Pig Improvement with Special Reference to the Number of Vertebrae —Variation of the Number of Vertebrae in Pigs—

S. TOHARA

Chief, 2nd Laboratory of Animal Physiology, Department of Animal Physiology, National Institute of Animal Industry

Introduction

The muscles of pigs are attached to the bones, and as an organ of movement, cooperate with them. So the bones have a close bearing upon carcass yield. For increasing production of pork the bones have to be improved. In short, it is necessary to elongate the pig body.

It has been some time that the number of vertebrae, which has great individual variation, was presumed to control the length of body. The authors established the technique of taking X-ray photos of young pigs to know the number of vertebrae, which revealed the status of individual variation. Some feeding experiments were conducted to clarify the relationship between the number of vertebrae and the carcass yield. Then the mode of inheritance of the number of vertebrae was studied, which concluded this series of research.

The techniques of the X-ray Photography

Photo 1 shows the portable X-ray apparatus which can be operated in any countryside where there is an electric source of 100V to know the number of vertebrae of a young pig. This enables us to investigate the animal without slaughtering. Either direct or indirect photography will do. It is possible to take photos of side view or front view.

For anesthesia of pigs, which is necessary for X-ray photography, the inhalation of ether seems to be simple and fitting, since it proved to leave no bad after-effect upon growth of pigs.

We compared the fertility of the pigs used in the experiments with the control pigs which did not undergo X-ray photography. No difference was detected, which eliminated any damage of radiation.

It is necessary to read clearly the border between vertebrae when counting the bones in the film. Photo 2 is the X-ray photo view of a young pig. To distinguish the border between the cervical vertebrae and

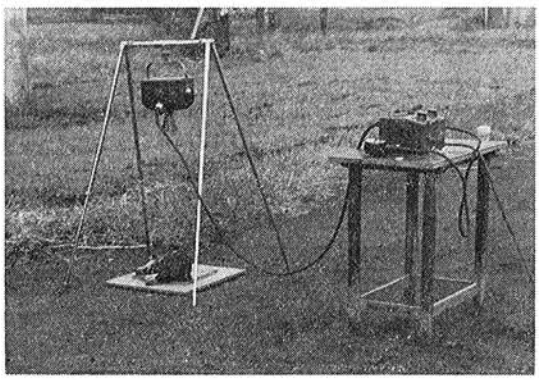

Fig. 1 X-ray photography under way in field

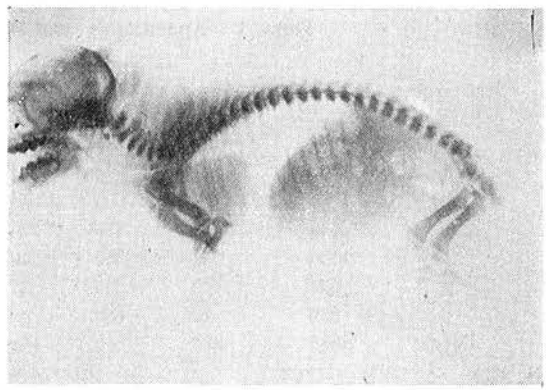

Fig. 2 Side view X-ray photograph of a young pig

the thoracic vertebrae, the shape of spinous process and the attachment of a rib are the markers. That between the lumbar and the sacral will be known by the width of the cartilage bone connecting the two and a shadow at the joint of the cervical vertebrae and the thoracic vertebrae can be known by the presence of a rib, and the difference in shape will tell the lumbar from the sacral.

Variation in the number of vertebrae

The pig vertebrae consist of cervical, lumbar, sacral and coccygeal, of which the most closely connected with the body length are thoracic and lumbar vertebrae. The number of cervical vertebrae is almost always 7, while variation is wide in the thoracic and the lumbar vertebrae. So far as we have investigated, according to the number of thoracic, they can be grouped into 6, i. e. 13-18, while from the number of lumber vertebrae, they will be classified into 3, i.e. 5, 6, and 7 lumber vertebrae. The possible combinations of these make 6 types, i. e. of 19-25 thoracic plus lumbar vertebrae.

Middle Yorkshires are the breed well acclimatized in Japan.

They can be grouped into 5 according to the number of thoracic, 14-18, of which 14, 15 and 16 comprise the majority while 17 and 18 are very scarce. From the number of lumbar vertebrae, they are classified into 3, i. e. 5-7, of which majority are of 6 or 7 bones, whereas those possessing 5 bones are very few.

From the sum of the thoracic and lumbar, they can be grouped into 6, i. e. 20-25, of 21 type is leading 22-type, followed by 20-type, while 23-24 or 25-type seldom appear (Table 1). Presumably the majority of Middle Yorkshires kept in Japan are 21- or 22-type.

