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OSTEOCHONDROSIS AND ARTHROSIS IN PIGS

V. A COMPARISON OF THE INCIDENCE IN THREE DIFFERENT LINES OF THE NORWEGIAN LANDRACE BREED

By

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GRØNDALEN, TRYGVE and ODD 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. — Investigations were carried out on 289 slaughter pigs, 56 breeding boars, and 51 breeding sows in a selection experiment started in 1964. The animals belonged to 4th—6th generations. One line has been selected for thin backfat and rapid growth (LBL) and 1 for thick backfat and slow growth (HBL). In addition a control line (CL) not subjected to selection was established in 1967. The pigs were kept as far as possible under identical conditions of housing and feeding, so that differences between lines should be primarily of genetic nature. The skeleton, measured as the length of bones and vertebral column, was statistically significantly smaller ($P < 0.01$) in HBL than in CL and LBL. The difference between CL and LBL was slight. No essential proportional changes in the skeleton took place. Patho-anatomical findings in the skeleton comprised, in all 3 lines, osteochondrosis, arthrosis, degeneration of the intervertebral discs, spondylosis, and epiphyseal separation. There were a lower incidence and statistically significant ($P < 0.01$) lower degree of total lesions in joints and bones in HBL, both as regards the slaughter pigs, boars and sows. The fact that the lumbar region of the vertebral column consistently showed the greatest difference in degree and incidence of lesions between the lines, suggests that this becomes the weakest skeletal part in pigs with a rapidly growing skeleton.

osteochondrosis; arthrosis; line differences; pig.

Literature studies carried out in connection with previous publications (*Grøndalen* 1974 a, b, c) have shown that most investigations concerning the incidence of skeletal lesions in pigs have been carried out on animals which were, in the circumstances, highly improved. In order to clarify the effect of selective improvement for thin backfat and rapid growth rate

on the incidence of osteochondrosis and arthrosis, skeletons from pigs involved in a selection experiment were collected and examined during the years 1971 and 1972.

MATERIALS AND METHODS

Investigations involved 289 slaughter pigs (material I), 56 boars (material II) and 51 sows (material III). Skeletons were collected from these animals, which were included in a selection experiment at the Institute of Animal Genetics and Breeding of the Agricultural University of Norway (*Standal* 1967). The selection experiment was started in 1964. The material involved in the present investigation thus comprised animals of the 4th, 5th and 6th generations. Selection is based on an index combining backfat thickness and rate of weight gain, 1 line being selected for high backfat thickness and low rate of gain (High Backfat Line, HBL) and 1 line for low backfat thickness and high rate of gain (Low Backfat Line, LBL). In a third line (Control Line, CL) no deliberate selection has taken place. This line was established in 1967 and based on random choice of parents to each successive generation. The purpose of the experiment is not only to investigate the effect of selection per se, but also to disclose any side effects of the selection on characteristics such as fertility, viability, leg weakness and carcase quality.

As far as possible, attempts have been made to ensure that conditions of feeding and housing are the same for all lines. The animals are fed twice daily according to the Norwegian B standard (*Breirem & Homb* 1972). The ration fed up to 50 kg live weight contains about 14 % digestible crude protein, 0.75 % calcium and 0.65 % phosphorus, thereafter about 11 % digestible crude protein, 0.63 % calcium and 0.54 % phosphorus.

In 1971, after about 5 generations, the average backfat thickness in HBL was 37.4 mm, in LBL 22.5 mm and in CL 28.3 mm, that is a difference of 14.9 mm between HBL and LBL. The average daily rate of gain during the period from weaning to 90 kg live weight was in 1971 569 g for HBL, 631 g for LBL and 598 g for CL. The hams plus loin comprised on average 18 % of the total carcase weight in HBL, 19.5 % in LBL and 18.6 % in CL, while the average area of a cross section of the Musculus longissimus dorsi behind the ribs was 26.3 cm^2 in HBL, 28.7 cm^2 in LBL, and 27.1 cm^2 in CL (*Vangen* 1972).

In material I, there were 152 gilts and 137 castrates. Of these, 112 (66 gilts and 46 castrates) were from HBL, 91 (49 gilts and 42 castrates) from LBL, and 86 (37 gilts and 49 castrates) from CL. Slaughtering took place weekly, the pigs being slaughtered as near to 90 kg live weight as was possible.

