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From the Department of Pathology, Veterinary College of Norway,
Oslo.

LEG WEAKNESS IN PIGS

II. LITTER DIFFERENCES IN LEG WEAKNESS, SKELETAL LESIONS, JOINT SHAPE AND EXTERIOR CONFORMATION

By

Trygve Grøndalen

GRØNDALEN, TRYGVE: *Leg weakness in pigs. II. Litter differences in leg weakness, skeletal lesions, joint shape and exterior conformation.* Acta vet. scand. 1974, *15*, 574—586. — Investigations were carried out concerning possible litter differences in locomotory ability and exterior conformation, and possible litter and sire group differences in the occurrence of skeletal lesions and in joint shape. The animals were from a breed experiment involving 6 litters, 8 feeding experiments involving 64 litters, and a selection experiment totalling 70 litters and 25 sire groups distributed in 3 lines. One hundred and twenty-one out of 285 P values for litter or sire group differences were statistically significant ($P < 0.05$). This shows, with reservations concerning the possibility that different environmental conditions up to 20 kg live weight may have produced a litter effect on pigs from the breed and feeding experiments, that heredity plays a significant part in the leg weakness complex. It seems justified to conclude that it partly is the inheritance of certain joint shapes and exterior conformational features, which influence the degree of joint lesions and locomotory ability and give rise to litter differences. This gives the theoretical possibility of selecting for more lasting joints and better locomotory ability using criteria based on joint shape and exterior conformation.

leg weakness; skeletal lesions; genetics; pig.

Funkquist (1929—30), *Holst* (1949) and *Christensen* (1953) have all suggested that heredity is strongly implicated in copulatory impotence caused by leg weakness in boars. *Grøndalen* (1970, 1972), *Nielsen et al.* (1971) and *Nielsen* (1973) have demonstrated differences between litters both as regards the occurrence of leg weakness and of skeletal lesions. *Bring* (1972) demonstrated the same with regard to sire groups.

Regarding skeletal shape, *Schilling* (1963) and *Grøndalen* (1974 c) have demonstrated breed differences, *Bring* differences between sire groups and *Grøndalen* (1972) differences between litters.

Smith (1966) found that the heritability of leg weakness score is rather low, and consequently a genetic decrease in the amount of leg weakness in pigs would be slow and difficult to achieve. On the other hand, *Teuscher et al.* (1972) found a heritability coefficient of 0.5 for leg weakness. They considered, however, that this figure was too high.

In order to throw light on the hereditary aspects of the leg weakness complex, investigations concerning litter and sire group differences were carried out.

MATERIALS AND METHODS

The methods applied in the judgement of exterior conformation, locomotory ability (gait score), skeletal lesions (lesion score) and joint shape have been described (*Grøndalen* 1974 e, f). Lesion type and predeliction sites have also been described (*Grøndalen* 1974 a, b). Statistical processing of results was carried out using standard methods.*

Material I

This comprised 6 litters, each consisting of 6 pigs. Three litters were Yorkshire and 3 Landrace. All litters were kept under equal experimental conditions. The material has been described with regard to experimental design, skeletal lesions and leg weakness (*Grøndalen* 1974 c, f).

Material II

This consisted of animals taking part in 8 feeding experiments each involving 48 boars or gilts. The pigs in each experiment were derived from 8 litters, each of 6 animals. They were arranged factorally 2 × 3, and the litters were kept under equal experimental conditions. The material has been described with regard to experimental design, skeletal lesions and leg weakness (*Grøndalen* 1974 d, f, *Hanssen* 1974). The statistical method used was a factorally analysis of variance.

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* The statistical calculations were carried out at the Computing Centre, Agricultural University of Norway.

Material III

This consisted of in all 289 animals from a selection experiment involving 3 different Landrace lines. Selection was made in 2 different directions with regard to back-fat thickness and growth rate (High Backfat Line, HBL, Low Backfat Line, LBL). The third line was a control line (CL) in which no deliberate selection was made. The sire groups, litters and individuals are listed in Table 1. The animals were the whole life kept as far as possible under the same conditions of management and environment. The experiment and material have been described previously, among other aspects, with regard to experimental design and skeletal lesions (*Standal* 1967, *Vangen* 1972, *Grøndalen & Vangen* 1974). The statistical method used was a hierarchic analysis of variance.

Table 1. A survey of the number of sire groups, litters and individuals in each line in the selection experiment (Material III).

