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Epidemiological Studies of Piglet Diarrhoea in Intensively Managed Danish Sow Herds

I. Pre-weaning diarrhoea

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Svensmark, B., S. E. Jorsal, K. Nielsen and P. Willeberg: Epidemiological studies of piglet diarrhoea in intensively managed Danish sow herds. I. Pre-weaning diarrhoea. Acta vet. scand. 1989, 30, 43–53. – The study comprised 70,796 litters in 104 sow herds, observed from 1976 through 1982. Weaning age decreased from approx. 42 days to approx. 30 days during the observation period. Diseases and symptoms were recorded together with production parameters (feeding, barn construction, economic returns etc.). The mean incidence rate of pre-weaning diarrhoea was 6.8 % of litters, with considerable inter-herd differences (incidence rates from 0 to approx. 50 %). There was a slight increase in incidence during the autumn (August through October). Incidence rates increased with litter size, with a peak incidence in litters of 11–13 piglets, and decreased with increasing parity of the sow. There was a positive association between occurrence of arthritis and pre-weaning diarrhoea in the litters, and litters from sows with post parturient disease (MMA complex) had 1.8 times higher risk of getting diarrhoea than litters from healthy sows. No important differences among breeds were found.

Small herds (< 200 farrowings per year) had higher incidence rates than large herds (400–499 farrowings per year). Herds with a gilt proportion above 30 % had an incidence rate of 12.3 %, i. e. nearly twice as high as the overall mean (6.8 %). There was a trend towards a higher incidence rate in litters kept in traditional pens (i. e. large pens with solid floor and loose sows) than in intensive pens (i. e. small pens with slatted flooring and tethered sows).

The overall pre-weaning mortality rate was 16.2 % of pigs born, half of which was due to stillbirths (6.3 %) and overlaid piglets (2.2 %). In litters with pre-weaning diarrhoea, the mortality rate was 19 %, compared to 13 % in litters without occurrence of diarrhoea. This difference accounts for an excess loss of 0.6 piglets from birth to weaning in diarrhoeic vs. non-diarrhoeic litters. Piglets from litters with pre-weaning diarrhoea had reduced weight gain. Thus, on the average, they were 2.2 days older at 25 kg bodyweight and weighed 0.4 kg less at 30 days than piglets from non-diarrhoeic litters. Also, litters with pre-weaning diarrhoea had a significantly increased risk of post-weaning diarrhoea.

The present information forms a basis for defining acceptable disease thresholds in suckling litters in intensively managed herds.

morbidity; mortality; risk factors; post-natal period; scours.

Introduction

Diarrhoeal disorders are among the most common causes of losses in swine herds, and several studies of morbidity and mortality from diarrhoea during the suckling period have been published from Scandinavia and elsewhere (*Bäckström* 1973, *Nielsen et al.* 1976, *Simensen & Karlberg* 1980, *Halgaard* 1981, *English & Morrison* 1984, *Spicer et al.* 1986). However, with the rapidly chang-

ing infrastructure of the swine industry alterations in disease patterns occur over short time intervals. Accordingly, there is a need to continuously analyze components of morbidity and mortality in order to obtain tools for rational intervention.

The present series of papers is based upon studies in Danish sow herds participating in the so-called "Field tests of Production Systems" (under the "National Committee for Pig Breeding"). A full report of the studies has been published by *Svensmark* (1984).

Material and methods

Participating herds

The study comprised altogether 70,796 litters born during the period from 1976 through 1982 in 104 sow herds. Not all herds were observed for the entire 7 year period, the average observation period being between 2 and 3 years. All herds were intensively managed, with separate units for mating, pregnant sows, farrowing, early weaned piglets and fatteners. During the investigation period, weaning age decreased considerably, viz. from 42 days in 1976 to approx. 30 days in 1982 (Fig. 1). In most herds sows were tethered, either in pregnancy units or in the farrowing units or both. Straw for bedding was used only in small quantities or not at all. Many farrowing units had perforated or slatted flooring. Feeding and water supply were automated.