Of the 56 boars comprising material II, 24 were from HBL, 17 from LBL and 15 from CL. The boars had served only 4—5 sows and were thus young at slaughter. Average age at slaughter was 9 months, no boar being over 10 months. Serious locomotory problems were rarely seen among the boars.

Of the 51 sows comprising material III, 21 were from HBL, 17 from LBL and 13 from CL. They were slaughtered after having had 4 litters, and were thus seldom over 3 years old. Some had to be slaughtered before they had farrowed 4 litters, mainly because of fertility problems or leg weakness. All sows and boars which were slaughtered during the collection period for breeding animals were subjected to post-mortem examination.

The animals in all materials were slaughtered in the normal way, marked and deboned. The pigs in material I were split lengthwise along the vertebral column. Back length from the medial anterior border of the pubis (pecten ossis pubis) to the cranial aspect of the atlas was measured in cm. One foreleg, 1 side of the lumbar region of the vertebral column and pelvis, and 1 hind leg were examined for lesions in joints and bones. The cartilage and bone tissue was sectioned with a saw or knife in order to disclose hidden lesions. Lesions were judged as previously described (*Grøndalen* 1974 c) according to a scale from 1 (normal) to 5 (severe degree lesion). Sections for histological examination were taken from the costochondral junctions and from the third metacarpal bone of 15 animals in each line from material I. These sections were treated as described in a previous article (*Grøndalen* 1974 a). The fat and ash contents of 20 third metacarpal bones from each line in material I were determined. The bones were scraped clean to the periosteum, broken into pieces and dried for 24 hrs. at 80°C. Thereafter extraction to constant weight with ether in Soxlett's apparatus was carried out (about 5 hrs.). Extracted matter (= weight loss) was expressed as a percentage of the weight of inweighed substance. The bone samples were then powdered in a mechanical mortar and 1 sample was dried for 18 hrs. at 80°C. Dry matter (= weight of dried substance) was expressed as a percentage of

the inweighed fat free substance. The sample was thereafter ashed at 450°C for 18 hrs., and the weight of ash expressed as a percentage of the weight of dry matter*.

In the case of materials II and III, both forelegs, both hindlegs, the pelvis and the lumbar region of the vertebral column were examined macroscopically with regard to joint and bone lesions. They were judged as for material I. Bacteriological examination was carried out on 5 degenerated intervertebral discs derived from material III**.

The shape and size of bones and joints were measured in all materials. Although this and the methods used will be returned to (*Grøndalen* 1974 e), some results will be given at the present time. All individual observations were transferred onto punch cards and statistical calculations carried out according to standard programs of statistical analyses***. The P value for differences between lines in the tables is based on the analyses of variance. The standard deviation is not given, as the P value together with the mean lesion score seems to give sufficient information about the present material. Results were evaluated without knowledge as to which line the animals belonged.

RESULTS

Patho-anatomical findings in the skeleton in all lines comprised osteochondrosis, arthrosis, degenerated intervertebral discs, spondylosis, and epiphyseolysis. The diagnoses osteochondrosis and arthrosis have been defined previously (*Grøndalen* 1974 a, b).

Material I. Slaughter pigs

At slaughter, animals from HBL were on average 177 days old, from LBL 168 days and from CL 175 days. Average daily weight gain during the period from weaning to slaughter was 580 g, 616 g and 586 g for HBL, LBL, and CL respectively.

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* The chemical investigations were carried out at the Department of Biochemistry, Veterinary College of Norway.

** The bacteriological investigations were carried out at the Department of Microbiology and Immunology, Veterinary College of Norway.

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

Gross examination

No significant differences between castrates and gilts within lines as regards the total score of skeletal lesions were demonstrated ($P > 0.05$). There was a statistically significant difference between lines as regard size measured as length of the back, femur, and tibia ($P < 0.01$ for all 3 lines). In HBL, average back length was 93.9 cm, average length of the femur 17.7 cm and average length of the tibia 16.4 cm. Corresponding figures for LBL were 98.9 cm, 18.6 cm and 17.6 cm, and for CL 98.2 cm, 18.6 cm and 17.5 cm. The relationship between these measurements was almost the same in all lines. Thus the pigs seemed generally to be different in size. In the investigated material, there was no essential difference in size as regards LBL and CL pigs.