High backfat line (HBL) number of			Low backfat line (LBL) number of			Control line (CL) number of		
sire groups	litters	individuals	sire groups	litters	individuals	sire groups	litters	individuals
1	1	1	1	3	7	1	5	21
1	3	8	1	1	4	1	3	16
1	3	13	1	6	29	1	3	11
1	2	6	1	3	9	1	3	17
1	1	6	1	4	18	1	1	2
1	2	7	1	3	9	1	5	19
1	4	18	1	2	6			
1	3	23	1	2	8			
1	3	14	1	1	1			
1	3	16						
10	25	112	9	25	91	6	20	86

RESULTS

Material I

The main litter differences in material I are shown in Table 2. The differences between litters were statistically significant ($P < 0.05$) for the characteristics gait score, condyle-length axis angle of the femur and exterior conformation concerning the lumbar region and hams.

Table 2. Mean litter score and statistical significance (P) for litter differences for some characteristics investigated in the breed experiment (Material I).

Litter	Mean gait score	Mean lesion score for the medial condyle of femur	Mean lesion score for the elbow joint	Condyle-length axis angle of the femur in °	Twisting of the medial condyle of the femur in °	Difference in height between the medial and the lateral part of the inter-condyloid eminence of tibia in mm	The narrowness of the lumbar region	The broadness of the hams	The relative broadness at the stifle joints
1 (Landrace)	5.4	1.8	1.9	94	7	2.0	2.9	3.2	2.3
2 "	7.5	1.9	2.5	93	11	1.9	1.0	2.0	2.0
3 "	5.7	3.2	1.7	89	12	3.0	2.2	3.0	2.9
1 (Yorkshire)	6.9	1.2	2.0	92	9	1.8	1.0	1.4	1.0
2 "	6.4	1.2	1.9	94	6	1.7	1.0	1.2	1.0
3 "	6.4	1.8	1.6	93	10	2.2	1.4	1.8	1.9
Stat. sign. (P) for litter differences	<0.05	>0.05	>0.05	<0.05	>0.05	>0.05	<0.01	<0.05	<0.05

Material II

Mean gait scores for litters in the 8 different experiments are listed in Table 3. The differences were statistically significant ($P < 0.05$) in 3 of the 8 experiments. Average figures in the other experiments also showed marked differences between litters. The average figures for lesion score as regards the medial condyle of the femur are given separately in Table 4, as this joint most often showed statistically significant difference in lesions between litters. Regarding the other lesion scores, anatomical details and exterior conformational features, only the degree of statistical significance (P) for litter differences in the various experiments have been listed (Table 5). The table shows that there were variations between experiments in the occurrence of litter differences. SV 64, SV 68 and SV 84 showed the highest incidence of litter differences, SV 80, SV 95 and SV 111 the lowest, while the incidence in SV 75 and SV 104 was between these groups. There were also differences between the various characteristics. A statistically significant litter difference ($P < 0.05$) was present with regard to lesion score in the elbow joint and in the distal epiphyseal plate of the ulna in only 1 experiment,

Table 3. Mean litter gait score and statistical significance (P) for litter differences in the feeding experiments (Material II).

Litter	Mean gait score in experiments							
	SV 64 (♂)	SV 68 (♀)	SV 75 (♂)	SV 80 (♀)	SV 84 (♂)	SV 95 (♀)	SV 111 (♂)	SV 104 (♀)
1	4.7	4.0	5.3	6.3	5.5	5.2	5.3	6.5
2	6.2	4.2	4.0	5.5	6.0	5.0	6.2	5.8
3	6.3	5.2	6.4	5.8	4.7	5.7	4.7	6.0
4	5.0	5.0	5.6	6.2	5.5	6.8	6.2	6.2
5	5.2	5.2	4.7	6.5	4.8	6.3	5.5	5.0
6	5.5	6.2	5.3	6.3	5.7	5.4	6.5	5.3
7	4.5	5.3	6.0	5.3	6.0	6.0	6.0	5.3
8	6.5	4.7	4.7	6.3	5.7	5.7	5.5	5.3
Stat. sign. (P) for litter differences	<0.05	<0.05	>0.05	>0.05	>0.05	<0.05	>0.05	>0.05

T a b l e 4. Mean litter lesion score in the medial condyle of the femur and statistical significance (P) for litter differences in the feeding experiments (Material II).

