1	2.02 (1.14–3.60)
Neonatal diarrhoea	1	1.23 (0.85–1.77)
Arthritis	1	1.38 (0.87–2.18)
Scrotal hernia	1	1.24 (0.82–1.86)

Relationship between diseases in the sow and piglets

The health of the piglets may be influenced by disease in the sow. The relationships between the 3 most frequent diseases in the sow and the 2 most important diseases in piglets are shown in Table 3. This table reveals an important direct relationship between disease in the sow and risk of disease in piglets. There was an increased risk of neonatal diarrhoea if the sow suffered from MMA or mastitis, and also a tendency to

Table 3. Influence of disease in sows on disease incidence in piglets. Relative risk (RR) and 95 % confidence level (95 % CL).

Disease in sow	Disease in piglets	RR	(95 % CL)
MMA –	Neonatal	1	
MMA +	Diarrhoea	3.66	(3.02–4.43)
MMA –	Arthritis	1	
MMA +		1.03	(0.80–1.33)
Mastitis –	Neonatal	1	
Mastitis +	diarrhoea	1.63	(1.24–2.14)
Mastitis –	Arthritis	1	
Mastitis +		1.24	(0.83–1.86)
Metritis –	Neonatal	1	
Metritis +	diarrhoea	1.03	(0.54–1.95)
Metritis –	Arthritis	1	
Metritis +		1.36	(0.70–2.67)

increased risk of arthritis if the sow suffered from metritis or mastitis. These relationships further increases the importance of the 3 most frequently occurring sow diseases.

Relationship between different performance traits

The mean performance levels per litter for some reproduction traits during the 3 year period was:

Number of piglets born dead:	0.83
Number of piglets born alive:	10.70
Number alive at 3 weeks:	9.00

The phenotypic correlation between the various variables is shown in Table 4, adjusted for the effect of herd, breed and litter number. There was a positive correlation between the total number of liveborn piglets and several other traits. As expected, there was a positive correlation between total number of piglets born and number of piglets born dead. There was also a positive correlation between total number of piglets born and the loss from birth till weaning, and between the number of piglets born dead and the loss from birth till weaning.

Differences between breeds, and the influence of certain diseases on performance

The differences in performance between the 2 breeds and the influence of certain diseases on performance, were investigated, results being given in Tables 5–7. As can be seen from Table 5, hybrid sows had significantly better performance for several reproduction traits. It is to be expected that diseased sows will be less productive than healthy animals. As expected, several diseases were also found to influence performance levels. Sows with dystocia produced fewer live-born piglets and, conversely, more still-born piglets. With regard to the MMA-syndrome, diseased sows proved to have larger numbers of

Table 4. Phenotypic correlation between several performance traits*.

	Born dead	Born alive	Loss until weaning	Total loss	Alive at 3 weeks
Total no. piglets born	0.345	0.907	0.467	0.562	0.689
No. born dead		–0.083	0.071	0.626	–0.141
No. born alive			0.464	0.315	0.795
Loss first 3 weeks				0.822	–0.168
Total loss incl. still-born					–0.212

* All the correlations are significantly different from zero ($p < 0.0001$).

Table 5. Influence of breed on performance.

Model		Total no. born 1	Born alive 2	Born dead 2	Loss 3	Alive at 3 weeks 3	Total loss 3
Norwegian landrace	Mean	11.39	10.55	0.83	1.59	8.97	2.54
	LSM	11.88	9.84	1.59	1.94	8.67	2.97
		A	A	A	A	A	A
Hybrids (NL* Y)	Mean	11.91	11.15	0.76	1.78	9.37	2.42
	LSM	12.53	10.63	1.52	1.77	8.84	2.77
		B	B	A	B	B	A

*) Numbers with different letters are significantly different from each other ($p < 0.05$). Numbers with the same letter are not significantly different.

liveborn piglets and alive at 3 weeks as compared with healthy sows even though the piglet loss was greater than for healthy sows. For litters diseased from neonatal diarrhoea, piglet losses were increased and there was a decreased number of piglets alive at 3 weeks compared to healthy litters. However, the opposite effect of piglet arthritis on performance was observed. Neither mastitis nor metritis exerted any significant effect on performance traits.