The only significant difference found between lines as regards joint shape concerned the head of the femur. On subjective judgement, the head of the femur had a more spherical shape in pigs belonging to HBL than in LBL and CL, a consequence of this being that its diameter was markedly less in HBL. The shorter bones in the HBL were also more slender than in the other lines so that the amount of bone tissue seemed to be lesser in this line.

A lumbar vertebrae count was made in 41 animals in all, 16 of these having 7 lumbar vertebrae, and 25 having 6 lumbar vertebrae. Of the 21 animals from HBL, 7 (33.3 %) had 7 lumbar vertebrae, while 4 (36.4 %) of 11 animals from LBL and 5 (55.5 %) of 9 from CL had 7 lumbar vertebrae.

Most of the results of the patho-anatomical investigations of bones and joints in material I are given in Table 1. Statistical calculations concerning differences between 2 and 2 lines have not been carried out. This is the case for all 3 materials. In addition to the results shown in Table 1, the following observations regarding material I may be mentioned:

There was a severe degree arthrosis present in the shoulder joint in 3 animals. Of the 97 animals that had lesions in the elbow joint, 86 were affected in the medial condyle of the humerus. Periostitis of the metaphyseal region at the distal epiphyseal plate of the ulna was present in 4 animals. Severe degeneration of intervertebral discs and anchylosing spondylosis in the lumbar region of the vertebral column was present in 3 animals, 1 from each line, while 10 animals, 2 of which were from HBL, showed a mild

Table 1. Incidence of lesions in the joints and the bones, mean lesion score and significance for line differences in the slaughter pigs (material I).

Diagnosis	High backfat line (HBL) 112 pigs			Low backfat line (LBL) 91 pigs			Control line (CL) 86 pigs			Significance for line differences (P) calculated on lesion score
	incidence		mean lesion score	incidence		mean lesion score	incidence		mean lesion score	
	number	%		number	%		number	%		
osteochondrosis in the joint cartilage of scapula	45	40.2	1.4	37	40.7	1.5	39	45.3	1.5	n.s.*
osteochondrosis and arthrosis in the elbow joint	36	32.1	1.5	33	36.3	1.8	28	32.6	1.8	n.s.
osteochondrosis in the distal epiphyseal plate of ulna	48	42.9	1.8	44	48.4	1.8	42	48.8	1.7	n.s.
arthrosis in the lumbar intervertebral joints	3	2.7	1.0	13	14.3	1.2	18	20.9	1.3	$P < 0.01$
osteochondrosis and arthrosis in the medial condyle of femur	74**	66.0	1.8	76***	83.5	2.4	62**	72.1	2.0	$P < 0.001$
projections in the distal epiphyseal plate and the metaphysis of femur	21	18.8	1.3	41	45.1	1.8	20	23.3	1.4	$P < 0.01$
osteochondrosis and arthrosis in the talus	39	34.8	1.4	36	39.6	1.5	32	37.2	1.5	n.s.
total affected pigs	106	94.6	1.5	90	98.9	1.7	83	96.5	1.6	$P < 0.01$

* n.s.: not significant ($P > 0.05$).
** no pig with arthrosis.
*** two pigs with arthrosis: 2.2 %.

degree of intervertebral disc degeneration, mostly in the lumbosacral joint. Arthrosis of the lumbar intervertebral joints most often involved lumbar vertebrae 3 and 4. One animal from CL showed severe degree arthrosis in the hip joint. Only 2 animals (0.7 %), both from LBL, showed open lesions (arthrosis) of the medial condyle of the femur. Three animals showed moderate degree of osteochondrosis also in the lateral condyle of the femur. Fraying and cracking of the medial meniscus in the femorotibial joint were seen in 3 animals.

Table 2. Incidence of lesions in the joints and the bones, mean lesion score and significance for line differences in the boars (material II).