Litter	Mean lesion score in the medial condyle of femur in experiments							
	SV 64 (♂)	SV 68 (♀)	SV 75 (♂)	SV 80 (♀)	SV 84 (♂)	SV 95 (♀)	SV 111 (♂)	SV 104 (♀)
1	2.5	3.7	2.2	3.0	2.7	2.3	3.8	3.5
2	3.5	2.0	3.3	3.2	3.0	2.0	2.2	1.3
3	2.7	2.0	1.8	3.7	3.5	1.5	2.5	1.5
4	2.5	1.5	2.6	2.5	2.3	2.8	2.8	1.0
5	3.0	3.6	2.3	2.7	1.5	2.4	3.2	2.5
6	2.5	2.7	2.8	1.8	3.2	2.3	1.8	2.2
7	3.2	1.8	3.7	2.5	2.8	2.8	3.0	1.7
8	3.0	3.8	3.5	2.7	2.5	2.8	3.8	2.7
Stat. sign. (P) for litter differences	>0.05	<0.001	<0.05	>0.05	<0.01	>0.05	<0.01	<0.01

Table 5. Statistical significance (P) for litter differences for some characteristics investigated in the feeding experiments (Material II).

Characteristic	Statistical significance (P) for litter differences in experiments							
	SV 64	SV 68	SV 75	SV 80	SV 84	SV 95	SV 111	SV 104
lesion score of the elbow joint	n.s.*	n.s.	n.s.	n.s.	< 0.001	n.s.	n.s.	n.s.
lesion score of the distal epiphyseal plate of the ulna	n.s.	n.s.	< 0.01	n.s.	n.s.	n.s.	n.s.	n.s.
lesion score of the lumbar intervertebral joints	—**	—	—	n.s.	n.s.	n.s.	< 0.05	< 0.05
projections in the distal epiphyseal plate of the femur	< 0.001	n.s.	< 0.01	n.s.	n.s.	n.s.	< 0.01	< 0.01
total lesion score	—	—	—	< 0.001	< 0.01	n.s.	n.s.	< 0.001
broadness of the semilunar notch	< 0.001	< 0.001	n.s.	< 0.01	< 0.01	n.s.	n.s.	n.s.
opening of the elbow joint	n.s.	< 0.001	< 0.001	n.s.	< 0.001	n.s.	n.s.	n.s.
steepness of the volar part of the lateral condyle of humerus	—	—	< 0.001	< 0.05	< 0.001	n.s.	n.s.	n.s.
twisting of the semilunar notch	—	—	n.s.	< 0.05	< 0.01	n.s.	< 0.05	n.s.
ridge on the radius	—	—	—	—	< 0.01	n.s.	n.s.	n.s.
ridge on the humerus	—	—	—	n.s.	< 0.05	n.s.	n.s.	< 0.05
index of the shape of the elbow joint	—	—	—	—	< 0.001	n.s.	n.s.	n.s.
condyle-length axis angle of the femur	n.s.	< 0.001	< 0.05	n.s.	n.s.	n.s.	n.s.	< 0.05
twisting of the medial condyle of femur	< 0.01	< 0.001	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
difference in height between the 2 parts of the intercondyloid eminence of tibia	< 0.05	< 0.05	< 0.01	n.s.	< 0.01	< 0.001	n.s.	< 0.05
index of the shape of the stifle joint	< 0.05	< 0.001	< 0.01	< 0.05	< 0.05	< 0.001	n.s.	< 0.05
length of the femur	< 0.01	< 0.001	n.s.	n.s.	< 0.01	n.s.	n.s.	< 0.05
difference in height between the head of femur and trochanter major	< 0.001	—	< 0.05	—	< 0.001	< 0.01	n.s.	n.s.
length of the vertebral column	< 0.01	< 0.001	n.s.	n.s.	< 0.05	n.s.	n.s.	< 0.01
narrowness of the lumbar region	—	—	< 0.01	n.s.	< 0.001	< 0.001	n.s.	n.s.
broadness of the hams	—	—	—	n.s.	< 0.001	< 0.05	< 0.05	< 0.05
relative broadness at the stifle joints	—	—	< 0.001	n.s.	< 0.01	n.s.	n.s.	n.s.

