Ann. Génét. Sél. anim., 1973, **5** (3), 381-388.

FIELD TESTING OF YOUNG BREEDING PIGS (1)

I. — DESCRIPTION OF THE CONSTRUCTION OF A PERFORMANCE INDEX

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SUMMARY

In order to construct a performance index, that could be used in field testing of young breeding pigs, samples of gilts and of boars from the *Dutch Landrace* breed and the *Dutch Yorkshire* breed were measured 3 or 2 times. The sample sizes varied from 150 to 286.

The index chosen was a linear combination of 2 scores : a score for weight and a score for backfat thickness.

The score for weight was based on the « average » regression of weight on age within animals and the score for backfat thickness on the « average » regression of backfat thickness on weight within animals.

The index distribution was scaled in such a way that the index values could vary between 0 (bad) and 20 (very good).

For practical use the index values were tabulated. For each age class the corresponding index value can be read from these tables for each combination of weight and backfat thickness. The repeatability of the index was in the order of .85, so it was concluded that for farm testing one measurement would suffice.

INTRODUCTION

Farm testing of young breeding gilts of 5 1/2-8-months old started in the Netherlands at the end of 1968 in the province of Limburg. During the last years this system became increasingly popular and at the moment about 10 000 young animals have been tested. The method performed has been the usual one, weighing the animals and measuring their backfat thickness by means of ultrasonics.

In order to rank the animals the weight was corrected for age ; backfat thickness was corrected for weight. The corrected values were transformed to scores and a linear combination of both scores gave the final index.

(1) Publication no. A 271 of the *Research Institute for Animal Husbandry « Schoonoord »*.

In practice it turned out that the older animals — and consequently the heavier animals — usually got a higher index than the younger ones. A preliminary investigation showed this was caused by an inaccurate correction of weight for age, this correction having been obtained from the regression coefficient of weight on age, based on individual observations, with one observation per animal.

It was assumed that the regression of weight on age *within* animals could be a better basis for correction. To estimate this regression coefficient a special measuring programme was performed, in which a sample of animals was measured more than once.

MATERIAL

A sample of young gilts and boars from two breeds (*Dutch Landrace* = DL and *Dutch Yorkshire* = DY), spread over many farms, was taken. The gilts were measured three times with a 30-day interval between each measurment, the boars were measured twice, also with a 30-day interval. The average backfat thickness of four measuring point was used. The four measuring points were obtained by the following procedure. The posterior edge of the cartilage of the scapulum and the posterior edge of the last rib were palpated on the right side of the animal. Through each of these two points a line was drawn perpendicular to the midline of the back. The distance between the two intersection points with the mildine of the back was divided into 3 equal parts and was extended in posterior direction by the lenght of such a « third » part. Then the most anterior point (on the shoulder) was omitted. The backfat thickness was measured five cm lateral to the four remaining points. The numbers of animals and the means of the traits for each of the 3 or 2 measurements are given in table 1.

TABLE I

Means of traits measured

	Number of animals	1st measurement			2nd measurement			3rd measurement		
		Age in days	Weight in kg	Backfat thickness in mm	Age in days	Weight in kg	Backfat thickness in mm	Age in days	Weight in kg	Backfat thickness in mm
DL gilts	286	177.8	83.3	12.7	209.8	101.5	15.0	238.1	116.8	17.4
DY gilts	276	183.4	84.5	11.6	213.8	101.8	13.2	243.5	116.9	14.7
DL boars	150	175.9	86.0	13.6	205.2	106.9	15.7	—	—	—
DY boars	220	169.5	83.2	11.1	199.7	104.5	12.9	—	—	—

The table shows differences in means between sexes and also between breeds. At about the same weight the DY-animals have less backfat than DL-animals. This difference is not reflected in a difference of fat percentage, when carcasses of animals of both breeds are dissected. The reason for this discrepancy is a difference in the distribution of the fat layer between the two breeds. DY has more fat at the shoulder and less at the loin than DL. The fat thickness at the shoulder, measured by means of ultrasonics, however, is not very accurate and is therefore not included in the average ultrasonic backfat thickness.

REGRESSION BETWEEN AND WITHIN ANIMALS

The linear regression of weight on age, and of backfat thickness on weight was estimated *between* as well as *within* animals. Also the total regression was estimated. The *between* animals regression is the regression based on animal means. The *within* animals regression is based on the sum of products and sum of squares, estimated within each animal and pooled over animals.

The results are shown in table 2.

TABLE 2

Coefficients of regression of weight on age and of backfat thickness on weight
(the number of animals is given in table 1)

	Regression of weight in kg on age (in days)			Regression of backfat thickness (in mm) on weight (in kg)		
	between animals	within animals	total	between animals	within animals	total
DL gilts	.354	.555	.515	.135	.139	.137
DY gilts	.192	.537	.453	.158	.095	.120
DL boars	.418	.716	.640	.129	.105	.118
DY boars	.853	.700	.734	.104	.086	.098

The table clearly shows the difference between the two kinds of regression coefficient : *between* animals versus *within* animals, especially for the regression of weight on age. In the latter case the regression between animals is lower than the regression within animals, except for DY-boars.