Diagnosis	High backfat line (HBL) 24 boars			Low backfat line (LBL) 17 boars			Control line (CL) 15 boars			Significance for line differences (P) calculated on lesion score
	incidence		mean lesion score	incidence		mean lesion score	incidence		mean lesion score	
	number	%		number	%		number	%		
arthrosis in the elbow joint	14	58.3	1.8	12	70.6	2.4	7	46.7	1.8	n.s.
arthrosis in the lumbar intervertebral joints	7	29.2	1.4	13	76.5	2.7	6	40.0	1.7	$P < 0.01$
degenerated lumbar intervertebral discs	0	0.0	1.0	3	17.6	1.2	0	0.0	1.0	$P < 0.05$
arthrosis in the hip joint	2	8.3	1.1	7	41.2	1.5	1	13.3	1.1	$P < 0.05$
arthrosis in the femorotibial joint	9	37.5	1.9	6	35.3	1.9	6	40.0	1.7	n.s.
arthrosis in the tarsal joints	10	41.7	1.5	10	58.8	1.8	8	53.3	1.6	n.s.
total affected boars	22	91.7	1.4	17	100.0	1.8	14	93.3	1.4	$P < 0.01$

Histological examination

Evidence of rickets or generalized osteodystrophia fibrosa was not demonstrated on histological examination of sections from material I, neither were there any morphological differences demonstrated between the lines as regards the cancellous bone or cartilage. The pericytic osteolysis and the osteoclastic activity did not generally seem to be of a pathological nature.

Chemical examination

Average results of fat extraction were 24.9 % extracted matter in HBL, 27.5 % in LBL and 26.6 % in CL. Ashing gave in average 62.0 % ash in dry matter in HBL, 60.9 % in LBL and 60.9 % in CL. Differences in fat and ash content were not statistically significant ($P > 0.05$).

Table 3. Incidence of lesions in the joints and the bones, mean lesion score and significance for line differences in the sows (material III).

Diagnosis	High backfat line (HBL) 21 sows			Low backfat line (LBL) 17 sows			Control line (CL) 13 sows			Significance for line differences (P) calculated on lesion score
	incidence		mean lesion score	incidence		mean lesion score	incidence		mean lesion score	
	number	%		number	%		number	%		
arthrosis in the shoulder joint	1	4.8	1.1	6	35.3	1.7	4	30.8	1.5	$P < 0.01$
arthrosis in the elbow joint	5	23.8	1.4	12	70.6	2.1	6	46.2	1.6	n.s.
arthrosis in the lumbar intervertebral joints	9	42.9	1.7	13	76.5	2.5	7	53.8	1.7	$P < 0.05$
degenerated lumbar intervertebral discs	6	28.6	1.4	11	64.7	1.8	10	76.9	2.0	$P < 0.05$
lumbar anchylosing spondylosis	6	28.6	1.3	8	47.1	1.7	4	30.8	1.5	n.s.
arthrosis in the hip joint	4	19.0	1.2	9	52.9	1.8	7	53.8	1.6	$P < 0.05$
epiphyseolysis tuber ischii	2	9.5	1.4	2	11.8	1.5	1	7.7	1.3	n.s.
arthrosis in the femorotibial joint	12	57.1	1.9	14	82.4	2.4	7	53.8	1.8	n.s.
arthrosis in the tarsal joints	9	42.9	1.6	15	88.2	2.7	10	76.9	2.0	$P < 0.01$
total affected sows	16	76.2	1.5	17	100.0	2.1	12	92.3	1.7	$P < 0.01$

Other examinations

Statistically significant differences ($P < 0.05$) between sire groups and litters within all 3 lines as regards various patho-anatomical findings and shape of bones and joints were demonstrated. This will be returned to in a subsequent article.

Material II. Boars

As in the case of slaughter pigs, there were statistically significant differences in bone size between lines ($P < 0.01$). The average length of the femur in cm was 20.3, 22.4 and 21.5 in HBL,

Table 4. Relation between lesions in different parts of the skeleton.

