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Epidemiological and Genetical Studies in Norwegian Pig Herds
III. Herd Effects

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Lingaas, F.: Epidemiological and genetical studies in Norwegian pig herds. III. Herd effects. Acta vet. scand. 1991, 32, 97–105. – Herd differences in disease incidence in 70 Norwegian pig herds were assessed by health card registrations. Such differences proved to be considerable. The incidence of the MMA-syndrome, mastitis, metritis and neonatal diarrhoea was higher in herds producing only weaners ("weaner herds") than in herds with combined production. The mean disease incidence in herds providing breeding stock for the Norwegian Pig Breeders' Association ("breeding herds") was at the same level as in ordinary combined production herds. There was no consistent relationship between changes in disease incidence and herd size, though the incidence of the MMA-syndrome was lower in the largest herds.

health records; herd variation; herd size;herd categories; swine; health cards; MMA-syndrome; mastitis; metritis; neonatal diarrhoea; arthritis; scrotal hernia.

Introduction

Several studies have shown that different herd effects are responsible for some of the variation found both in production levels and disease incidence in pig herds (*Bäckström* 1973, *Karlberg* 1981, *Bäckström et al.* 1982, *Jorsal* 1983, *Grøndalen & Gjestvang* 1986, *Jørgensen* 1986). As far as the author is aware, however, no previous studies have been carried out on herd differences for the MMA-syndrome, mastitis, metritis, neonatal diarrhoea, arthritis and scrotal hernia in Norwegian pig herds. Nor has the disease incidence in different categories of herds been compared. Though comparison of the different herd categories will usually not provide any explanation of disease etiology, it may contribute to reveal environmental factors of importance for disease incidence.

When dealing with diseases in pigs, it is important to obtain a better knowledge of how various environmental factors influence disease incidence. This is important, not only for the successful implementation of preventive veterinary medicine at the herd level, but is also of significance when analyzing the effect of separate environmental or genetic factors on disease frequencies. Data on the disease incidence in different herd categories would also be of interest. In this regard it is especially important to ascertain if disease incidence in the Norwegian "closed" breeding herds is lower than in other types of herds.

The present study has mainly focused on the 6 most frequently recorded diseases, and considers the significance and importance of herd size and production type on disease incidence.

Material and methods

The epidemiological study was based on disease registrations in 70 pig herds in the south-eastern part of Norway. The sows were observed throughout the year and the piglets from farrowing until weaning. Disease recording was performed during a 3 year period from 1984 to 1986 (*Lingaas & Rønningen* 1990), the basis dataset constituting 8350 observations. All the monitored herds participated in the Norwegian herd performance recording scheme (*Landsrådet for husdyrkontrollen* 1986). This was a necessary prerequisite to obtain basic information on identity and pedigree. Herd size varied from 3 to 70 sows (average = 25), which is a representative range for Norwegian herds undertaking performance recording.

Disease frequency estimations were based on first incidence. The incidence rate of most diseases in the study was below 1 % per farrowing (*Lingaas & Rønningen* 1991) and relatively few diseases accounted for most of the entries in the disease records. In order to eliminate differences between veterinarians with regard to the reporting of cases of mastitis and metritis occurring with the first 3 days post partum, these were reclassified as MMA.

A closed breeding system for pigs exists in Norway. About 120 selected herds ("breeding herds") throughout the country send animals to performance testing stations owned by the Norwegian Pig Breeders' Association. Disease registrations were performed both in breeding herds and in ordinary commercial herds. In the breeding herds, all pigs apart from those sent for testing as potential breeding stock, were fattened through to slaughter. The ordinary commercial herds, however, included both herds producing only weaners for sale ("weaner herds") as well as herds producing both piglets and slaughter pigs ("combined herds").

Information on various feeding, husbandry and environmental factors were collected during herd visits. A questionnaire was also sent to the farmers to obtain additional information about environmental factors.

Statistical methods

Relative risk (RR) was estimated according to *Mantel & Haenszel* (1959), (*SAS Institute Inc.* 1985). Different methods for the correction of the RR are described. As the present data were derived from many small-sized herds, Mantel-Haenszel's method, rather than logarithmic correction, was used to adjust relative risk (*Fleiss* 1981).