The number of Berkshires in Japan is very

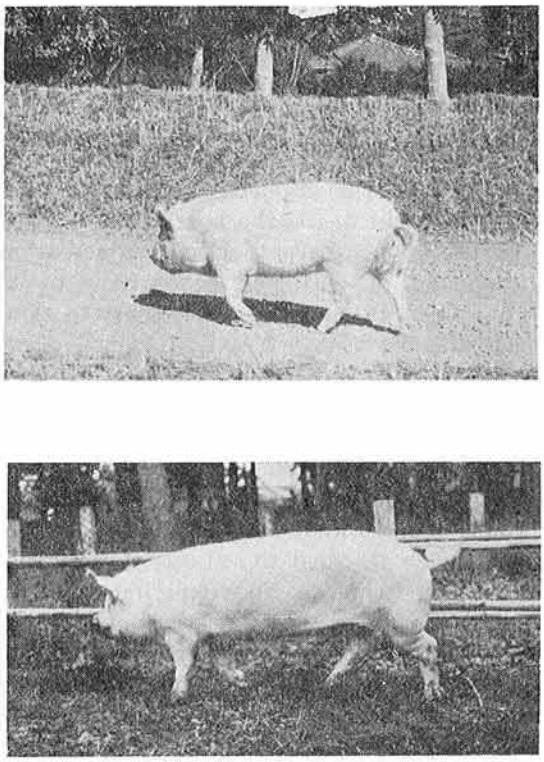

Fig. 3 Middle Yorkshires of 21 (Top) Thoracic + lumbar Type and of 23 Type (Bottom)

Table 1. Appearance rate of vertebral number* in different herds

Research area	Number of pig	Vertebral No.						Mean value	Standard deviation
		20	21	22	23	24	25		
A	1307	149	790	346	16	6		21.19	0.65
C	1057	61	805	185	3	3		21.13	0.52
G	545	36	359	149	1			21.21	0.55
I	1136	31	680	403	22			21.18	0.57
K	634	9	323	278	13	6	5	21.53	0.69
T	959	42	788	129				21.09	0.41
Total	5638	328	3745	1490	55	15	5	21.24	0.58

* Number of thoracic and lumbar vertebrae

small compared with Middle Yorkshires. But they are expected to play an important role in the production of crosses in the future. From the number of thoracic vertebrae, Berkshires are grouped into 3, i.e. 14-16, among which 14-type is by far the most numerous. From lumbar vertebrae, they can be classified into 3, i. e. 5-7 types, of which 6-type was most frequent, and the sum of thoracic-lumbar fell into three types, i. e. 20-22. The majority belong to 21- or 22-type.

The characteristics of Landrace are the long mid-body and the rapid growth. The number of thoracic vertebrae is 14-16, of which 16 is by far the most numerous, while that of lumbar vertebrae is 5-7, of which 6 is most frequent. From the sum of thoracic-lumbar, they can be grouped into 21-23, of which 22-type is decidedly large in number. Among the Landrace themselves, there is some variation in the number of thoracic and lumbar vertebrae according to their habitat. When their means are compared, Swedish Landrace tops, which is followed by English and American breeds.

Besides Landrace, small numbers of Hampshires, Minnesota No. 2, Durocs, etc. are kept in Japan. Adding the Chinese breed and wild boar to these, comparisons were made of the means of the number of their thoracic and lumbar vertebrae, which revealed that Landrace had the largest number, followed by Hampshire, Middle Yorkshire, Minnesota No. 2, Berkshire, Duroc, Chinese breed, and wild boar which had the smallest number. This fact shows that the improvement of pigs is unintentionally proceeding in the direction of the animal having a larger number of vertebrae since a wild boar, the prototype of pigs, has such a small number of the bones, the Chinese breed, which is yet retarded in improvement, is second to it, and, advancing to the more improved breeds, Landrace has the largest number of vertebrae.

As for the number of vertebrae in the carcasses, investigations revealed that a cross had the number of vertebrae in the neighbourhood of the mean between those of the parents. The knowledge of the number of vertebrae is useful in the production of a cross.

Table 2. Frequency of variant type of the vertebral number in some breeds.