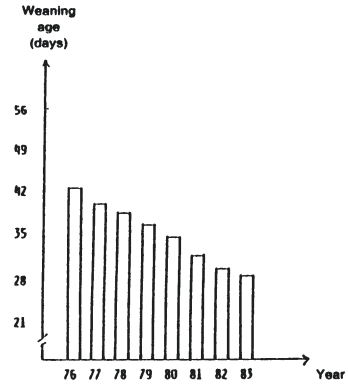

Figure 1. Weaning age among all herds participating in the field tests 1976–1983 (84,079 litters). Average weaning age decreased from approx. 42 days to approx. 30 days during the period covered by this study.

Data recording

Owners kept records on diseases and symptoms appearing in the sows and litters, and every 2 weeks the herds were visited by a technician who collected the disease data and recorded data on production. The following diseases or symptoms were recorded on a litter basis by the owner:

Pre- and post-weaning diarrhoea
Skin lesions (dermatitis, eczema)
Respiratory disorders (sneezing, coughing, dyspnoea)
Tail-biting, ear- and navel suckling
Arthritis
Hoof lesions
Heterogeneous size of piglets at weaning.

A litter was recorded as diarrhoeic when more than 25 % of the piglets were scouring or when the litter was medically treated because of diarrhoea. Similarly, skin lesions and respiratory disorders were recorded when more than 25 % of the litter showed symptoms. For arthritis, tail biting and ear- and navel suckling, the litter was recorded if 1 or more piglets showed symptoms.

A full etiological diagnosis was only sought when symptoms were so serious that veterinary care was required.

The following additional information was recorded for each litter:

Number of piglets:
Liveborn
Stillborn
Overlaid
Alive at 7 and 21 days of age.

Furthermore, data on parity, weight, feeding, economic return, barn construction,

management and other production parameters were recorded.

Analyses

From the above data, the following parameters were estimated:

Average weight of piglets at 30 days of age = average weight at weaning × 30 days/length of suckling period.

Average age at 25 kg =

$$\frac{\log\left(\frac{25}{\text{weaning weight}}\right) \times (\text{age at sale} - \text{weaning age})}{\log\left(\frac{\text{weight at sale}}{\text{weaning weight}}\right)}$$

Data were stored on magnetic tape at the computer at UNI-C, Lyngby, and were accessed by terminal. All numerical analyses were made using *SAS (Statistical Analysis System)* (1982).

The following disease parameters were calculated:

Incidence rate (% of litters): Number of litters with diarrhoea recorded × 100 / number of litters born.

Mortality rate (% of piglets born): Number of deaths × 100 / number of piglets born.

Case fatality rate (% of piglets with diarrhoea): Number of piglets dying from diarrhoea × 100 / number of piglets with diarrhoea.

Corrections for possible confounding factors (herd effects, litter size, sow's parity a. o.) were made by indirect standardization as described by *Lilienfeld & Lilienfeld* (1980).

Relative risk (R) was calculated as the ratio of incidence rates for exposed and non-exposed to factors possibly associated with diarrhoea. Chi-square analysis was used to test for differences in incidence rates. All tests had 1 degree of freedom and the following levels of significance were used:

Not significant (NS): $p > 0.05$

*: $0.05 > p > 0.01$

**: $0.01 > p > 0.001$

***: $0.001 > p$

Production results measured as continuous variables were evaluated by means of multiple regression analyses (GLM procedure), and the t-test was used to compare means using the above mentioned significance levels.

Results

Temporal variations

Pre-weaning diarrhoea was observed in 4,805 of the 70,796 litters, i. e. an overall incidence rate of 6,8 %. There were, however, considerable differences among herds. As shown in Fig. 2, most of the herds had yearly incidence rates below 5 %, but in some herds up to 40–50 % of the litters born in a given year experienced pre-weaning diarrhoea. Accordingly, corrections were made for individual herd effects in most calculations reported below.

There was little variation across the years 1976–82. The lowest incidence was 5.4 % (1977), the highest was 7.8 % (1979).