* n.s.: not significant (P > 0.05). ** —: not investigated.

while this was present in 5 of the 8 experiments with regard to lesion score of the medial condyle of femur. As regards anatomical details of bones and joints, the difference in height between the medial and lateral part of the intercondyloid eminence of the tibia showed statistically significant litter differences

Table 6. Statistical significance (P) for litter and sire group differences for some characteristics investigated in the selection experiment (Material III).

Characteristic	Statistical significance (P) for					
	sire group differences in			litter differences in		
	HBL	LBL	CL	HBL	LBL	CL
lesion score of the elbow joint	< 0.05	n.s.*	n.s.	n.s.	< 0.01	n.s.
lesion score of the distal epiphyseal plate of the ulna	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
lesion score of the lumbar intervertebral joints	n.s.	n.s.	< 0.05	n.s.	< 0.05	n.s.
lesion score of the medial condyle of femur	n.s.	n.s.	n.s.	< 0.05	< 0.001	n.s.
projections in the distal epiphyseal plate of the femur	n.s.	n.s.	< 0.001	< 0.001	n.s.	n.s.
total lesion score	n.s.	n.s.	< 0.01	< 0.05	< 0.01	n.s.
broadness of the semilunar notch	< 0.05	< 0.05	n.s.	< 0.01	< 0.05	n.s.
"opening" of the elbow joint	n.s.	n.s.	< 0.01	n.s.	< 0.001	n.s.
steepness of the volar part of the lateral condyle of humerus	n.s.	< 0.01	n.s.	< 0.05	< 0.05	< 0.001
twisting of the semilunar notch	n.s.	n.s.	n.s.	n.s.	n.s.	< 0.05
ridge on the radius	n.s.	n.s.	n.s.	n.s.	< 0.05	n.s.
ridge on the humerus	n.s.	n.s.	n.s.	n.s.	< 0.05	n.s.
index of the shape of the elbow joint	n.s.	< 0.05	n.s.	< 0.05	< 0.01	< 0.001
condyle-length axis angle of the femur	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
twisting of the medial condyle of the femur	n.s.	n.s.	< 0.05	n.s.	< 0.05	n.s.
difference in height between the 2 parts of the intercondyloid eminence of tibia	n.s.	< 0.01	n.s.	n.s.	n.s.	< 0.01
index of the shape of the stifle joint	n.s.	< 0.01	n.s.	n.s.	n.s.	< 0.05
length of the femur	< 0.05	< 0.05	< 0.01	< 0.05	n.s.	< 0.05
difference in height between the head of femur and trochanter major	n.s.	< 0.05	n.s.	< 0.05	n.s.	n.s.

*n.s.: not significant ($P > 0.05$).

($P < 0.05$) in 6 experiments, while the twisting of the medial condyle of the femur showed the same in the 2 first experiments only. Results for the other characteristics lay between the mentioned outer limits.

Material III

The degree of statistical significance (P) for litter and sire group variations within the different lines, is shown in Table 6. The characteristic lesion score of the distal epiphyseal plate of the ulna and the condyle-length axis angle of the femur did not show statistical significant litter or sire group differences ($P > 0.05$) in any line. On the other hand, the length of the femur showed sire group differences in all 3 lines and litter differences in 2 lines ($P < 0.05$).

DISCUSSION AND CONCLUSIONS

The purpose of investigating the materials with regard to litter and sire group differences was to throw light on the hereditary aspects of leg weakness. The aim was also to try to open possibilities for selection by finding suitable selection criteria. Quite a number of characteristics were investigated with regard to possible litter differences. Although litter differences for several characteristics were statistically significant ($P < 0.05$), they are not all described here. It was decided to concentrate on gait score and lesion score as well as the characteristics regarding joint shape and exterior conformation which have been shown to have a connection with gait or lesion score (*Grøndalen* 1974 e, f). The results must be considered as being a survey of the selection criteria concerning skeletal shape and exterior conformation which might be taken into consideration. The information which is given concerning results may seem scarse. However, as the matter was one of demonstrating any litter effects, and not of demonstrating which litter was the best or poorest, the information supplied seems sufficient. The material was not considered large enough to justify calculating heritability.