Sites for lesions related	Correlation coefficient calculated on lesion score		
	Mat. I 289 slaughter pigs	Mat. II 56 boars	Mat. III 51 sows
elbow joint — distal epiphyseal plate of ulna	0.02	n.i.*	n.i.
„ „ — tarsal joint	—0.01	0.08	0.25
„ „ — medial condyle of femur	0.09	0.15	0.40***
„ „ — hip joint	n.i.	—0.07	0.17
„ „ — lumbar intervertebral joints	0.09	0.10	0.20
tarsal joint — medial condyle of femur	0.11	—0.36***	0.26
„ „ — hip joint	ni.	0.20	0.29**
„ „ — lumbar intervertebral joints	—0.03	0.28**	0.23
medial condyle of femur — hip joint	n.i.	—0.13	0.04
„ „ „ „ — lumbar intervertebral joints	0.04	—0.11	0.21
hip joint — lumbar intervertebral joints	n.i.	0.24	0.11
lumbar intervertebral discs — lumbar intervertebral joints	n.i.	0.18	—0.06
lumbar vertebral bodies (anchylosing spondylosis) — lumbar intervertebral joints	n.i.	n.i.	—0.01
lumbar vertebral bodies — lumbar intervertebral discs	n.i.	n.i.	0.72***

* n.i. = not investigated.
** statistically significant $P < 0.05$.
*** statistically significant $P < 0.01$.

LBL and CL, respectively. Corresponding figures as regards the tibia, were 19.3, 21.4 and 20.5. One animal showed severe degree arthrosis in the shoulder joint and 1 animal a frayed and cracked medial meniscus in the femorotibial joint. Results of the pathoanatomical examinations of bones and joints in material II are otherwise shown in Table 2.

Material III. Sows

There were statistically significant differences ($P < 0.01$) in bone size between lines also in this material. The average length of the femur in cm in HBL, LBL and CL, respectively, was 21.7, 24.1 and 22.6, while the corresponding figures for the tibia were 20.7, 23.0 and 21.8. The heads of the femur were in the LBL on average 11.6 mm lower than the trochanter major, measured along the long axis of the bone, while the corresponding figures

for the HBL and the CL were 6.9 mm and 8.2 mm. One animal (HBL) had a distorted vertebra with unilateral contact with the ilium in the lumbosacral region, while 1 animal (HBL) showed marked unilateral osteophyte formation and production of fibrous tissue in the sacroiliac joint. Repaired separation of the tuber ischii was seen in 5 animals, the separation being bilateral in 3 of these. Bacteriological examination of 5 degenerated intervertebral discs gave either negative results or non-specific mixed growth. Results of the patho-anatomical examinations of bones and joints carried out on material III are shown in Table 3.

Relationship between lesions in various parts of the skeleton

The correlation coefficients for lesion score as regards the various joints and skeletal parts were calculated. These results, as far as the most usual lesion sites are concerned, are shown in Table 4.

DISCUSSION AND CONCLUSIONS

As far as possible, the pigs in materials I, II and III were subjected to the same conditions of housing and feeding. They were derived from the same 1964 population, which has since then been selected on the basis of backfat thickness and rate of weight gain. Any difference between the lines should therefore be primarily of a genetic nature. The amount of muscle in the body has increased in LBL and decreased in HBL in comparison to CL, both calculated as % of body weight and amount formed each day. The pigs in the HBL seemed to have markedly less amount of bone tissue than the other pigs at 100 kg live weight. The speeds at which muscle and bone are formed seem therefore roughly to follow each other. This agrees with the findings of *Zimmermann* (1959—60).

Increase in size was fairly proportional so that the increase in length of the femur and tibia was comparatively as great as the increase in back length. *Immisch* (1966) found the same during investigations concerning pigs of differing back length from the same breed. *Schilling* (1963) and *Grøndalen* (1974 c) have demonstrated differences of proportion in the skeletons of animals with different back lengths and from different breeds, and also differences in bone and joint shape. In the present material statistically significant differences between lines with respect to

bone and joint shape were not demonstrated except in the case of the hip joint where the head of the femur was rounder, smaller, and more normal positioned in HBL than in the other lines. Thus as regards the development and shape of the skeleton, bone size was the characteristic influenced by selection according to the criteria mentioned. When compared with CL, it was the HBL animals which had changed most.