As shown in Fig. 3, the incidence rate was lowest in spring (March through May) and highest in late summer and autumn (August through October). Since the proportion of gilts' litters and the incidence rates of MMA complex also showed monthly variations, a correction for these 2 parameters was made. This eliminated the seasonal variation as regards the low incidence during spring, whereas the higher incidence during autumn remained.

Sow/litter factors

Parity of the sow. Litters from gilts had higher incidence rates than litters from older sows (Fig. 4). When adjusted for occurrence of MMA-complex (see below), the relative risk for litters from gilts was 1.4 as com-

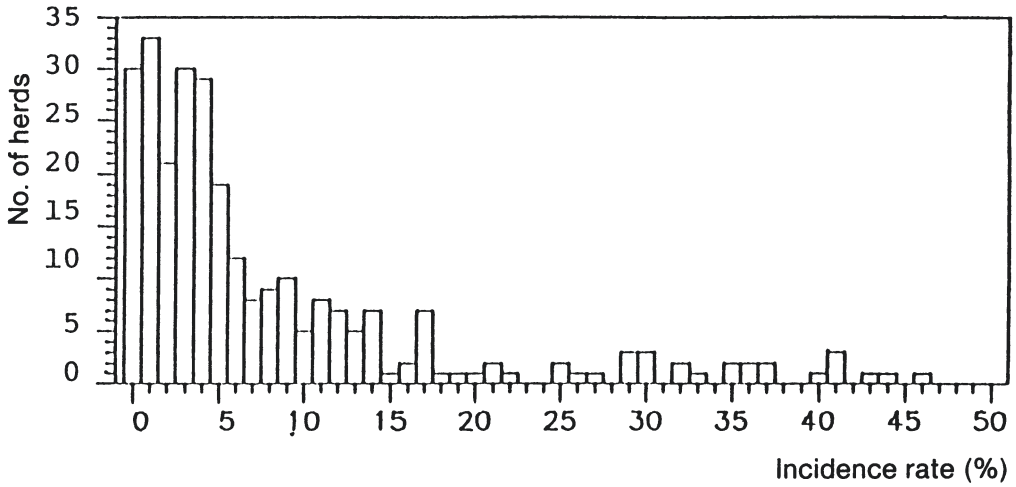

Figure 2. Distribution of the proportion of litters with pre-weaning diarrhoea per year of observation among herds participating in the study. The figure covers the whole 7-year-period of study.

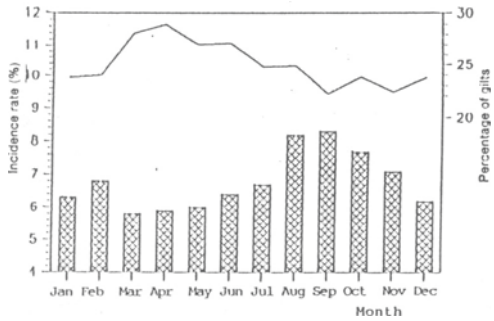

Figure 3. Seasonal variation of pre-weaning diarrhoea (bars) and of proportion of gilts' litters (top curve).

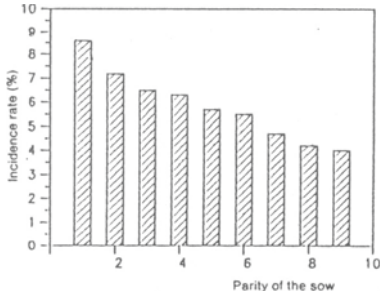

Figure 4. Proportion of litters with pre-weaning diarrhoea by parity of the sow.

pared to litters from older sows. The difference is highly significant ($p < 0.001$).

MMA complex in the sow. In a study of diseases among the sows in the present material, *Jorsal* (1983) showed that gilts had slightly higher incidence rates of the MMA-complex (i. e. metritis-mastitis-agalactia) than sows. Incidence rates were 11.0 and 10.4 % in gilts and sows, respectively. In the present study, MMA occurred after 7,104 farrowings. Incidence rate of pre-weaning diarrhoea in these litters was 11.7 %, compared with 6.2 % in 62,884 litters from healthy sows (Table 1). When data were corrected for parity, the relative risk in litters after sows with MMA was still 1.8 compared to litters after healthy sows. This difference is highly significant ($p < 0.001$).

