Acta vet. scand. 1974, *15*, 555—573.

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

LEG WEAKNESS IN PIGS

I. INCIDENCE AND RELATIONSHIP TO SKELETAL LESIONS, FEED LEVEL, PROTEIN AND MINERAL SUPPLY, EXERCISE AND EXTERIOR CONFORMATION

By

Trygve Grøndalen

GRØNDALEN, TRYGVE: *Leg weakness in pigs. I. Incidence and relationship to skeletal lesions, feed level, protein and mineral supply, exercise and exterior conformation.* Acta vet. scand. 1974, *15*, 555—573. — Out of 373 Landrace boars and gilts involved in feeding experiments, 18.2 % showed severe degree leg weakness and 30 % mild degree leg weakness at 100 kg live weight. Of the boars at pig A.I. stations 23.9 % were slaughtered because of leg weakness, 75 % of these being under 1½ years. The practical significance of leg weakness is greatest in young breeding stock. High feed level in slaughter pigs resulted in poorer locomotory ability than medium feed level. Exercise resulted in pigs showing better movements. Variations of minerals and protein within limits used in practical feeding did not have any influence on the incidence of leg weakness. There was no statistically significant relationship ($P > 0.05$) between joint lesions and locomotory ability in pigs at 100 kg live weight, although severe lesions seemed to lead to poorer mobility. The joint regions which seemed to be mainly involved in severe degree leg weakness in boars were the elbow and stifle joints (31.3 %), the lumbar intervertebral joints (28.1 %) and the hip region (15.6 %). There was a significant relationship between narrow lumbar region, broad hams, large relative width between the stifle joints, and poor locomotory ability in slaughter pigs.

leg weakness; skeletal lesions; nutrition; exercise; conformation; pig.

Leg weakness is a well accepted term used to describe pigs with poor locomotory ability. It is not an exact diagnosis, but is used more and more frequently. For the last 10—15 years the syndrome has been considered of great significance in pig production. The first reports of a somewhat widespread occurrence of locomotory problems without an exact diagnosis concerned boars. The problem manifested itself as an inability to copulate. As early as 1929—30 *Funkquist* described cases where Swedish Landrace boars were not able to complete the mating act, though he could demonstrate no reason for this. The boars mounted the sow but often slid off again. *Funkquist* considered this form of impotence to be hereditary, probably inherited through the dam. *Holst* (1949) demonstrated similar mating problems in Swedish boars descending from sows imported from Denmark. According to *Holst* inability to copulate was previously thought to be secondary to acute or chronic infections. In the cases which were described, however, such infections or other causes could not be demonstrated. The problem occurred within certain lines, and *Holst* considered the condition to be of hereditary origin. *Christensen* (1953) described the occurrence in Sweden of mating problems in 9 boars, 8 of which were between 9 and 18 months old. They were most often lying, showed stiffness when moving, and had difficulties in mounting the phantom. Pronounced changes in the larger joints of both fore and hind legs were demonstrated on post-mortem examination. *Christensen* called the condition chronic deforming arthrosis and found that the patho-anatomical changes in the bones and joints were an excellent explanation for the clinical symptoms. He assumed that a special genetically conditioned predisposition was involved in the development of this form of impotentia coeundi in boars.

Subsequently much work has been done on this problem in several countries. Nevertheless, it is difficult to say how widespread the condition is, as the diagnosis is a highly subjective one. From Scotland, *Smith & Smith* (1965) stated that 30—40 % of tested boars showed leg weakness. Reports from a testing station in West Germany show an increase in the incidence of pigs with leg weakness from 14 % in 1965 to 28 % in 1969 (*Teuscher et al.* 1972). Out of a total of 170 boars around 100—120 kg live weight, investigated at the Norwegian boar testing station during the period 1969—70, 27 (15.9 %) showed a severe degree and 32 (18.8 %) a milder degree of leg weakness (*Grøndalen*, unpublished). Replies to a questionnaire sent to 181 herd owners who had bought boars from different places in Norway showed that 28 boars (15.5 %) developed serious and 18 (9.9 %) milder locomotory or mating problems (*Aamdal* 1970).

In a selection experiment in Norway in which 1 line was selected for rapid growth rate and thin back fat (LBL) and another for slow growth rate and thick back fat (HBL) while a third line was used as a control (CL) (*Grøndalen & Vangen* 1974), leg weakness was responsible for the culling of 20.5 % of the LBL sows, 15.0 % of the CL sows and 13.8 % of the HBL sows (*Vangen* 1972). *Penny* (1972) refers to 3 different investigations in which, respectively, 10.7 %, 33.2 % and 20.4 % of sows were culled because of lameness or paralysis.

The aetiologi of leg weakness is complex. *Thurley* (1967) listed the following 4 points:

1) The degree of myofibrillar hypoplasia present at birth
2) The amount of exercise taken during growth
3) The rapidity of growth
4) The severity of articular damage arising during the period of susceptibility when muscles are somewhat weak.