Routine histological examination did not reveal any morphological differences between lines in the structure of cancellous bone or cartilage. Neither were there any statistically significant differences between lines in fat or ash content of the third metacarpal bone. There was, however, a strong tendency to higher ash content in HBL. This is contrary to the results obtained by *Günther & Rosin* (1970) from an investigation concerning complete skeletons from modern and older type pigs. The same authors (1970/71) demonstrated that mineralization was very variable within the skeleton and that there was very little difference in mineralization in modern and older type pigs, as regards the distal parts of the extremities. The difference was large as regards the scapula and barrel (ribcage). It is therefore possible that one of the reasons why results in the present study seem to be qualitatively different is that only the third metacarpal bone was examined. Even though the ash percentage seemed to be higher in HBL, it is highly probable that total mineral deposition in bones was quantitatively greater in the other lines, as the HBL animals had smaller bones at the same live weight. Quantitatively, therefore, the results obtained by *Günther & Rosin* (1970) and those presented in this article are in agreement. *Günther & Rosin* (1970/71) concluded inter al. that the low matrix content of bone in the modern type of pigs is a sign of intense growth in the bone tissue. The LBL pigs undoubtedly showed a more intense growth of bone tissue than the HBL animals, but nevertheless the amount of fat free organic tissue (matrix) laid down in bone was relatively greater than the amount of mineral substance. Thus the results do not agree as regards the matrix content of bone. Neither does a general consideration of bone physiology seem to point to a low matrix content being indicative of intense growth in bone.

In all 3 lines there was a high total incidence of skeletal lesions. The lesions mainly consisted of osteochondrosis and arthrosis as regards the slaughter animals, and arthrosis, spon-

dylosis, degeneration of intervertebral discs and epiphyseal separation as regards the breeding animals, these findings thus being the same as previously described (*Grøndalen* 1974 a, b). The lesions also had the same predeliction sites as previously described.

There was no statistically significant difference in the sum of lesions between castrates and gilts. Materials II and III comprised animals of such different ages that it is difficult to compare boars and sows. Nevertheless, some conclusions can be drawn as regards lesions which are usually progressive. It would be expected, in the absense of sex differences, that such lesions shown by the boars, these being much younger than the sows at slaughter, would by less severe and less frequent.

The extent of foreleg lesions in materials I, II and III did not essentially deviate from findings in previous investigations (*Grøndalen* 1974 a, b). There were no lesions of any great severity in the tarsal joint of the slaughter pigs and boars. However, in the sows, joint changes, at times great, and osteophyte formation were present mediodistally in the tarsus. There was also a statistically significant difference ($P < 0.01$) between lines in tarsal lesions in the sow material. Several authors have asserted that tarsal changes are significant in the leg weakness complex (*Sabec et al.* 1961, *Schilling* 1963, *Bollwahn et al.* 1970) and connected the changes with the presence of a long back. The investigations presented here seem to confirm the supposition that there is a connection between tarsal changes and back length or size of the animal. They do not, however, indicate whether or not tarsal changes have any significance for mobility.

As regards the severity of lesions in the femorotibial joint in material I there was a statistically significant difference ($P < 0.001$) between lines. Only 2 animals in material I showed an open lesion (arthrosis) of the medial condyle of the femur. Both were from LBL, giving an incidence of arthrosis in the medial condyle of the femur in LBL of 2.2 %. An incidence of arthrosis of the medial condyle of the femur at 100 kg live weight of up to 16 % has been demonstrated in previously investigated materials (*Grøndalen* 1974 a). The low incidence in the present material may possibly be due to the animals having been slaughtered at 90 kg live weight. There was no essential difference in femorotibial joint lesions between lines in material II and III. Selection of breeding animals based on criteria

other than those mentioned, was not carried out, so the explanation cannot be found there. The lesions on the medial condyle of the femur in material I were, apart from the 2 mentioned cases, of a degree that have previously been considered as capable of healing without affecting the joint cavity (*Grøndalen* 1974 b). This possibility of repair is probably a major reason why no differences are present as regards the breeding animals. The reason why there was a higher incidence of lesions in the medial condyle of the femur in the slaughter pig material (material I) than in the others is that while both arthrosis and osteochondrosis were considered in the former, only arthrosis was considered in the latter. The use of these diagnoses has been explained previously (*Grøndalen* 1974 a, b).