Breed. Among the breeds or crossbreeds, the highest incidence rate of pre-weaning diarrhoea was observed in litters of Danish Landrace (7.8 %) and the lowest in crossings between Danish Landrace, Yorkshire and Hampshire (LYH, 3.8 %). However, when corrections were made for herd effects, litter

Table 1. Pre-weaning diarrhoea and MMA-complex in the sow.

	Litters at risk	Incidence rate %	Relative risk: Crude	Relative risk: Adjusted for parity
Metritis/mastitis in the sow	7,104	11.7	1.9***	1.8***
No metritis/mastitis in the sow	62,884	6.2	1	1

Table 2. Pre-weaning diarrhoea and litter size.

Litter size	Litters with diarrhoea	Litters at risk	Incidence rate %	Relative risk
1–4	32	1,050	3.1	0.5***
5–7	306	5,606	5.4	0.8***
8–10	2,416	36,282	6.7	1
11–13	1,909	25.654	7.4	1.1***
14–15	123	1,932	6.4	1.0 NS
16–	18	269	6.7	1.0 NS

size and parity of sow, the only significant finding was a low rate among litters of Landrace/Yorkshire crossings (LY).

Litter size. An increasing incidence rate of pre-weaning diarrhoea was observed when the litter size increased up to 11–13 piglets (Table 2). Above this size, the incidence rate remained constant.

Arthritis. Arthritis was recorded in 1,589 litters. In these litters, the incidence of pre-weaning diarrhoea was 9.2 %, compared with 6.7 % in 45,533 litters without arthritis (Table 3). The difference is significant ($p < 0.001$). It was not possible from the data to ascertain, whether arthritis or diarrhoea was the primary condition or whether both depended on one or more common factors.

Herd factors

Herd size. Herd size was expressed as the number of farrowings per year. Small herds (< 200 farrowing/year) had an incidence rate of 8.8 %, whereas large herds (400–499 farrowings/year) had an incidence rate of 7.1 %. A correction was made for differences in proportion of gilts, which was larger in small than in large herds. After this correction, small herds still had the highest risk (Table 4).

Table 3. Pre-weaning diarrhoea and arthritis.

	Litters at risk	Incidence rate %	Relative risk: Crude	Relative risk: Adjusted for litter size	Relative risk: Adjusted for metritis/ mastitis
Arthritis	1,589	9.2	1.4***	1.4***	1.3***
No arthritis	45,533	6.7	1	1	1

Table 4. Pre-weaning diarrhoea and herd size.

Farrowings per year	Percentage of gilts	Litters at risk	Incidence rate %	Relative risk	
				Crude	Adjusted for percentage of gilts
100–199	30.4	3,806	8.8	1.0 NS	1.1 NS
200–299	24.8	11,944	8.6	1	1
300–399	24.6	11,587	6.2	0.7***	0.8***
400–499	21.8	9,298	7.1	0.8***	0.9***
500–	24.3	6,387	7.3	0.9**	1.0 NS

Gilt proportion. Herds where the proportion of gilts exceeded 30 % of the breeding animals had the highest incidence of pre-weaning diarrhoea (12.3 %). For gilt proportions between 15 and 30 % the average incidence rates varied between 6.5 and 9.2 %. The differences were highly statistically significant (Table 5).

Table 5. Pre-weaning diarrhoea and percentage of gilts in the herds.

Percentage of gilts in the herds	Number of farrowings	Incidence rate %	Relative risk
–14.9	4,025	7.2	0.6***
15–19.9	10,654	9.2	0.8***
20–24.9	11,504	7.2	0.6***
25–29.9	8,622	6.5	0.5***
30–	7,580	12.3	1

Farrowing pen. Traditional and intensive farrowing pen types were compared in 2 herds in which both systems were present. A farrowing pen was recorded as "traditional" if the sow was loose, if the pen had solid floor without slats, if there was access to a dung alley and if the area of the pen was above 6 square meters. In the "intensive" farrowing pen the sow was tethered, the floor was perforated and the surface area was approx. 3 square meters.