He assured that cases where 1—3 were the underlying cause had a favourable prognosis if treated, but that 4 tended to be irreversible. *Kurzweg & Winkler* (1972) summarized an investigational series by stating that mechanical-static causes as well as metabolic disturbances were aetiological factors in leg weakness in slaughter pigs. *Nielsen* (1973) concluded that leg weakness occurs in bacon pigs and young breeding stock and that only some of the degenerative joint and bone lesions which occur in most pig breeds during the growth period can be related to locomotory disturbances. He considered that rapid growth and lack of exercise are factors which are most likely to provoke clinically manifest symptoms. Furthermore he demonstrated that the calcium and phosphorus content of the ration, within a wide range, has no influence on the occurrence of leg weakness and arthrosis, and that genetical disposition to these conditions seems to exist.

Studies of the literature in connection with previous investigations (*Grøndalen* 1974 a, b, c, d, e, *Grøndalen & Grøndalen* 1974, *Grøndalen & Vangen*) have otherwise shown that most investigations of leg weakness have been concerned with various disease conditions of the skeleton.

In order to clarify the incidence of leg weakness and the relation to some supposed causal factors, the pigs in some experiments were systematically examined with regard to locomotory ability.

MATERIALS AND METHODS

Material I

This material consisted of 3 Landrace litters, each comprising 6 gilts or castrates and the same number of litters and animals of the Yorkshire breed, 36 animals in all. They were kept in pens of 6. Each pen was approx. 6 m^2 with a cement floor. In order to investigate the effect of exercise, half of each litter, 18 animals in all, were given 20 min. exercise at a brisk walking pace on a cement floor 3 times a week from the time they were first included in the trial at 25 kg live weight until they were slaughtered at 117—123 kg live weight. All pigs were examined prior to slaughter on the same cement floor and judgement made of their exterior features and gait. The methods employed in the judgement of skeletal lesions and exterior conformation have been described previously (*Grøndalen* 1974 e). When judging locomotory ability the Norwegian Pig Breeding Association's scale as applied at the Norwegian Boar Testing Station ranging from 4 for very poor locomotory ability to 8 for very good locomotory ability, was used. It is difficult to give an exact description of the criteria applied in judging locomotory ability, as final judgment represented a total evaluation. Emphasis was placed on the pig's ability to get to it's feet, whether it could trot, how easily and lightly it moved, whether it had stiff gait, and whether it slipped about. Thus a score of 3 was given to animals which could not get to their feet without help, a score of 4 to animals with pronounced locomotory difficulties, a score of 5 to animals showing a relatively mild degree of leg weakness, while animals receiving a score of 6, 7, or 8 were more or less good on their feet. The scale figures given refer to the pig about a week before slaughter. Results were punched onto punch cards and statistical calculations carried out using standard programs for analyses of variance and regression.* A further description of the material with regard to the experimental design and the skeletal lesions has been given in a previous paper (*Grøndalen* 1974 c).

Material II

This material has been previously described with regard to skeletal lesions, experimental organization, collection of samples

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

etc. (*Grøndalen* 1974 d, *Hanssen* 1974). It consisted of animals used in 4 feeding experiments involving boars and 4 involving gilts. Each experiment should involve 48 animals. In all, 373 animals were examined. The following factors were varied: Feed level (B-norm +10 % to —20 %), feeding levels of calcium (7—12 g/kg feed), phosphorus (6—10 g/kg feed) and protein (9—26 %). The animals were examined as to locomotory ability on the same cement floor once a month from 25 kg live weight to approx. 60 kg live weight, thereafter once a week or fortnight until slaughter close to 100 kg live weight. However, the animals in the experiments SV 104 and SV 111 were examined once a week during the first and last part of the experiments, and once a fortnight from approx. 40—60 kg live weight. All animals were judged with regard to locomotory ability and conformation in the same way as material I, the treatment of results also being the same. Various systems for identifying the individual pigs with regard to clinical and post-mortem examination were used.

Material III

This consisted of 83 Landrace boars with an age-spread from 7 months to 4½ years. Data concerning locomotory ability before slaughter, reason for slaughter and age were obtained from those using the boars. Of the 83 boars, 16 had been sent in from various places for post-mortem examination because of clinical locomotory problems, whereas 67, slaughtered for various reasons, were sent in for routine post-mortem examination from the station where boars used for artificial insemination (a.i.) were housed. This material has been previously described with regard to skeletal lesions (*Grøndalen* 1974 b).