Material I comprised 2 breeds, such that a breed effect was present, though there were also large differences between litters within breeds. The main factor of uncertainty in the materials presented is that the pigs in materials I and II were kept under different environmental conditions until approx. 20 kg live weight. It is shown that different feed levels from 20 to 100 kg live weight influence the shape of the femur (*Grøndalen* 1974 d). A similar effect is possible also up to 20 kg live weight. Besides, different feed levels would give an immature skeleton in relation to body weight and maybe also influence the locomotory ability. There was in the feeding experiments (material II) a large variation between experiments in the occurrence of litter differences. A homogenous experimental material is advantageous when seen from the feeding side. It does, however, make it difficult to demonstrate possible hereditary aspects. In SV 111, 6 litters were recruited from the same herd. In this experiment there were few litter differences. The animals were not closely related, so the results give cause for reflection concerning environmental influences up to 20 kg live weight. As regards material III, attempts were made to maintain the same environment during all stages of production such that differences between litter and sire groups would be primarily of genetical nature.

One hundred and twenty-one out of 285 P values for litter or sire group differences given in this paper were statistically significant ($P < 0.05$). This suggests that heredity plays a real part in the leg weakness complex. This is in agreement with the opinion of *Teuscher et al.* (1972) and *Nielsen* (1973). Relationships between skeletal lesions and joint shape and between exterior conformational features and locomotory ability have previously been demonstrated (*Grøndalen* 1974 e, f). Thus it is possible that the litter differences as regards joint lesions are partly due to inherited differences in joint shape. In the same way, poor locomotory ability may be partly due to a certain inherited shape of the hind quarters. There may therefore be reason to reevaluate the criteria upon which judgement of exterior features is based, and place more importance on breeding from animals with the most functionally correct bodies. This would have to be done without essentially changing the economically important characteristics of the pig.

Smith (1966) found that heritability for leg weakness score was rather low, while *Teuscher et al.* found it to be 0.5. It is probable that heritability for single details within the complex can be calculated with more certainty, and probably to a higher figure than heritability for the overall complex "leg weakness". It is also probable that by throwing light on the single details of the complex, it would be easier to clarify its aetiology and pathogenesis.

It should be mentioned that general weakness in musculature, cartilage and bone structure has been considered only to a slight extent in the present experiments (*Grøndalen & Vangen* 1974). *Thurley* (1967) mentions the degree of myofibrillar hypoplasia at birth as being a cause of leg weakness. This condition varies with different breeds (*Staun* 1963).

Sabec et al. (1972) have investigated the tensile and shearing strength of bones, and suggested that these might be used as selection criteria with regard to attaining better bone structure. According to *Nielsen* selection trials based on gross joint lesion scores of slaughtered offsprings and littermates are started in Denmark. There are thus criteria besides joint shape and exterior conformation which can be taken into consideration.

As a main conclusion it can be stated that heredity seems to play a significant part in the leg weakness problem. The way in which heredity influences the occurrence of joint lesions and leg weakness seems, however, still rather unclear. General inherited weakness of the muscles, ligaments, cartilage and bone tissue is a possible causal factor. Nevertheless, it is considered that the present investigations show that the inheritance of unfavourably shaped joints and of an unfavourable exterior conformation is a significant aetiological factor.

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SAMMENDRAG

„Leg weakness" hos gris. II. Kullforskjeller i „leg weakness", skjelett-lesjoner, leddutforming og eksteriør.

Det er undersøkt for kullforskjeller i bevegelsesevne og eksteriør og kull- og fedregruppeforskjeller i leddlesjoner og leddutforming. Grisene var fra et raseforsøk med 6 kull, 8 foringsforsøk med tilsammen 64 kull og et seleksjonsforsøk med tilsammen 70 kull og 25 fedregrupper fordelt på 3 linjer. Etthundreogtjueen av de 285 P-verdiene for kull- eller fedregruppeforskjeller en har omtalt i denne artikkelen, var statistisk sikre ($P < 0{,}05$). Dette viser, med forbehold for muligheter for kulleffekt av forskjellig miljø fram til 20 kg levende vekt for dyr fra rase- og foringsforsøkene, at arv spiller en vesentlig rolle i „leg weakness"-komplekset. En mener å ha vist at det delvis er nedarving av spesiell leddutforming og eksteriør som påvirker grad av leddlesjoner og bevegelsesevne og fører til kullforskjeller. Dette gir teoretisk en mulighet for seleksjon for mer holdbare ledd og bedre bevegelsesevne ved hjelp av kriterier som angår leddutforming og eksteriør.

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Reprints may be requested from: Trygve Grøndalen, Veterinary College of Norway, Postboks 8146, Oslo Dep., Oslo 1, Norway.