Table 6. Influence of dystocia and the MMA-syndrome on performance.

Model			Born alive 2	Born dead 2
Dystocia	–	Mean	10.65	0.80
		LSM	11.49	0.97
			A	A
	+	Mean	8.27	1.98
		LSM	9.03	2.13
			B	B
MMA	–	Mean	10.48	0.79
		LSM	9.94	1.49
			A	A
	+	Mean	11.15	0.95
		LSM	10.59	1.62
			B	B

*) Numbers with different letters are significantly different from each other ($p < 0.05$). Numbers with the same letter are not significantly different.

Discussion

Breed differences in disease incidence may arise through genetical differences in disease resistance. In the present study, a higher disease incidence was demonstrated in Norwegian landrace compared to hybrids (NL * Y) for several of the most frequent diseases. This is in accordance with the work of *Jorsal* (1983), and may either have been a general effect of heterosis or a favourable additive effect specifically associated with the Yorkshire breed. Purebreed Yorkshire sows were not available for study in the investigated herds. Therefore it was not possible to assess which of the 2 possibilities was in fact responsible for the lower disease incidence.

A tendency for recurrence was revealed for the most frequent diseases. As regards the MMA-syndrome this finding was in accordance with those of *Jorsal* (1983). The tendency to recur was not significantly different from 1 after adjustment for herd with regard to mastitis. The risk of metritis was increased if the sow had metritis in the previous lactation period. No studies on mastitis and metritis in this aspect have been reported previously. The mechanism responsible for the tendency for a disease to recur is not known and will certainly vary for the different diseases. A possible general impairment of disease resistance after illness could

Table 7. Influence of the MMA-syndrome, neonatal diarrhoea and arthritis on performance.

Model		Loss		Alive at 3 weeks		Total loss	
		Mean 3	LSM 3	Mean 3	LSM 3	Mean 3	LSM 3
MMA	–	1.51 A	1.73 A	8.96 A	8.88 A	2.30 A	2.60 A
	+	1.96 B	1.97 B	9.20 B	8.64 B	2.92 B	3.00 B
Neonatal diarrhoea	–	1.56 A	1.56 A	9.00 A	9.05 A	2.39 A	2.50 A
	+	2.38 B	2.15 B	9.19 B	8.47 B	3.16 B	3.10 B
Arthritis	–	1.60 A	1.99 A	8.98 A	8.62 A	2.42 A	2.90 A
	+	1.71 A	1.71 B	9.87 B	8.90 B	2.69 B	2.80 A

*) Numbers with different letters are significantly different from zero ($p < 0.05$). Numbers with the same letter are not significantly different.

result in an increased risk of recurrence. However, such a tendency could also develop as a result of genetic differences between animals in their proneness to disease or susceptibility to adverse environmental effects. There was also a tendency for diseases to recur in successive litters of piglets. When considering these diseases, it was the tendency of a sow to produce diseased litters that was estimated. It is unlikely that diseases in the piglets will have any negative effects on the sow. Nor is it likely that sows with diseased litters are systematically treated differently from those with healthy litters. It is more probable that genetic or maternal factors are the underlying cause of any tendency for disease to recur in successive litters.

An important observation was the connection between disease in the sow and disease in piglets. There was a significant increased risk of neonatal diarrhoea if the sow suffered from MMA or mastitis, and also a tendency to increased incidence of arthritis in piglets if the sow suffered from mastitis or metritis. A similar finding was made by *Jorsal* (1983) with regard to the MMA-syndrome. The probable explanation is reduced production of colostrum, with consequent reduction in the supply of energy and antibodies to the piglets. Greater exposure to infection because of disease in the sow may also contribute to an increased risk of disease in piglets. Genetic differences in disease resistance between animals may also be a significant factor. Poor genetic resistance to infectious diseases will often be transmitted from the sow to the piglets.

The positive correlation between total number of piglets born and the number of piglets born dead is probably due to prolonged farrowing time with a greater likelihood of dy-

stocia or other complications. The positive correlation between the number of piglets born alive and the loss from birth until weaning, was probably an effect of competition for food and maternal antibodies in the colostrum.