RESULTS

Material I

Some pigs distinguished themselves by moving heavily already at 40—50 kg live weight. These had broad hams and a narrow lumbar region. Several pigs developed leg weakness at 70—90 kg live weight. The group which had been exercised received an average gait score of 6.6, while those which had been refused exercise, received an average gait score of 6.1. Individual score ranged from 4 to 8 in the exercised group, and from 4 to 7 in the non-exercised group. The difference between the groups was statistically significant ($P < 0.05$). If the exercised animals slipped, they were usually able to transfer weight to other legs such that they remainded on their feet, whereas the unexercised pigs usually slipped further and fell down. It seemed that unexercised Landrace pigs were less mobile than unexercised Yorkshire pigs. However, the material was too small to allow any conclusion to be drawn. The conformation of the hindquarters showed large variations. The characteristics which, besides exercise, seemed to have the greatest relation to locomotory ability were the narrowness of the lumbar region, the broadness of the hams, the relative broadness at the stifle joints, the lesion score of the medial condyle of the femur and the mean joint lesion score. These are listed in Table 1.

Table 1. The relation between gait score, joint lesions and some exterior features of the pigs in material I.

Gait score	Number of pigs	Mean values according to gait score of the				
		mean joint lesion score	lesion score of the stifle joint	narrowness of the lumbar region	broadness of the hams	relative broadness at the stifle joints
4	3	2.6	3.7	3.3	3.7	3.0
5	3	1.9	1.3	2.3	2.7	2.0
6	12	1.8	1.8	1.8	2.1	2.0
7	15	1.6	1.5	1.1	1.7	1.5
8	3	2.1	2.0	1.0	2.0	2.0
Correlation coefficient gait score/lesion or exterior score		—0.28	—0.34	—0.75	—0.55	—0.39
Statistical significance (P)		> 0.05	> 0.05	< 0.001	< 0.001	< 0.05

Material II

Lameness due to random injuries and infections occurred. Hoof injuries, which were most common in animals with very unevenly sized hooves, were not especially frequent. Some pigs showed signs of leg weakness already at approx. 40 kg live weight. Some of these became progressively worse approaching slaughter weight, whereas the condition in others was more stable. Most of the pigs with marked leg weakness at slaughter, showed signs at 70—90 kg live weight. As regards SV 104 and SV 111 the pigs in the low feed level groups had a good gait score up to approx. 90 kg, but developed locomotory problems subsequently. The total numbers of animals with the various gait scores at slaughter are shown in Table 2. The 5 animals not able

Table 2. Number and percentage of pigs with the different gait scores in material II and average daily weight gain.

Gait score		Number	%	Daily weight gain in g	
				until 60 kg live weight	60—100 kg live weight
3	(not able to arise)	5	1.3	775	782
4	(severe degree leg weakness)	63	16.9	772	882
5	(mild degree leg weakness)	112	30.0	662	810
6	(satisfactory movements)	114	30.6	659	834
7	(good movements)	75	20.1	644	801
8	(very good movements)	4	1.1	556	781
		373	100		

to get onto their feet were from the 2 first experiments with boars and from the group fed B norm +10 %. One of the pigs had "open" osteochondrosis (arthrosis) in the stifle joints, 1 had infectious polyarthritis and periarthritis, 1 showed rupture of the joint capsules of the hip joint, and 2 showed a marked inflammatory reaction in the capsules of the stifle and elbow joints. Bacteriological examination of these proved negative. Table 3 shows the mean gait score in the different feed level groups in different experiments. As regards the boar experiments SV 75 and SV 84, the difference in gait score between high and low feed level groups was statistically significant ($P < 0.05$). Apart from SV 104, there was a tendency in all experiments towards a better gait score in the low feed level groups. In SV 95 a statistically significant relationship ($P < 0.05$) between gait score and mean joint lesion score was demonstrated. Statistically significant relationship could not be established in the other experiments. Neither was there any constant relationship between lesion score in the individual joints and gait score. However, the 20 animals with open lesions in the medial condyle of the femur (arthrosis) had an average gait score of 4.9 as opposed to 5.6 for the rest of the material.

Table 3. Mean gait score and age of the pigs at 100 kg live weight in feed level groups in material II.

Experiment	Sex	Feed level				Significance for group differences in gait score (P)
		B norm + 10 %		B norm — 10 or 20 %		
		mean gait score	mean age in days	mean gait score	mean age in days	
SV 64	♂	5.5	170	—	—	—
„ 68	♀	5.0	188	—	—	—
„ 75	♂	4.8	171	5.6	198	< 0.05
„ 80	♀	5.9	171	6.2	201	> 0.05
„ 84	♂	5.1	169	5.8	202	< 0.01
„ 95	♀	5.6	174	6.0	202	> 0.05
„ 111	♂	5.6	176	5.8	199	> 0.05
„ 104	♀	5.8	190	5.6	209	> 0.05

There was no statistically significant difference in gait score between the groups fed different levels of minerals or protein, nor was there any such tendency. Experiments SV 104 and SV 111, in which feeding levels of protein varied greatly between the groups, were followed closely as regards clinical signs right from the time they were included in experiments. However, at no point in time any marked difference in locomotory ability between the groups was observed.