There is no doubt that the regression coefficient of weight on age *within* animals is reflecting the real growth rate in that particular age range much better than the regression *between* animals.

The regression between animals will be affected by any preselection among the animals, and also by a less representative choice of the sample. The differences between the various « between animals regressions » of table 2 are not in accordance with the growth data of these breeds and sexes, shown in progeny testing stations.

Restricting ourselves to the regression *within* animals, then we see a clear sex difference: the regression of weight on age in boars is higher than in gilts. This is in accordance with the higher growth rate of boars. Within sexes there are no breed differences.

For the regression of backfat thickness on weight the differences between the two types of regression coefficients (between versus within animals) are not so striking as for the regression of weight on age. The regression between animals is higher than the regression within animals, except for DL-gilts.

With regard to the regression within animals there are sex as well as breed differences. Boars have a lower regression then gilts and DY-animals have a lower regression than DL-animals.

CONSTRUCTION OF SCORES FOR WEIGHT AND BACKFAT THICKNESS

The goal of the investigation was to construct a performance index, which should be a combination of two scores : a score for weight and a score for backfat thickness. The results of the analysis, presented in tables 1 and 2, led to the conclusion that it was necessary to base the scores on the regression within animals. Furthermore different scores for each sex and breed should be used. Besides that it was found that animals that were heavier at a given age, had a higher regression of weight on age. Similarly, animals that had thicker backfat at a given weight showed a higher regression of backfat thickness on weight. In order to take this into account the following procedure was taken for the construction of the scores. This will be described for the construction of the score for weight.

For each animal the regression of weight y on age x was calculated :

$$y = a + b(x - \bar{x}) \tag{1}$$

where a : estimate of intercept,
b : estimate of regression coefficient,
$\bar{x}$: mean age in sample.

Averaging all the individual a and b-values gives the equation of the « average » regression line :

$$y = \bar{a} + \bar{b}(x - \bar{x}) \tag{2}$$

where $\bar{a}$: mean of all a-values (intercepts) = estimated mean weight in population at the age $\bar{x}$,
$\bar{b}$: mean of all b-values (regression coefficients).

Now the equation of an individual line can be written as :

$$y = (\bar{a} + \Delta_a) + (\bar{b} + \Delta_b)(x - \bar{x}) \tag{3}$$

where $\Delta_a = a - \bar{a}$, and $\Delta_b = b - \bar{b}$.

The relation between the regression coefficient b and the intercept a is expressed by means of the regression equation :

$$\Delta_b = c\,\Delta_a \tag{4}$$

where c : estimated coefficient of regression of b on a.

Substitution of (4) in (3) leads to :

$$y = (\bar{a} + \Delta_a) + (\bar{b} + c\,\Delta_a)(x - \bar{x}) \tag{5}$$

which equation can be rearranged to :

$$y = \bar{a} + \bar{b}(x - \bar{x}) + \Delta_a + c\,\Delta_a(x - \bar{x}) \tag{6}$$

Suppose we have a new observation (y_0, x_0). This can be written as $(y_0, x_0 - \bar{x})$. Substitution of these values in (6) gives :

$$y_0 = \bar{a} + \bar{b}(x_0 - \bar{x}) + \Delta_o a + c\,\Delta_o a\,(x_o - \bar{x}) \tag{7}$$

Since $\bar{a}$, $\bar{b}$, x_0, $\bar{x}$, y_0 and c are known, $\Delta_o a$ can be solved :

$$\Delta_o a = \frac{y_0 - \bar{a} - \bar{b}(x_0 - \bar{x})}{1 + c(x_0 - \bar{x})} \tag{8}$$

Now the score for weight is defined as

$$\text{score } 1 = \frac{\Delta_o a}{s_a}$$

where s_a : estimated standard deviation of individual a-values.

In an analogous way the score for backfat thickness, which is called score 2, can be derived.

In table 3 the necessary quantities for the construction of the scores are summarized.