The incidence of pre-weaning diarrhoea was slightly lower in litters from the intensive farrowing pens (3.2 % scouring litters) than in those from the traditional pens (4.7 % scouring litters). A correction for weaning age – which was 36 days in the traditional farrowing pens and 31 days in the intensive pens – reduced the difference to a non-significant level.

Consequences of pre-weaning diarrhoea

Mortality rate. The total mortality rate in the 70,796 litters during the 7-year-period (1976–1982) was 16.2 % of pigs born. As shown in Table 6, this figure included 6.3 % stillborn piglets. Of the 9.9 % post-natal mortality, by far the most part – 7.1 % – occurred during the first week of life. Overlaid piglets accounted for 2.2 %. Thus, approximately 70 % of the post-natal mortality occurred within the first week after birth.

Table 6. Age-specific pre-weaning mortality.

Age-group	Mortality rate (%) of pigs born (liveborn + stillborn)	Proportional mortality (%)
Stillborn	6.3	39.0
0-7 days (% overlays)	7.1(2.2)	43.8(13.8)
8-21 days	2.0	12.0
> 21 days	0.8	5.2
	16.2	100.0

In litters with pre-weaning diarrhoea, the overall mortality rate was 18.9 %, compared

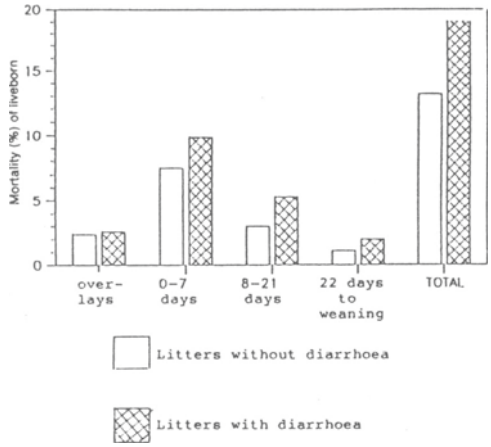

Figure 5. Pre-weaning mortality in relation to pre-weaning diarrhoea.

to 13.1 % in litters where diarrhoea was not recorded. These figures have been corrected for litter size, occurrence of MMA in the sow and arthritis in the piglets, all of which cause an increased litter mortality. The adjusted mortality rates are shown in Fig. 5. The difference between mortality in diarrhoeic and non-diarrhoeic litters is highly significant ($p < 0.001$). This means that an average of 2.15 piglets were lost between birth and weaning in litters where diarrhoea occurred, as compared to a loss of 1.5 piglets in litters without occurrence of diarrhoea.

Weight gains. The incidence of uneven litters, i. e. litters with 1 or more undersized pigs at weaning, was 3.7 times higher in litters where diarrhoea had been recorded during the suckling period than in litters where diarrhoea had not occurred. Correction for the effect of arthritis in the piglets – which also has an adverse effect upon growth – did not change this difference, which is highly significant ($p < 0.001$, Table 7).

Calculation of the parameters "weight at 30 days" and "age at 25 kg" revealed that pigs from litters with diarrhoea weighed an average of 0.4 kg less at 30 days and were 2.2 days older at 25 kg weight than piglets from litters where diarrhoea had not been recorded during the suckling period. As shown in Table 8, these differences are highly significant ($p < 0.001$).

Diseases after weaning. There was a highly significantly increased risk of post-weaning diarrhoea in litters with pre-weaning diarrhoea. There was a slight trend towards a decreased incidence of skin lesions (dermatitis and eczema) in such litters. For respiratory diseases, the data did not reveal a significantly increased incidence in litters where pre-weaning diarrhoea had occurred.

Discussion

Since age at weaning differed among herds, the period at risk of observing pre-weaning diarrhoea varied accordingly. The most accurate way of taking this into account in the analysis would be to express the incidence of diarrhoea in terms of a per-unit-of-time basis, i. e. a "true" incidence rate (*Martin et al.*

Table 7. Pre-weaning diarrhoea and occurrence of uneven litters at weaning.