Most of the animals had relatively upright pasterns of the fore legs. In the experiments where this aspect of conformation varied, it was the animals which had sloping pasterns without at the same time showing "buck knees" (anterior deviation of the carpal) which had the best gait score. Animals with extremely small medial hooves on the hind legs usually had a poor gait score. Otherwise no relationship between gait score and conformation of the fore legs, hock joints, distal parts of the hind legs or length of the back could be demonstrated.

Features of exterior conformation which often showed a statistically significant relationship ($P < 0.05$) with gait score were the shape of the lumbar region, the broadness of the hind quarters seen from behind, and the relative broadness at the stifle joints seen from behind. These 3 conformation features were investigated in the last 4 experiments (SV 84, 95, 104 and 111). The relationship between gait score and these 3 features is shown in Table 4. The same table also shows the mean joint lesion score in relation to gait score.

Table 4. The relation between gait score, joint lesions and some exterior features of the pigs in 4 feeding experiments of material II.

Experiment	Gait score	Number of pigs	Mean values according to gait score of the			
			mean joint lesion score	narrowness of the lumbar region	broadness of the hams	relative broadness at the stifle joints
SV 84	4	8	2.6	3.1	2.9	2.6
	5	15	2.3	2.7	2.8	2.7
	6	17	2.0	2.4	2.2	2.1
	7	5	2.5	1.4	1.8	1.6
	8	1	2.5	1.0	1.0	1.0
Corr. coeff. gait score/ lesion or exterior score			—0.10	—0.62	—0.54	—0.55
Statistical significance (P)			> 0.05	< 0.001	< 0.001	< 0.001
SV 95	4	5	2.9 (5)*	2.6	3.0	2.8
	5	15	1.7 (13)	2.3	2.4	2.3
	6	14	2.0 (11)	2.1	2.2	2.1
	7	9	1.8 (7)	2.0	2.0	2.1
	8	3	1.8 (2)	2.0	2.3	2.0
Corr. coeff. gait score/ lesion or exterior score			—0.34	—0.36	—0.39	—0.36
Statistical significance (P)			< 0.05	< 0.05	< 0.01	< 0.05
SV 104	4	4	2.3	2.8	3.0	2.8
	5	16	2.1	2.4	2.5	2.2
	6	18	1.9	2.1	2.1	2.2
	7	9	2.0	2.0	1.8	2.1
Corr. coeff. gait score/ lesion or exterior score			—0.13	—0.52	—0.56	—0.23
Statistical significance (P)			> 0.05	< 0.001	< 0.001	> 0.05
SV 111	4	5	2.3	2.2	2.2	2.2
	5	15	2.4	2.5	2.5	2.3
	6	14	2.5	2.1	2.3	2.1
	7	12	2.0	2.0	2.0	2.0
Corr coeff. gait score/ lesion or exterior score			—0.20	—0.37	—0.24	—0.29
Statistical significance (P)			> 0.05	< 0.05	> 0.05	< 0.05

* The figures in brackets are number of pigs examined for joint lesions in experiment SV 95.

Material III

The relationship between age and the reason for slaughter of the 67 boars which were sent in from the boar a.i. stations, is shown in Table 5. The boars were divided into 3 groups, 1 group showing pronounced leg weakness, 1 group with no sign of leg weakness and an uncertain group.

Table 5. The relation between age and the reason for slaughtering the 67 boars from a.i. stations, material III.

Age	Number investi-gated	The reason for slaughtering the boars					
		leg weakness		Impotentia coeundi etc.		other reasons, good movements	
		number	%	number	%	number	%
< 1½ year	34	12	35.3	16	47.1	6	17.6
> 1½ year	33	4	12.1	11	33.3	18	54.5
	67	16	23.9	27	40.3	24	35.8

In the 24 boars which were positively known to have good legs, it was possible to demonstrate severe degree arthrosis only in the elbow joint. Though severe degree arthrosis was quite often listed in several joints in the 27 boars with impotentia coeundi, it was nevertheless by far most common in the 32 boars slaughtered because of leg weakness (Table 6).

Table 6. The relation between the reason for slaughtering and severe degree joint lesions of the 83 boars in material III.

Diagnosis Severe degree arthrosis in the	The reason for slaughtering the boars					
	leg weakness (32 boars)		Impotentia coeundi etc. (27 boars)		other reasons, good movements (24 boars)	
	number	%	number	%	number	%
elbow joints	16	50.0	5	18.5	3	12.5
lumbar intervertebral joints	10	45.5*	1	4.3**	0	0.0
hip joints	2	6.3	1	3.7	0	0.0
femoro/tibial joints	11	34.4	3	11.1	0	0.0
epiphyseolysis of the femoral head	4	12.5	0	0.0	0	0.0

* 22 of the boars were investigated in the lumbar region.
** 23 of the boars were investigated in the lumbar region.