The effect of herd size on disease incidence was adjusted for year and herd type using indirect standardization (*Lilienfeld & Lilienfeld* 1980).

Some production parameters for the herd categories were compared using the following models:

Model 1: This model was used on the total number of piglets born. Disease variables were not consdered 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: The effect of environmental factors on the number of piglets born alive/dead. This 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). Model 2 corresponded to model 1 with the addition of the following 2 effects:
F_o = effect of the MMA-syndrome
H_p = effect of dystocia

Model 3: Effect on the number of piglets at 3 weeks after weaning, the number of piglets dying from farrowing until 3 weeks, and the total loss (born dead + dead during the first 3 weeks). Model 3 corresponded to model 1 with the addition of the following five effects:
L_o = effect of "o" number of piglets 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

Model 4. The effects of some herd factors on the incidence of the MMA-syndrome were tested using the following model.
$Y_{ijklmnopqr} = \mu + A_i + B_j + C_k + D_l + E_m + F_n + G_o + H_k + G_o{*}H_p + I_q + e_{ijklmnopqr}$ where
$Y_{ijklmnopq}$ = the dependent categorical variable diseased/non diseased
μ = "Least squares Mean"
A_i = effect of i'th year
B_j = effect of j'th herd status; where "j" had the following values; 1 = weaner herd, 2 = breeding herd, 3 = combined herd
C_k = effect of litter number "k"
D_l = effect of breed "l"
E_m = effect of total number "m" of born piglets
F_n = effect of month "n"
G_o = the effect of confinement (tethering) at farrowing
H_p = the effect of concentrates at farrowing
$G_o{*}H_p$ = the interaction term tethering*feeding concentrates at farrowing
I_q = the effect of roughage
$e_{ijklmnopqr}$ = random error

Results

Herd variation in disease incidence

The mean number of farrowings per herd during the 3 years period was 50 (range: 6–150). For comparison of disease incidences in herds of about equal size, all herds with between 30 and 60 farrowings per herd were selected. In Fig. 1, both the herd variation in the total number of registered diseases per farrowing, and the variation in the occurrence of the MMA-syndrome, mastitis and metritis are shown.
It is obvious that there is considerable variation in disease incidence between equal sized herds, both for the total number of recorded diseases and for the sum of the MMA-syndrome, mastitis and metritis.

The effect of different types of production

About 15 % of the herds were registered as breeding herds by the Norwegian Pig Breeders' Association. These herds are intruded to combine high production levels with good environmental and hygienic standards. Another 20 % of the herds had only been producing weaners for sale during the 3 year period in question. The various categories of herds were compared with regard to the risk of occurrence of certain frequently encountered diseases. Results are given in Tables 1 through 3.
Table 1 and 2 shows that there is an increased risk of several diseases in weaner herds compared to other herds and a reduced risk of several diseases in "breeding herds" when compared to all other herds. The group "other herds" in Table 2, however, includes weaner herds as well as combined produc-