The cases of tuber ischial separation were spread over all lines. The lesions had undergone repair. Healed separation of the tuber ischii was also demonstrated in a previous material as a random finding (*Grøndalen* 1974 b). It therefore seems clear that these lesions do not necessarily lead to such serious locomotory problems that the animal must be slaughtered, though it is reasonable to suppose that the animals had great locomotory difficulties when the injury occurred. According to *Pettersson & Reiland* (1967) this injury is considered to be most common at first parturition and is a not insignificant cause of emergency slaughter of sows.

Arthrosis of the hip joint occurred in only 1 animal in material I. The incidence of this lesion increased with increasing age such that material III was affected most. There was also a statistically significant difference ($P < 0.05$) between lines both in material II and material III, HBL being the least affected and LBL the most affected. *Kurzweg & Winkler* (1972) also reported a high incidence of severe arthrosis in the hip joint in long modern pigs, and related this to changes in the shape of the acetabulum and head/neck of the femur. The present study partly supports this, as the shape of the head of the femur was the only statistically significant recorded anatomical difference between lines. The lower positioned head of the femur in the LBL in material III indicates that premature closure of the epiphyseal plate of the head of the femur (*Grøndalen* 1974 b) might be more common in the LBL than in the HBL.

As regards material I (slaughter pigs) and material II (boars) there were few animals with degenerated intervertebral discs

and anchylosing spondylosis. In material III (sows), however, this was very common in all 3 lines, although there was a statistically significant ($P < 0.05$) lower degree of degenerated intervertebral discs in HBL.

A difference in the incidence and degree of severity of degenerated intervertebral discs and anchylosing spondylosis between sows and boars has previously been pointed out, and a difference in loading factors was suggested as an aetiological factor, even though a study of the literature had pointed to an infectious cause (*Grabell et al.* 1962, *Spiegel et al.* 1972). Differences in load can occur within sexes, but special emphasis was put on differences between sexes (*Grøndalen* 1974 b). The animals in materials II and III were, as mentioned previously, not of the same age, and therefore not especially well suited for comparison. The fact that the sows in HBL, which were shorter and smaller than the others, showed a statistically significant lower degree of degeneration of the intervertebral discs supports the supposition that loading factors in the back play a part in the aetiology of intervertebral disc degeneration. Furthermore, bacteriological examination of 5 degenerated intervertebral discs was negative with regard to Erysipelas bacteria. The correlation coefficient between intervertebral disc degeneration and anchylosing spondylosis was 0.72. A relationship between intervertebral disc degeneration and anchylosing spondylosis has also previously been demonstrated in pigs (*Grøndalen* 1974 b). These conditions in the dog are discussed by *Hansen* (1952).

Arthrosis of the lumbar intervertebral joints was present in all 3 materials. This was the only joint region showing statistically significant differences in lesions between the lines in all 3 materials (material I: $P < 0.001$, material II: $P < 0.01$ and material III: $P < 0.05$). The animals in HBL were the least affected. Only 2.7 % of the HBL animals in material I (slaughter pigs) showed arthrosis in the lumbar intervertebral joints. In a previously investigated Yorkshire (Large White) material, 4.4 % of the animals had arthrosis in the lumbar intervertebral joints at 100 kg live weight (*Grøndalen* 1974 c). The HBL animals were thus somewhat similar to the Yorkshire material. Incidence in CL and LBL was 20.9 % and 14.3 % respectively. This is a lower incidence than that shown in pigs at 100 kg live weight from the Veterinary College of Norway's research station (*Grøndalen* 1974 a), but higher than shown by the in-

vestigated Yorkshire pigs. It would be expected that incidence in CL would be somewhere between the incidence in HBL and LBL. This was generally the case. In this connection it is interesting to note that animals from CL in material I were not half way between HBL and LBL in size, but were almost as long in the back and almost the same size as LBL. As regards materials II (boars) and III (sows), the incidence of arthrosis in the lumbar intervertebral joints in LBL was very high, being 76.5 % in both materials. The severity of lesions was statistically significantly lower in HBL, although even here incidence was as high as 29.2 % in material II and 42.9 % in material III. Incidence in CL lay between HBL and LBL. In contrast to material I, the long bones of the animals in CL in materials II and III were about half way between HBL and LBL in size. Sows and boars showed a fairly similar incidence and degree of arthrosis in the lumbar intervertebral joints even though the boars were considerably younger at slaughter. This strengthens the previous supposition (*Grøndalen* 1974 b) that boars are more easily subject to the development of arthrosis in the lumbar intervertebral joints than sows.