Table 7 is based on an overall evaluation of the patho-anatomical findings and case histories, and is an effort to elucidate which joint regions are mostly involved when arthrosis leads to leg weakness. Animals with a relative mild degree of arthrosis, which were suspected of suffering from inter al. muscular diseases, as well as animals with severe degree arthrosis in several joints or other combinations than mentioned, are included in the column "other reasons or combinations". It is also possible that there were animals with severe degree arthrosis in the lumbar intervertebral joints as only 22 of the 32 boars were examined in this region. Moreover the tarsal joints and the hooves were examined in only few of the animals.

Table 7. The relation between joints which, judged on the basis of degree of lesions and case history, seem to be the main cause of severe degree leg weakness in material III.

Joints	Number of boars	%
the elbow and/or the femorotibial joints	10	31.3
the lumbar intervertebral joints	9	28.1
the hip joint and epiphyseolysis of the femoral head	5	15.6
other reasons of combinations	8	25.0
	32	100

DISCUSSION AND CONCLUSIONS

The term leg weakness is not an exact diagnosis. The scale (gait score) has not been used with the aim of diagnosing conditions in different parts of the skeleton or musculature. It is based on an overall evaluation of the ability to move. As judged by results from boar testing stations in Norway (*Grøndalen*, unpublished) and results from material II in the present investigation, it seems that 15—20 % of pigs at approx. 100 kg live weight show leg weakness to a serious degree, while a further 20—30 % show a milder degree of leg weakness. It is difficult to compare the incidence in Norwegian pigs with that found in other countries, as details of the methods used in judging the condition abroad are not known. However, there seems to be good agreement with the results obtained by *Smith & Smith* (1965) in Scotland and by *Teuscher et al.* (1972) in West Germany.

There is no essential difference in the incidence of leg weakness in boars as compared with gilts at 100 kg live weight. This has also been expressed by *Vaughan* (1971).

About 24 % of the boars sent in from pig a.i. stations were slaughtered because of leg weakness. This figure corresponds well with earlier experience in Norway (*Aamdal* 1970) and with results from Sweden (*Bring* 1972). As regards boars from Norwegian a.i. stations, the group "Impotentia coeundi etc." probably includes a number of animals with poor legs. It should also be kept in mind that a number of animals with poor legs are culled before getting to the a.i. stations. The group "leg weakness" consisted mainly (75 %) of animals under 1½ years, while the group "good movements" consisted mainly (75 %) of animals over 1½ years. This suggests that leg weakness is chiefly a problem of the young animal, and that an animal which reaches the age of about 1½ years without developing locomotory problems has passed the "risk period". One of the reasons for this is probably that pigs over 1½ years have passed the rapidly growing period. They are, thus, not so likely to have weak musculature, cartilage or bone tissue. Moreover a selection is present, as it is usually the constitutionally strong animals which are allowed to live longer than 1½ years.

The results presented by *Penny* (1972) and *Vangen* (1972) suggest that approx. 20 % of sows are slaughtered because of poor legs. *Vangen*'s results suggest that highly selected pigs are more prone to leg weakness than the older type of pig.

The significance of leg weakness can be difficult to evaluate. The animal protection aspects are usually considered less than the economic aspects. If slaughter pigs cannot be loaded on to trucks easily for transport to slaughter house, extra time and therefore higher costs will be the result. Moreover, if the condition is severe, it may cause slow weight gain, less efficient feed conversion or poor carcase quality. These aspects have not been considered in the present materials. On the breeding side the problem of leg weakness is of unquestionable importance. Inter al. the great difference between the value of the breeding boar and the price obtained for the carcase if the boar has to be slaughtered prematurely causes considerable economic loss. In addition, there are problems involved in getting the sows pregnant at the right time, and problems concerning sows which are poor on their feet around the time of parturition.

Leg weakness has a complex aetiology. High feed level or rapid growth have a considerable influence on the mobility of slaughter pigs. This is in agreement with observations made by *Thurley* (1967), *Nielsen* (1969), *Vaughan, Bring*, and *Nielsen* (1973). The high feed level pigs of the present investigations seemed to develop leg weakness at an earlier age than the lower feed level pigs. Evaluation at the same age, instead of the same weight, for example 160 days, would probably have demonstrated greater difference in gait score between feed level groups. A significant relationship between rapid weight gain to 60 kg live weight and low gait score before slaughter was demonstrated (Table 2). This was calculated on the 8 feeding experiments of material II together (*Hanssen* 1974). Whether this has a connection with genetically determined or feeding determined rapid growth rate is difficult to evaluate on the basis of the present results. Such obvious relationship was not demonstrated for the period 60—100 kg live weight. The lack of this might suggest that leg weakness gives rise to slowing down the growth rate. It is difficult to conclude. However, feeding schemes seem to be of great interest when discussing the aetiology of leg weakness.