Breed	No. of cases	Vertebral No.						
		19	20	21	22	23	24	Mean
Wild pig*	19	19 (100)						19.0
Chinese	106	106 (100)						19.0
Duroc	124		59 (47.6)	60 (48.4)	5 (4.0)			20.6
Berkshire	122		45 (36.9)	76 (62.3)	1 (0.8)			20.6
Minnesota No. 2	126		27 (21.4)	86 (68.3)	13 (10.3)			20.9
Hampshire	124		2 (1.6)	90 (72.6)	31 (25.0)	1 (0.8)		21.3
Landrace	395			44 (11.1)	321 (81.3)	30 (7.6)		22.0
Middle Yorkshire	514		60 (11.7)	377 (73.3)	72 (14.0)	4 (0.8)	1 (0.2)	21.0
Total	1530	125 (8.2)	193 (12.6)	733 (47.9)	443 (28.9)	35 (2.3)	1 (0.1)	21.0

* Sus scrofa leucomystac Temminck

( ) % of the type in all cases

Relationship between the number of vertebrae and pork yield

It has been widely believed that the longer the body length the larger the meat yield. Regrettably this has not been proved by experimental results.

Among Middle Yorkshires kept in Japan, the frequency of occurrence of 21-type is the highest, followed by 22-type and 20-type in this order. The author considered that the investigation of meat yield of the respective types might lead to furnishing a criterion for the selection of superior types. And this would be a topical suggestion to the pig industry. Feeding experiments, therefore, were conducted after the method of tests of meat production performance. The results disclosed that there was little difference in growth rate (number of days to 90 kg of live weight) and feed requirement. In body length, length of back loin I and II, 22-type is longer than 21-type, investigations were made on the relationship between the number of vertebrae and the lengths of the parts of the body, which showed that the more the number of vertebrae, the longer were the carcass length and lengths of back loin I and II. Further the comparison was made according to breed on the relationship between the number of vertebrae and body length. The result is presented in Table 3, in which the larger the number of the bones, the longer was the body length.

The primary aim of trying to have an increased number of vertebrae was to seek a longer body length. So the size of individual bone counts. In other words, however larger the number of vertebrae, if the individual bones were small, it would not fulfill the original purpose. So investigations were made to determine the relationship between the number of vertebrae and the length of individual bones. The results showed that, though it was detected the tendency for a shorter individual bone in the animals with more number of vertebrae, but the difference was not so marked as to influence the body length. It would be safe, therefore, to say that to get the pigs with more number of vertebrae is necessary for lengthening the mid-body of a pig.

Further comparisons were made on the yields of shoulder, loin, bacon and ham of each type. Those possessing larger numbers of vertebrae recorded larger yields of loin and bacon, but smaller yield of ham. In other words, pigs with more vertebrae seemed disadvantageous in ham production. But when meat/fat ratio was compared in dressed carcass and quarters, the animals with a larger number of vertebrae had more meat and less fat.

Thus it can be interpreted that the smaller ham yield came from the smaller amount of fat, which is rather desirable

Table 3. Relation between vertebral No. and carcass mesurment

Vertebral No.	No. of cases	Carcass mesurement				
		Carcass weight (kg)	Carcass length (cm)	Length of B. L. I* (cm)	Length of B. L. II* (cm)	Carcass width (cm)
20	8	61.16	88.25	73.90	62.38	33.35
21	55	61.86	89.83	75.53	65.20	33.66
22	50	61.40	913.8	76.79	67.41	33.78
23	4	62.73	95.68	78.78	68.75	35.08
24	3	61.33	96.77	82.43	73.10	32.33
Coefficient of correlation			r=0.497**	r=0.478**	r=0.707**	r=0.05

* I. The length from cranial end of pubis to cranial end of first thoracic.
II. The length from cawdal end of last lumbar to cranial end of first thoracic.

** Significant ($P<0.01$)

from the viewpoint of carcass quality. This tendency is also true with Berkshires and Landraces.

Summarizing, a pig with a larger number of vertebrae has a longer carcass and less fat. To meet the current demands of the market for a carcass with more meat and less fat, it would be desirable to have a pig with longer body, i.e. with larger number of vertebrae, and to slaughter it early enough before it gets too much fat.

However, a larger number of vertebrae is not the over-all index of a better pig. Excess often give birth to a new weakness. So we had better to seek a proper limit. Here is the author's proposal as indices for selection. For Middle Yorkshires, cull 20-Type and 21-Type, and increase 22-Type and 23-Type. For Berkshires, cull 20-Type, and increase 21- and 22-Types. For Landrace, cull 21-Type, and increase 23-Type. All these will be in the direction of longer body length.

In Japan, in Middle Yorkshires, 24-Type and even 25-Type sometimes make appearance. However, they lack sturdiness. Since larger the number of vertebrae, the longer is the pig body, selection must take into account eliminating the possible weaknesses such as mentioned above. Efforts should be made in the direction of the production of breeders in the future.

Inheritance of the number of vertebrae

It has been made clear that there is variation in the number of vertebrae in pigs, and that they control the lengthening of the mid-body of the animals. Naturally expectation arises for the application of this to the early determination of breeders, if the mode of inheritance is to be clarified. At present, since the number of vertebrae is not known, the longer mid-body is used as an index for selection. The author made investigations on the number of vertebrae of the litters per sire, and found that there was considerable variation in the number according to the strain of the sire, and that the number had close bearing upon the body length of the pigs.