The results presented in Table 4 show that generally there was no strong relationship between the severity of lesions in different joints. Correlation coefficients were sometimes very low, sometimes negative. With a typical systemic disease, a stronger relationship would have been expected. According to *Kurzweg & Winkler* nothing which suggests a generalized osteopathy in pigs with joint lesions has been observed. Neither has this been demonstrated during investigation of the 3 lines of Landrace pigs, although the generally more marked tendency to lesions in LBL should be noted.

There is a possibility that the rapidly growing bone and cartilage tissue in animals in LBL was weaker than the slower growing tissue in HBL, even though no morphological differences could be demonstrated by light microscopy. In this connection, *Zimmermann* has demonstrated that development of the fineness and firm consistency of bone tissue cannot be hastened, but comes more with age than with growth rate. There is, thus, a possibility for general overloading of the cartilage and bone tissue. However, *Grøndalen* (1974 d) has shown that rapid weight gain induced by a high level of feeding, does not necessarily give a higher incidence and degree of joint lesions. Local overloading due to poor stability could on the other hand be a possible explanation.

Joint stability can be said to depend on musculature, ligaments and joint shape. A connection between joint shape and joint lesions has previously been demonstrated (*Grøndalen* 1972, 1974 c). However, in the present study, the only statistically significant difference in the shape of bones and joints or body proportions between lines, concerned the head of the femur, so that the cause of the difference in the incidence and degree of lesions cannot be found here.

According to *Kurzweg & Winkler* the occurrence of degenerative processes in the musculature of modern pigs is very common. *Thurley* (1967) also considers that there is a strong connection between musculature on the one hand and leg weakness and joint lesions on the other. Investigations concerning musculature have not been carried out in the animals from the 3 Landrace lines, but the possibility exists that differences between the lines as regards lesions may be primarily due to differences in muscle strength or ability to use the muscles. *Kurzweg & Winkler* also refer to investigations which suggest that long pigs have to bend the back considerably in a dorsal direction, placing their feet well under the body, in order to hold the back up. It does not seem that they examined joints in the vertebral column, but nevertheless the investigations referred to suggest that a long back becomes weak and that total back length may play a significant part in the development of joint lesions, even though the growth of the skeleton is otherwise proportional.

Although the causes cannot be considered as being clarified, the investigations concerning the 3 lines of pigs clearly show that, generally, the large, rapidly growing animals with thin backfat are more subject to the development of skeletal lesions than the small, slowly growing animals with thick backfat, this being particularly true as regards the lumbar region of the vertebral column.

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SAMMENDRAG

Osteochondrose og arthrose hos gris. V. En sammenligning av forekomst i tre forskjellige linjer av norsk landsvin.

Det er undersøkt 289 slaktegriser, 56 avlsråner og 51 avlspurker fra et seleksjonseksperiment. Eksperimentet startet i 1964. De undersøkte dyra tilhørte 4.—6. generasjon. En linje er blitt selektert for tynt ryggspekk og hurtig tilvekst (LBL) og en for tykt ryggspekk og sen tilvekst (HBL). Dessuten ble en kontrollinje (CL) som ikke selekteres etablert i 1967. Det er tilstrebet å holde likt miljø og lik foring for linjene. Forskjellene mellom linjene skulle derfor primært være av genetisk natur. Dyra i HBL hadde et statistisk sikkert ($P < 0.01$) mindre skjelett enn CL og LBL målt som lengde av knokler og columna. Mellom LBL og CL var forskjellen liten. Det har ikke skjedd noen vesentlig proporsjonsendring i skjelettet. De pato-anatomiske funn i skjelettet i alle linjer var osteochondrose og arthrose, degenererte intervertebralskiver, spondylose og epifyseløsninger. Det var

mindre frekvens og statistisk sikkert ($P < 0,01$) mindre grad av sum lesjoner i skjelettet i HBL både for slaktegriser, råner og purker. Det faktum at lumbaldelen av ryggen gjennomgående viste de største forskjeller i grad og frekvens av lesjoner mellom linjene, tyder på at ryggen blir den svakeste skjelettdel hos griser med hurtigvoksende skjelett.

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