It is previously stated (*Grøndalen* 1974 d) that the degree and incidence of joint lesions were not essentially different between feed level groups, nor was hyaline muscle degeneration demonstrated by histological investigation in slaughtered pigs. According to *Aas-Hansen* (1973), serum levels of glutamate-pyruvate-transaminase (GPT) and glutamate-oxalacetate-transaminase (GOT) examined on blood samples collected at slaughter of pigs in material II were somewhat raised. The reason for this was considered to be stress suffered during transport and handling prior to slaughter. Average level for the experiments ranged from 39 to 57 with regard to GPT and from 64 to 100 for GOT (Sigma Frankle units). There was a statistically significant difference ($P < 0.05$) between feed level groups in regard to GPT in 4 experiments. However, no general tendency was present as the feed level group showing the highest levels of GPT varied in the different experiments. GOT levels also showed a somewhat random variation. This suggests that environmental factors in connection with transport and slaughter were decisive as regards serum transaminase values. It is thus difficult to evaluate any difference in muscle quality between pigs on high or low rations.

It is equally difficult to evaluate the part which musculature plays in the leg weakness complex, on the basis of these experiments and samples taken. Tocopherol acetate was fed at a level of 10 mg/kg feed in the first 4 experiments and at 25 mg/kg feed in the last 4. The 5 boars which became recumbent were involved in the first 4 experiments. The same was the case for 2 pigs which died as a result of muscle degeneration. Although transaminase values and histological examinations of musculature of slaughtered pigs did not give any definite evidence, the practical results support the assumption that muscle quality is a significant factor in the leg weakness complex (*Thurley, Kurzweg & Winkler* 1972, *Grøndalen & Vangen* 1974). Thurley is of the opinion that the degree of myofibrillar hypoplasia present at birth may also be of essential significance as regards the development of leg weakness.

The present study shows that feeding levels of minerals within limits used in practice have no influence on the degree of leg weakness. This is in agreement with *Vaughan* and *Kurzweg & Winkler*.

Results obtained by *Månsson et al.* (1971) showed that extremely high amounts of protein could lead to synovitis with clinical signs. The locomotory ability of the pigs in experiments SV 104 and SV 111 was therefore examined frequently. It was not possible at any time during the experiments, however, to demonstrate significant differences in gait score between protein groups. Proliferation of bursae and joint capsule reaction occurred. However, these conditions are relatively common in pigs (*Grøndalen* 1974 a). Therefore, on the basis of the feeding experiments described in this article, protein per se seems not to have any effect of practical significance on the degree of leg weakness in pigs. The growth promoting effect of protein, especially with regard to boars, may however have a certain significance.

The experiments in which pigs were exercised involved so few animals that care has to be taken when drawing conclusions. The subjective impression was that exercised pigs developed an easier action. This was especially true of Landrace pigs. It is reasonable to suppose that muscle strength increases with exercise. It also seemed likely that the ability to use the proper muscles at the right time was considerably more developed in the exercised animals. This might be a significant factor. The degree of joint lesions was not influenced by exercise. It is otherwise a generally held opinion that exercise has a favourable influence on locomotory ability in pigs (*Thurley, Vaughan, Nielsen* 1973).

The term "leg weakness" has a clinical foundation. Its application may vary, sometimes one gets the impression that it is wrongly considered as being synonymous with joint lesions. The present study shows no significant relationship between joint lesions and leg weakness in slaughter pigs. There is, however, a tendency for more severe joint lesions, for example open lesions in the medial condyle of the femur, to show relationship to severe degree leg weakness. This opinion is shared by among others *Thurley* and *Nielsen* (1973). On the other hand, the present study shows that non-infectious severe degree skeletal lesions are the main cause of leg weakness in breeding boars. Only in the elbow joint severe degree arthrosis could be demonstrated in animals showing good movements, whereas animals slaughtered because of leg weakness showed a high incidence of severe degree arthrosis in several joints. Animals with severe degree arthrosis were also included under the heading of "Impotentia coeundi". This might suggest that copulatory impotence in some of the animals was in fact due to joint lesions. The results on boars are in agreement with the opinion of *Christensen* (1953), *Hansen & Reiland* (1968) and *Kurzweg & Winkler.*

In Table 7, an attempt has been made to elucidate which joints are the main cause of leg weakness in Norwegian breeding boars. Although the table has been compiled on the basis of subjective evaluation, it is considered that it gives a fairly reliable picture of the situation. The elbow and/or femorotibial joints seem to cause the greatest problems for approx. 30 % of boars with severe degree leg weakness, while the lumbar intervertebral joints account for approx. 30 %, and the hip joint for approx. 15 %. Various other factors or combinations cause trouble for the remaining 25 %. Investigations (*Grøndalen & Vangen*) concerning pigs with genetically determined differences in back length support the assumption that the back is a very weak part of the skeleton in modern pigs. Results from other investigations deviate somewhat from the results obtained in the present study. *Christensen* and *Kurzweg & Winkler* seem to attribute lesions in the hip joint most significance as regards leg weakness, while *Sabec et al.* (1961) and *Bollwahn et al.* (1970) seem to put most emphasis on lesions in the tarsus. It is not recorded whether or not these investigations included the intervertebral joints of the lumbar region. It is agreed, however, that a long back may result in unfavourable mechanical pressures on the skeleton.