	Litters at risk	Proportion of uneven litters (%)	Relative risk	
			Crude	Adjusted for arthritis
With diarrhoea	4,805	13.4	3.7***	3.7***
Without diarrhoea	65,991	3.6	1	1

Table 8. Pre-weaning diarrhoea and weight at 30 days of age and age at 25 kg bodyweight.

	Weight at 30 days, kg		Age at 25 kg, days	
	Un-adjusted	Adjusted for breed, litter size, metritis mastitis and arthritis	Un-adjusted	Adjusted for breed, litter size and age at weaning
With diarrhoea	7.0	6.7	83.3	81.7
Without diarrhoea	7.4	7.1	80.8	79.5
Difference	0.4***[1]	0.4***[2]	2.5***[1]	2.2***[2]

[1] Based on t-test
[2] Based on multiple regression

1987). In the present study the incidence has been expressed as a "risk" rate, i. e. a proportion, which implies that all litters had been observed for an equally long preweaning period. Since this was clearly not the case, the actual difference in weaning age was adjusted for in the analysis by indirect standardization when considered important. A somewhat similar situation existed regarding litter size, since larger litters experience larger amounts of individual piglet time at risk of diarrhoea than small litters (Table 2).

Data from litters originating from different herds were initially pooled in the analyses of the effect of any particular factor, e. g. parity of sows. A more accurate result would require a weighted mean of the effect observed in each of the herds. Weighting was, however, not possible when evaluating unique herd factors such as age at weaning and size of herd and, consequently, stratification by individual herd was done only in breed comparisons. Indirect standardization was otherwise used with regard to particularly relevant herd factors so that most of the likely confounding effects have been removed in the results presented.

The total mortality (i. e. pre-, peri- and post-natal deaths) in the 70,796 litters studied here was 16.2 % of pigs born, including 6.3 % – i. e. 39 % of the overall mortality – due to stillbirths. The remaining 9.9 % covered all deaths among live-born piglets. Of this postnatal mortality, by far the most significant part occurred during the first week of life: 7.1 % of the live-born piglets or 70 % of the post-natal mortality rate (Table 6).

Earlier Scandinavian studies on piglet mortality and morbidity have dealt with smaller and more traditionally managed herds. *Nielsen et al.* (1974) in Denmark, *Bäckström* (1973) in Sweden and *Simensen & Karlberg* (1980) in Norway reported very similar mortality rates of 22–23 % in such herds. As in the present material, the vast majority of this mortality occurred in the first week after birth. Similar findings were reported from the UK (*English & Morrison* 1984) and Australia (*Spicer et al.* 1986). Likewise, in a study of perinatal mortality, *Bille et al.*

(1974) found that about 60 % of the total pre-weaning loss occurred in the perinatal period. A mortality rate of 2 % observed by *Spicer et al.* (1986) were overlays – i. e. piglets crushed by the sow. This is similar to findings in the present material (2.2 %), whereas *Bille et al.* (1974) found appreciably more crushed piglets – 3.2 %. This difference is, undoubtedly, caused by the latter study comprising traditionally managed herds with loose sows and rather large farrowing pens with straw as bedding, compared with our study of tethered sows in small farrowing pens without bedding.

The incidence of pre-weaning diarrhoea in the present litters was 6.8 %, which is lower than reported by *Nielsen et al.* (1974) and *Bäckström* (1973) – 19 and 17 %, respectively. This difference is very likely due to differences in the recording criteria for diarrhoea, but also in herd sizes and management factors. Weaning age is one factor, others are hygiene level, design of farm buildings, climate control etc. Generally, intensively managed herds as studied here have a high level of hygiene, and the whole production system is under a close, continuous control. E. g. frequent inspection of the animals is routine in most modern swine production units. Finally, the methods of recording vary among different investigations. In the present study, litters were marked down for diarrhoea only if more than 25 % of the piglets were scouring or if veterinary care was required. Other authors use different criteria, thus *Svendsen et al.* (1975), using deaths due to diarrhoea as parameter, found that 18 % of all litters suffered deaths losses due to diarrhoea, with an average loss of 1.5 piglets per litter due to diarrhoea.