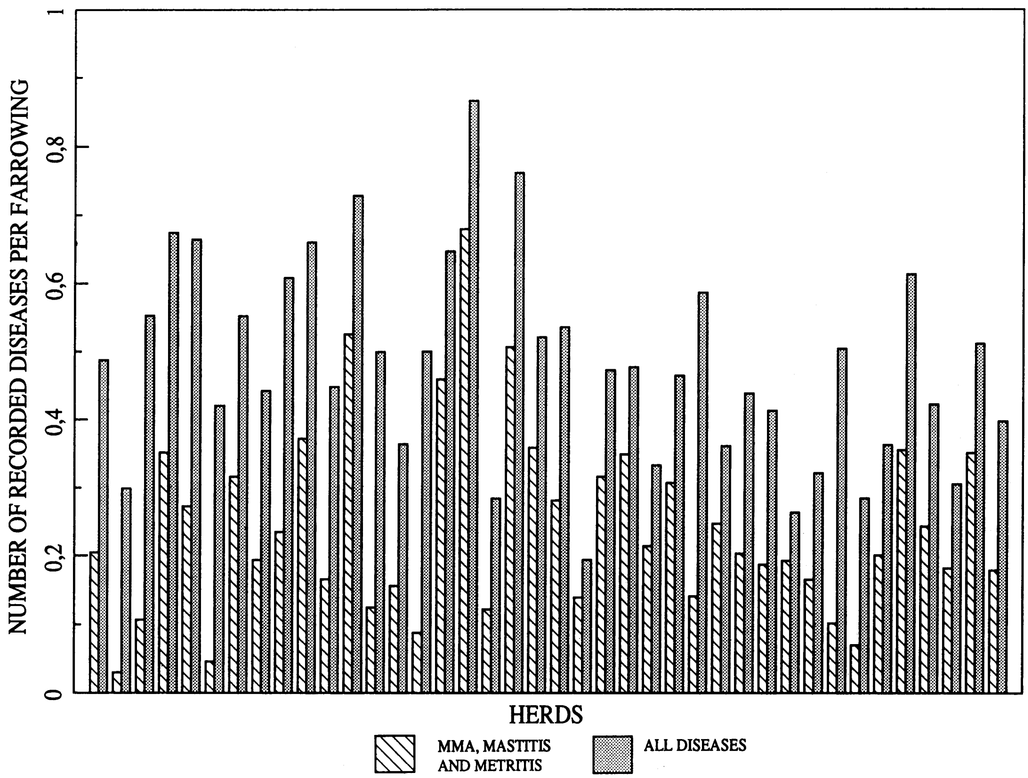

Figure 1. Herd variation in number of disease recordings. All diseases and MMA, mastitis and metritis.

tion herds. As mentioned above, combined production is practised in the breeding herds, and they therefore have to be compared to other combined production herds. This comparison (Table 3) shows that there was an increased risk of neonatal diarrhoea and scrotal hernia, and a reduced risk of metritis and piglet arthritis in breeding herds, compared to ordinary combined herds.

When considering performance in different herd categories as a possible factor to explain differences in disease incidence, the uncorrected means are of interest compared to the corrected means. The mean (uncorrected mean and least squares mean) per-

Table 1. Relative risk (and 95 % confidence interval) for some important diseases in weaner herds compared to combined herds.

	All diseases	MMA-syndrome	Mastitis	Metritis	Neonatal diarrhoea	Arthritis	Scrotal hernia
Weaner herds	1.30 (1.2–1.4)	1.57 (1.4–1.7)	1.77 (1.4–2.2)	3.00 (2.1–4.2)	2.29 (1.9–2.8)	1.35 (1.0–1.8)	1.01 (0.8–1.3)
Combined production	1	1	1	1	1	1	1

Table 2. Relative risk (and 95 % confidence interval) for some important diseases in breeding herds compared to other herds.

	All diseases	MMA-syndrome	Mastitis	Metritis	Neonatal diarrhoea	Arthritis	Scrotal hernia
Other herds	1.09 (1.0–1.2)	1.08 (1.0–1.2)	1.18 (0.9–1.5)	3.04 (1.6–5.8)	0.67 (0.6–0.8)	1.76 (1.3–2.4)	0.66 (0.5–0.8)
Breeding herds	1	1	1	1	1	1	1

Table 3. Relative risk (and 95 % confidence interval) for some important diseases in breeding herds and weaner herds, compared to combined production non-breeding herds.

	All diseases	MMA-syndrome	Mastitis	Metritis	Neonatal diarrhoea	Arthritis	Scrotal hernia
Weaner herds	1.3 (1.2–1.4)	1.6 (1.4–1.8)	1.7 (1.4–2.2)	2.5 (1.8–3.7)	2.9 (2.3–3.5)	1.2 (0.9–1.6)	1.1 (0.9–1.5)
Breeding herds	1.0 (0.9–1.0)	1.0 (0.9–1.2)	1.0 (0.7–1.2)	0.4 (1.2–0.8)	2.0 (1.6–2.5)	0.6 (0.4–0.8)	1.6 (1.3–1.9)
Combined production	1	1	1	1	1	1	1

Table 4. Production levels in different herd categories. Mean and Least squares mean (LSM).