The shapes of the lumbar region and hind quarters were conformational features which had a significant influence on locomotory ability in slaughter pigs. There was a marked relationship between a narrow concave lumbar region and poor locomotory ability. The same was true of broad hind quarters and large relative distance between the stifles. There was also a marked relationship between these conformational features themselves. *Schilling* (1963) also considered that the shape of the hams was significant for the animals' mobility. Differences in the shape of the hind quarters between breeds have been demonstrated (*Grøndalen* 1974 c). A previous article (*Grøndalen* 1974 e) includes illustrations of different types of pig. The reason why pigs possessing the mentioned conformational features show poor locomotory ability has not been clarified. They have a tendency to develop more marked lesions in the stifle joints (*Grøndalen* 1974 c), however, without this being the only mechanism. It is reasonable to suppose that the pelvis differs somewhat from animal to animal and that the tuber coxae, trochanter major and tuber ischii may be positioned in such a way that muscles in the hind quarters have unfavourable directions of pull, and that consequently the pigs show poor locomotory ability. It is also possible that pigs with broad hams have a genetically determined rapid muscle growth, and that this musculature is weak. However, evidence for this is lacking. The conformational features of broad hind quarters and concave lumbar region could be seen in pigs under 50 kg live weight. It may thus be possible to use these as selection criteria with regard to the individual, and recruit breeding animals which have a compact lumbar region, which do not have extremely broad hind quarters and which have straight hind legs as seen from behind. As pigs with round, broad hams most often have short femurs, the hams of "narrow" pigs must not necessarily be lighter than hams of "broad" pigs. Judgement of exterior conformation has not been as common in recent years as it was before. Such judgement may however be of significance in picking out animals with functionally good locomotory apparatus provided one has satisfactory criteria upon which to base such judgement.

ACKNOWLEDGEMENT

Thanks are due to the Computing Centre, Agricultural University of Norway, for help with the statistical processing of the observations.

REFERENCES

Aamdal, J.: Personal communication, 1970.

Aas-Hansen, M.: Personal communication, 1973.

Bollwahn, W., E. Lauprecht, J. Pohlenz, W. Schultze & E. Werhahn: Untersuchungen über das Auftreten und die Entwicklung der Arthrosis deformans tarsi beim Schwein in Abhängigkeit vom Alter der Tiere. (Investigations on the incidence and the pathogenesis of arthrosis deformans tarsi in swine in relation to the age of the animal). Z. Tierzuchtg Züchtgsbiol. 1970, *87*, 207—219.

Bring, K.: Preliminära resultat från studier av rörelsestörningar hos svin. (Preliminar results from studies on leg weakness in pigs). Lantbrukshögskolans Forsöksledarmöte, Uppsala 1972.

Christensen, N. O.: Impotentia coeundi in boars due to arthrosis deformans. Proc. XV Int. Vet. Congr., Stockholm 1953, Part I, *2*, 742—745.

Funkquist, H.: Erbliche Begattungsunfähigkeit bei Zuchtebern. (Hereditary impotentia coeundi in boars). Hereditas (Lund) 1929—30, *13*, 107—120.

Grøndalen, T.: Osteochondrosis and arthrosis in pigs. I. Incidence in animals up to 120 kg live weight. Acta vet. scand. 1974 a, *15*, 1—25.

Grøndalen, T.: Osteochondrosis and arthrosis in pigs. II. Incidence in breeding animals. Acta vet. scand. 1974 b, *15*, 26—42.

Grøndalen, T.: Osteochondrosis and arthrosis in pigs. III. A comparison of the incidence in young animals of the Norwegian Landrace and Yorkshire breeds. Acta vet. scand. 1974 c, *15*, 43—52.

Grøndalen, T.: Osteochondrosis and arthrosis in pigs. VI. Relationship to feed level and calcium, phosphorus and protein levels in the ration. Acta vet. scand. 1974 d, *15*, 147—169.

Grøndalen, T.: Osteochondrosis and arthrosis in pigs. VII. Relationship to joint shape and exterior conformation. Acta vet. scand. 1974 e, Suppl. 46.

Grøndalen, T. & J. Grøndalen: Osteochondrosis and arthrosis in pigs. IV. Effect of overloading on the distal epiphyseal plate of the ulna. Acta vet. scand. 1974, *15*, 53—60.

Grøndalen, T. & O. Vangen: Osteochondrosis and arthrosis in pigs. V. A comparison of the incidence in three different lines of the Norwegian Landrace breed. Acta vet. scand. 1974, *15*, 61—79.