On the other hand, investigations were made on the number of vertebrae of the offsprings of the parents whose vertebrae had already been counted. The results disclosed that variations of the number of the bones appeared even among the pigs produced from the parents having the same number of vertebrae, and that, the larger the number of the bones of the parents, the larger was the mean number of the litter (Table 4).

Thus the possibility of the genetic improvement of the number of vertebrae has been made clear. Our studies have proceeded to the estimation of heritability of the number of thoracic vertebrae, lumbar vertebrae, and the sum of these, to know the quantative bearing of genetic factors. The results revealed that these three hold rather

Table 4. Relation of vertebral no. between parent and child pig*

Vertebral no. of boar and sow	No. of litter	No. of piglet	Vertebral No.				Mean of vertebral no.
			20	21	22	23	
21×21	16	150	8 (5.33)	112 (74.67)	29 (19.33)	1 (0.67)	21.15
21×22	13	139	2 (1.44)	83 (59.71)	54 (38.85)		21.37
22×22	14	160	1 (0.62)	62 (38.75)	87 (54.38)	10 (6.25)	21.66
Total	43	449	11 (2.45)	257 (57.24)	170 (37.86)	11 (2.45)	21.03

* These data were obtained from I and C area.
( ) % of the type in all the cases.

high heritability, which fact ascertained that the individual selection is effective.

In retrospect, the historical investigation of the change in the number of vertebrae since the very outset of the X-ray studies of the number of vertebrae was conducted. The result told us that in the area where the selection of breeder pigs had already been well advanced, the number of vertebrae increased rapidly, whereas in the area where the selection was all but neglected, the number had scarcely changed. This proves the possibility of individual selection. For example, a pig with a smaller number of vertebrae, and consequently, a shorter body, if crossed with a breeder having a large number of vertebrae, can have a litter whose vertebrae numbers are larger.

Conclusion

The three pillars for the improvement of the pig are body type, early maturity and fecundity. The factor most important in body type is the body length, which has close relationship with the number of vertebrae. A series of investigations made by us brought about a method of X-ray photography applied to the young pigs, which, in turn, furnished a technique for the selection of breeder pigs for the improvement of pig production. Using this technique, selections can be made towards the animal with larger numbers of vertebrae, which will mean an efficient production of pigs of longer body length, and subsequently, of larger meat yield. This will be an efficient way to the improvement of pork pigs. Based upon this technique, future studies are hoped to proceed to the improvement of other important characters one by one, so that the period needed for breeding might be shortened. However, for the practical application of this to the improvement of pork pig, early estabilishment of collective breeding system is desired.

References

1) Tohara, S. Miyakawa, A., Wagai, B., Toriya, Y. and et al: Studies on the' Variation in the Number of Vertebrae of the Swine.
   I. On the Observation of Thoracic and Lumbar Vertebrae with X-ray Photograph. Bull. Nat. Inst. Agric. Sci. Series G, No. 20, 237 (1961)
   II. Variation of Number of Vertebrae According to Breeds. Bull. Nat. Inst. Animal Industry. No. 1, 149 (1963)
   III. Relationship of the Carcass Length with the Number of Vertebrae and Vertebral Length. Bull. Nat. Inst. Animal Industry. No. 2, 1 (1963)
   IV. On the Number of Vertebrae in Middle Yorkshire. Bull. Nat. Inst. Animal Industry. No. 8, 71 (1965)
   V. The Feeding Experiment with Swine of Different Vertebral Nnmbers. Bull. Nat. Inst. Animal Industry. No. 8, 71 (1965)
   VI. Genetic Aspects. Bull. Nat. Inst. Animal Industry. No. 9, 9 (1965)
2) King, J. W. B. and Roberts, R. C.: Carcass length in the bacon pig. Its association with vertebrae numbers and prediction from radiographs of the young pig. Animal Prod. **2, 1,** 59 (1960)
3) Hofmann, F. und Ritter, E.: Untersuchngen über die Röntgenologische Rippenzahlung beim Schwein. Arch. Tierz. **3,** 465 (1960)
4) Kliesch, J., Silber, E. und Horst, P.: Weiterer Beitrag zur Frag der Bedeutung der Körperlänge beim Schwein. Züchtungskunde **32, 6,** 263 (1960)
5. Fredeen, H. T. and Newman, J. A.: Rib and vertebral numbers in Swine.
   I. Variation observed in a large population. Animal Prod. **3,** 232 (1962)
   II. Genetic Aspect, Animal Prod. **3,** 240(1962)