Model	Total no. pigl. born 1	Born alive 2	Born dead 2	Loss 0–3 weeks 3	Alive at 3 weeks 3	Total loss 3
Mean						
Weaner herds	11.75 A	10.87 A	0.88 A	1.74 A	9.12 A	2.62 A
Breeding herds	11.49 B	10.84 A	0.65 B	1.49 B	9.35 B	2.14 B
Combined production	11.36 B	10.49 B	0.87 A	1.62 C	8.87 C	2.49 A
LSM						
Weaner herds	12.19 AC	10.14 A	1.61 A	1.90 A	8.72 A	2.97 A
Breeding herds	12.39 AB	10.57 B	1.46 AB	1.72 B	8.89 B	2.66 B
Combined production	12.03 AC	10.08 B	1.58 B	1.95 A	8.67 A	2.99 A

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

Table 5. The effect of herd size on the occurrence of 5 important diseases. Disease incidence, relative risk (RR) and 95 % confidence interval.

Herd-size in litters per year	Disease	Incidence (%)	RR and 95 % confidence interval
0–24	MMA	24.3	1
	Mastitis	6.5	1
	Metritis	1.2	1
	Neon. diarrh.	1.2	1
	Arthritis	4.0	1
25–49	MMA	20.1	0.80 (0.66–0.97)
	Mastitis	5.0	0.56 (0.36–0.87)
	Metritis	1.7	1.41 (0.59–3.41)
	Neon. diarrh.	5.0	1.36 (0.81–2.28)
	Arthritis	4.6	1.17 (0.70–1.95)
50–74	MMA	26.3	1.14 (0.96–1.37)
	Mastitis	4.6	0.79 (0.52–1.19)
	Metritis	1.8	1.39 (0.52–3.67)
	Neon. diarrh.	6.5	1.53 (0.89–2.63)
	Arthritis	4.2	1.12 (0.68–1.85)
75–100	MMA	18.7	0.88 (0.71–1.08)
	Mastitis	5.3	1.12 (0.73–1.72)
	Metritis	1.2	1.0 (0.49–5.64)
	Neon. diarrh.	7.1	1.95 (1.12–3.38)
	Arthritis	3.6	0.80 (0.44–1.43)
>100	MMA	8.8	0.35 (0.27–0.46)
	Mastitis	5.3	0.91 (0.57–1.46)
	Metritis	0.7	0.58 (0.21–1.62)
	Neon. diarrh.	0.9	0.32 (0.14–0.74)
	Arthritis	4.0	0.99 (0.56–1.74)

formance in different herd types in this investigation is shown in Table 4.

The performance figures (Table 4), show that the total number of piglets born per litter was highest in the weaner herds. By 3 weeks, however, the largest number of live piglets were found in the breeding units.

Herd size

The herds were classified into 5 groups according to the annual number of farrowings. The number of farrowings in a particular herd may vary from year to year and some herds were therefore represented in different size groups in different years. The estimates of the effect of herd size are presented as relative risk in Table 5.

A tendency towards reduced incidence of the MMA-syndrome with increasing herd size was observed. A similar tendency was not seen for mastitis. Herd size did not appear to exert any systematical influence on the incidence of piglet diarrhoea or inflammatory joint lesions.

Other herd factors

The effect of limiting the movement of sows, the effect of the amount of concentrates fed, and the effect of feeding roughage, were all tested with model 4. The amount of concentrates fed on the day of farrowing had no significant effect on the incidence of the MMA syndrome. However, a slightly increased incidence of the MMA-syndrome was observed in sows feed grass or hay as compared with sows not offered such roughage. There was also a significantly higher incidence of the MMA-syndrome in sows that had been loose in their pens on the day of farrowing compared to sows which were either confined by a bar at the rear of the stall, or which were tethered by a neck chain.

Discussion

Considerable variation in disease incidence was shown for all recorded diseases. It is therefore important to always account for the herd effect when analyzing disease records from pig herds. In the present study, weaner herds generally proved to have a higher disease incidence then the other herds. Though the reason for this difference is not obvious, it is possible that the more intensive production in these herds could have been a factor contributing to the high disease level. Table 2 shows that the disease incidence for several diseases in breeding herds was significantly lower than in the group "other herds". These differences were not due to a low disease incidence in the breeding herds. Rather, they were the result of a higher disease incidence in weaner herds. All the breeding herds fatten their piglets through to slaughter (combined production). These herds must therefore be compared to other combined herds. This comparison, which is presented in Table 3, shows that disease incidences in the breeding herds were similar to those in other combined herds.