Sows diseased from the MMA-syndrome proved to have larger number of piglets born live and alive at 3 weeks. This reflects an important phenotypic correlation between production level and disease incidence. *Jorsal* (1983) showed that sows ran a greater risk of suffering from the MMA-syndrome when litter size exceeded 10 piglets. The adverse economic impact of the MMA-syndrome is mainly due to piglet losses. Such losses increased by about half a piglet per litter in cases of MMA compared with healthy sows. This finding was in accordance with those of *Jorsal* (1983). Similar comparisons between healthy sows and sows suffering from mastitis and metritis revealed no significant differences in performance traits. One reason for this may have been that cases of these diseases which arose within the first 3 days after farrowing were reclassified and included under the MMA-syndrome. By definition therefore, cases defined as mastitis or metritis will only occur later than 3 days after farrowing, and will thus influence the health of the piglets to a lesser extent than the MMA-syndrome. While neonatal diarrhoea significantly increased piglet losses, this was not fornd to be the case for arthritis in piglets. The number of piglets alive at 3 weeks was higher in litters suffering from arthritis than in unaffected litters. This situation was probably an expression of greater disease problems in big litters. A large number of piglets competing for the available colostrum supply means that some or all will receive less than sufficient, with increased susceptibility to arthritis as a result.

Acknowledgements

The present study, which was supported by the Norwegian Pig Breeders' Association, would not have been possible without the excellent assistance of farmers and veterinarians in the county of Hedmark. I wish also to thank Prof. Preben Willeberg, Denmark, and Prof. Knut Rønningen, Norway, for useful advise during the study.

References

Central Bureau of Statistics of Norway. The Norwegian Veterinary Statistics, 1978–1982.

Jorsal SE: Morbiditet hos søer. Epidemiologiske undersøgelser i intensive sobesætninger med særligt henblik på farefebersyndromet. (Morbidity in sows. Epidemiological studies with a special reference to the MMA-complex). Ph. D.-thesis, Copenhagen 1983.

Landsrådet for husdyrkontrollen: Husdyrkontrollen i Norge, 1985. (The Norwegian Herd Performance Recording Scheme). Med statistikk fra kukontrollen, geitekontrollen, sauekontrollen og purkekontrollen. Landsrådet for husdyrkontrollen, 1986.

Lingaas F, Rønningen K: Epidemiological and genetical studies in Norwegian pig herds. I. Design of a disease recording system. Acta vet. scand. 1990, *31,* 243–249.

Mantel N, Haenszel W: Statistical aspects of the analysis of data from retrospective studies of disease. J. Natl. Cancer Inst. 1959, *22,* 719– 748.

SAS Institute Inc.: SAS User's guide: Statistics, Version 5 Edition, Cary, NC: SAS Institute Inc., 1985, 956 pp.

Solbu H: Disease recording in Norwegian dairy cattle. I. Disease incidence and non-genetic effects on mastitis, ketosis and milk fever. Z. Tierz. Züchtungsbiol. 1983, *100,* 139–157.

Sammendrag

Epidemiologiske og genetiske studier av sjukdommer i norske svinebesetninger.
IV. Rase effekter, recidivtendens og sammenhengen mellom sjukdom og noen produksjonsegenskaper.

Individuelle sjukdomsregistreringer ble gjennomført i 70 svinebesetninger fra 1984 til 1986. De fle-

ste sjukdommene hadde en lavere insidens enn 1 % per grising, og flesteparten av registreringene skyldtes 6 sjukdommer. Det ble observert en lavere insidens av flere viktige sjukdommer hos hybridpurker enn hos purker av norsk landrase. Undersøkelsen viste at der var økt risiko for sjukdom hos purker som hadde vært sjuke tidligere, og økt risiko for sjukdom i kull etter purker som tidligere hadde hatt sjuke kull. Risikoen for opptreden av spedgris-diaré og leddbetennelse hos spedgrisen var også forøket hvis purka ble sjuk av enten MMA-syndromet, mastitt eller metritt etter grising. De fleste av de hyppige forekommende lidelsene har økonomiske konsekvenser i form av redusert produksjon.

(Received July 10, 1989; accepted February 8, 1990).

Reprints may be requested from: Frode Lingaas, Department of Animal Genetics, Norwegian College of Veterinary Medicine, P. O. Box 8146 Dep., N-0033 Oslo 1, Norway.