Factors affecting the incidence of diarrhoea during the suckling period were parity of sow, occurrence of MMA complex in the sow, litter size, herd size and gilt proportion in the herd. However, a considerable variation among herds was evident, and some herds had an incidence of pre-weaning diarrhoea of 40–50 % during parts of the observation period (Fig. 2). The study was not designed to identify etiological agents, but probably such high incidences reflect the effect of infectious agents affecting the herd during a certain period. *Svendsen et al.* (1975) found that approx. 85 % of gastrointestinal disorders in piglets could be ascribed to infectious agents, mainly *E. coli.* Part of the present material (26 herds) was screened for rotavirus infection which was demonstrated in 77 % of the herds. This and post-weaning diarrhoea will be discussed in subsequent papers (*Svensmark et al.* 1989a, b).

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Sammendrag

Epidemiologiske undersøgelser af diarre hos grise i intensivt drevne sobesætninger

I Diarre i diegivningsperioden

Undersøgelsen blev gennemført 1976–82 blandt 70.796 kuld fra 104 sobesætninger under "rullende afprøvning". I løbet af undersøgelsesperioden faldt fravænningsalderen i de tilsluttede besætninger fra ca. 42 dage i 1976 til ca. 30 dage i 1982. Sygdomme og symptomer blev registreret af ejer. Desuden blev produktionsparametre registreret af landbrugstekniker (fodring, bygningsindretning, økonomi etc.).

Den gennemsnitlige kuldvise incidensrate for diarre i diegivningsperioden var 6.8 %. Der var betydelig forskel mellem besætninger (incidensrater fra 0 til ca. 50 %). Største incidensrater blev fundet i efterårsmånederne (august–oktober), men forskellene var små. Incidensraten steg med stigende kuldstørrelse til den højeste værdi for kuld med 11–13 grise, og faldt med stigende paritet hos soen. Der var en positiv sammenhæng mellem forekomst af arthritis og diarre i kuldet, og kuld efter søer med MMA-kompleks havde 1.8 gange større risiko for at udvikle diarre i diegivningsperioden end kuld efter søer uden puerperale sygdomme. Der påvistes ingen væsentlige raceforskelle.

Små besætninger (< 200 faringer/år) havde højere incidensrate for diarre i diegivningsperioden end store besætninger (200–499 faringer/år). Besætninger med gylteprocent over 30 havde en kuldincidens på 12.3 %, d. v. s. næsten dobbelt så høj som i materialet som helhed (6.8 %). Der sås en tendens til højere incidens blandt kuld der holdtes i traditionelle stier (store stier med fast gulv og løsgående so) end blandt kuld i såkaldte intensive stier (kassestier med drænet gulv og fikseret so).

Den totale mortalitetsrate i diegivningsperioden var 16.2 %. Ca. halvdelen af den totale mortalitet skyldtes dødfødte (6.3 %) eller klemte grise (2.2 %). Af øvrige dødsfald forekom ca. 70 % i den første leveuge.

I kuld, hvor diarre blev registreret i diegivningsperioden, var mortaliteten 19 %, sammenlignet med 13 % i kuld, hvor diarre ikke blev påvist. Denne forskel svarer til et ekstra tab på 0.6 gris fra fødsel til fravænning i kuld med diarre.

Grise fra kuld med diarre i diegivningsperioden havde nedsat tilvækst. Grisene var således 2.2 dage ældre ved 25 kg vægt og vejede 0.4 kg mindre ved 30 dages alder end grise fra raske kuld. Endvidere havde kuld med diarre i diegivningsperioden signifikant forhøjet risiko for diarre i fravænningsperioden.

Nærværende resultater kan danne basis for opstilling af grænser for acceptabelt sygdomsniveau blandt spædgrise i intensive produktionssystemer.

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