Several studies have indicated that disease incidence tends to increase with intensity of production and the size of the farms (*Ringarp* 1960, *Bäckström* 1973, *Nielsen* 1976). In the present work no tendency to increased disease incidence with increasing herd-size was observed. The incidence of the MMA-syndrome tended to decrease with increasing herd size. This contrasts with the results of *Bäckström* (1973) who found that the incidence of MMA increased with increasing herd size. The present results are, however, in accordance with the findings of *Ringarp* (1960) and *Nielsen* (1976). *Jorsal* (1983) could not find any linear connection between herd size and incidence of MMA. It is difficult to assess the effect of herd size per se, because increasing herd size is usually associated with concomitant changes in environmental factors such as ventilation systems, feeding routines, and general husbandry.

Several statistical models (models 1–3) were used to estimate the significance of the differences in performance parameters between herds. Differences in performance were found between the herd categories. The breeding herds were expected to have the best hygiene and husbandry standards, and it is seemingly somewhat discouraging that the total number of piglets born were lower than in the weaner herds. This is probably due to the short generation interval in the breeding herds, and consequently lower mean age of the sows. Nevertheless, when the least squares means for the herds were compared using the models adjusting for litter number (Table 4) the total number of piglets born and the number born alive were significantly higher in the breeding herds. The fact that the actual number of live piglets at 3 weeks was higher than in the other herds, in spite of lower numbers at birth, probably reflects the effect of good management and hygiene.

The MMA-syndrome was the most frequently occurring disease in sows in this material, and the variation between herds was obvious. The etiology of this syndrome has not yet been clearly elucidated, although various likely contributing factors have been considered. Bacterial infections, as well as several environmental factors connected with feeding and husbandry, are probably important factors in the etiology of the MMA-syndrome. In an earlier study (*Lingaas & Rønningen* 1991) the general herd effect was used in a multivariate model to test seasonal variation in the incidence of MMA. In the present study, an attempt was made to split up the herd effect into specific variables. Because a set of specific environmental effects would be confounded with the general herd effect it was not possible to retain the general herd effect in the model (model 4). The classification of suspected environmental factors is complex. This is because each herd has its own unique combination of feeding and husbandry routines. Statistical evaluation of the effects of environmental factors is therefore difficult. Moreover, frequent changes in routines were observed within each herd.

Several theories have been put forward regarding the significance of environmental factors for the incidence of the MMA-syndrome (*Ringarp 1960, Bäckström* 1973, *Threlfall* 1973, *Bäckström et al.* 1982). A commonly held view among farmers is that restriction of the sow's freedom to movement at the time of parturition is a contributing factor in increasing the incidence of MMA-syndrome, as is the amount and type of feed offered at this time. It is, however, to be expected that measures such as changes in routine procedures and practices would be introduced in an attempt to alleviate specific disease problems. This might explain the apparent higher frequency of the MMA-syndrome in herds feeding roughage, or in herds in which the sows were allowed the run of the pen at farrowing. It is doubtful if such practices would in fact lead to a higher incidence of disease.

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Sammendrag

Epidemiologiske og genetiske studier av sjukdommer i norske svinebesetninger. III. Besetningseffekter.

Undersøkelsen er basert på individuelle helsekortregistreringer i 70 svinebesetninger i Hedmark, og tar i hovedsak for seg forskjeller i sjykdomsinsidens mellom besetninger. De ble påvist store forskjeller mellom besetningene, og det var også signifikante forskjeller i sjukdomsinsidens mellom ulike besetningskategorier. Smågrisprodusenter hadde en høyere insidens av flere viktige sjukdommer sammenlignet med besetninger med kombinert produksjon. Sjukdomsinsidensen i foredlingsbesetningene var på samme nivå som ordinære besetninger med kombinert produksjon. Det kunne ikke påvises generelle, systematiske forskjeller i sjukdomsinsidens med økende besetningsstørrelse, men for MMA-syndromet var det en lavere insidens i de største besetningene.

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