Hansen, H.-J. & S. Reiland: Ledlidanden hos avelssvin. (Joint lesions in breeding pigs). Lact. Symp. Wenner-Gren Center, Stockh. 1968, 105—111.

Hanssen, J. T.: Virkningen av ulike ernæringsfaktorer på veksten hos avlssvin. (The effect of different dietary factors on growth and development in young boars and gilts). Thesis, Dept. Animal Nutrition, Agricultural University of Norway 1974.

Holst, S. J.: Sterility in boars. Nord. Vet.-Med. 1949, *1*, 87—120.

Kurzweg, W. & K. Winkler: Gesundheitliche Aspekte der Fleischschweinproduktion. Stellungs- und Gliedmasseanomalien. (Health aspects of pork production. Anomalies in the locomotory system). Angewandte Tierhygiene, Band 3, Gustav Fischer Verlag, Jena 1972.

Månsson, I., R. Norberg, B. Olhagen & N.-E. Björklund: Arthritis in pigs induced by dietary factors. Microbiologic, clinical and histological studies. Clin. exp. Immunol. 1971, *9*, 677—693.

Nielsen, H. E.: Orners vækst, frugtbarhed og holdbarhed ved forskellig fodring i opdrætningsperioden samt nogle resultater vedrørende søers frugtbarhed. (Growth rate, fertility and longevity of boars on different diets during rearing, and some results concerning fertility in sows). Rep. no. 375 Forsøgslaboratoriet, Statens Husdyrbrugsudvalg 1969, 1—45.

Nielsen, N. C.: Arthrose hos svin. (Arthrosis in pigs). Nord. Vet.-Med. 1973, *25*, 17—27.

Penny, R. H. C.: Some current thoughts on lameness in the pig. Vet. Ann. 1972, *13*, 31—36.

Sabec, D., E. Schilling & L. Cl. Schultz: Eine Arthrosis deformans des Sprunggelenkes beim Schwein. (Arthrosis deformans of the hock joint in pigs). Dtsch. tierärztl. Wschr. 1961, *68*, 231—236.

Schilling, E.: Rassenunterschiede am Skelett des Beckens und der Hinterextremitäten beim Schwein. (The differences in skeleton of the pelvis and the hind legs between pig breeds). Z. Tierzüchtg Züchtgsbiol. 1963, *78*, 293—324.

Smith, R. G. C. & C. Smith: Report on boar performance testing at Stirling. Animal Prod. 1965, *7*, 284.

Teuscher, T., J. H. Weniger & D. Steinhauf: Die Beinschwäche beim Schwein. Züchterische und produktionstechnische Bedeutung. (Leg weakness in pigs. Breeding and production importance). Schweinezucht und Schweinemast, Z. Schweineprod. 1972, *20*, 292—296.

Thurley, D. C.: Muskulaturentwicklung und Gliedmassenschwäche. (Muscle development and leg weakness). Dtsch. tierärztl. Wschr. 1967, *74*, 336—338.

Vangen, O.: Nye resultater fra seleksjonsforsøk med gris. (Results from a selection experiment with pigs). Proc. 4. Husdyrforsøksmøte, LOT, Oslo 1972, 33—36.

Vaughan, L. C.: Leg weakness in pigs. Vet. Rec. 1971, *89*, 81—85.

SAMMENDRAG

"Leg weakness" hos gris. I. Forekomst og relasjon til skjelettlesjoner, forstyrke, protein- og mineraltilførsel, mosjon og eksteriør.

Av 373 landsvinråner og -purker i foringsforsøk viste 18,2 % sterk grad og 30 % svak grad "leg weakness" ved 100 kg levende vekt. 23,9 % av avlsråner fra seminstasjonene ble slaktet p.g.a. sterk grad "leg weakness". 75 % av disse var under 1½ år. Den praktiske betydning av "leg weakness" er størst hos unge avlsdyr. Sterk foring av slaktegriser førte til dårligere bevegelsesevne enn middels sterk foring. Mosjon ga grisene sikrere og spenstigere bevegelser. Variasjon i mineral- og proteinmengden innenfor praktiske grenser for foring hadde ingen innflytelse på forekomst av "leg weakness". Det var ingen statistisk sikker sammenheng ($P > 0{,}05$) mellom leddlesjoner og bevegelsesevne hos griser ved 100 kg levende vekt, men store lesjoner syntes å føre til nedsatt bevegelsesevne. Hos avlsdyr var det sterk sammenheng mellom leddlesjoner og bevegelsesevne. De leddavdelinger som syntes å være mest ansvarlige for sterk grad „leg weakness" hos råner var albue- og bakkneledd (31,3 %), intervertebralledd i lumbalregionen (28,1 %), og hofteledd (15,6 %). Slaktegris med smalt lendeparti, brede skinker og stor relativ bredde mellom bakkne syntes å være predisponert for "leg weakness".

(Received April 4, 1974).

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