TABLE 3

Components for the construction of the scores

		$\bar{a}$	s_a	$\bar{b}$	c	$\bar{x}$	r_{ab}
Score for weight	DL ♀	100.332 73	10.517 00	.558 15	.002 88	208.588 58	.28
	DY ♀	101.043 07	13.071 37	.541 67	.001 23	213.571 26	.14
	DL ♂	96.342 97	11.747 78	.717 72	.002 87	190.556 67	.20
	DY ♂	93.586 29	12.757 59	.707 27	.006 70	184.615 91	.41
Score for backfat thickness	DL ♀	15.009 27	2.032 93	.137 67	.008 15	100.332 73	.34
	DY ♀	13.085 80	2.078 84	.097 79	.014 34	101.043 07	.55
	DL ♂	14.587 73	1.717 79	.100 10	.004 17	96.342 97	.14
	DY ♂	12.065 38	1.886 15	.085 78	.011 29	93.586 29	.39

Explanation of the symbols :

score for weight :

- $\bar{a}$: estimated mean weight in population = mean of all individual intercepts of regression of weight on age.
- s_a : standard deviation of intercepts a.
- $\bar{b}$: mean of individual coefficients of regression b of weight on age.
- c : estimate of coefficient of regression of individual b-values on a-values.
- $\bar{x}$: mean age in sample.
- r_{ab} : coefficient of correlation between intercept a and regression coefficient b.

score for backfat thickness :

- $\bar{a}$: estimated mean backfat thickness in population = mean of all individual intercepts of regression of backfat thickness on weight.
- s_a : standard deviation of intercepts a.
- $\bar{b}$: mean of individual coefficients of regression b of backfat thickness on weight.
- c : estimate of coefficient of regression of individual b-values on a-values.
- $\bar{x}$: mean weight in sample.
- r_{ab} : coefficient of correlation between intercept a and regression coefficient b.

In the last column of table 3 the correlation r_{ab} between the intercept a and the regression coefficient b of the individual regression lines are given. These correlations are not needed for the construction of the scores.

CONSTRUCTION OF AN INDEX AND INDEX-TABLES

In order to rank the animals on their performance a simple combination of both scores was taken. A high score for weight reflects a relative high growth rate and a low score for backfat thichness reflects a relative low backfat thickness. So a positive score for weight and a negative score for backfat thickness were desirable. Therefore the index was defined as :

$$\text{index} = \text{score 1} - \text{score 2}$$

In this index both scores have the same weight, which is debatable. It is of course possible to construct a more sophisticated index, in which the scores are given weights that are in accordance with their respective economic values and heritabilities. A model calculation, attaching reasonable economic weights and heritabilities to both traits showed us that the decision to give both scores the same weight is not far from the truth. In this calculation it was taken into account that in practice most breeders are feeding their animals restricted, so there is a rather strong correlation between growth rate and food conversion.

From the great number of animals on which they are based, both scores may be taken to have a distribution in the population with mean 0 and standard deviation 1. If the scores were uncorrelated, the index would have a distribution with mean 0 and standard deviation $\sqrt{1^2 + 1^2} = \sqrt{2} \approx 1.4$. An analysis showed that the scores were slightly unfavourably correlated. This is shown in table 4.

TABLE 4

Correlation between score for weight and score for backfat thickness

	Coefficient of correlation between score 1 and score 2		
	1st measurement	2nd measurement	3rd measurement
DL ♀	.11	.08	.02
DY ♀	.06	.05	— .02
DL ♂	.28	.26	
DY ♂	.16	.12	

In gilts the correlation is lower than in boars. It seems that the correlation is decreasing when the animals are getting older (compare first and later measurements). These correlations are much lower than those found by STANDAL (1962), although it must be taken into account that STANDAL used slightly different scores. His score for weight was based on the partial regressions of weight on age and backfat thickness and his score for backfat thickness was based on the partial regressions of backfat thickness on weight and age.

The observed standard deviation of the index of gilts was almost 1.4. The index of the boars had a lower standard deviation (about 1.25), because of the small unfavourable correlation between both scores in boars.

For practical purposes the use of negative values for the index was not desirable. For this reason the original index distribution was rescaled to a distribution with mean 10 and standard deviation = 2.5. This implied that in gilts an original value of — 4 standard deviations = — 5.6 was rescaled to 0 and a value of + 4 standard deviations = + 5.6 was rescaled to 20. The corresponding original values in boars were — 4 standard deviations = — 5 and + 4 standard deviations = + 5.

With this rescaling almost the whole distribution of observed index values will fall between 0 and 20. A value of 0 is indicating an animal with a very low performance and a value of 20 is indicating an animal with a very good performance.

To facilitate the use of the index, tables were constructed. For each age class (comprising 5 days) a separate table was made. In the table the corresponding index value is given for each weight (in classes of 2 kg) and each backfat thickness (in mm).

The ranges covered by these tables are :

	Age (days)	Weight (kg)	Backfat thickness (mm)
DL ♀	146-290	60-155	5-30
DY ♀	146-290	60-155	5-30
DL ♂	146-240	56-149	5-30
DY ♂	141-240	50-151	5-30

REPEATABILITY OF THE INDEX

To get an idea of the reliability of the index constructed the repeatability of this index was estimated. This was done by computing the correlation between the different indices of the same animal for the successive 2 or 3 measurements. The results are shown in table 5.

TABLE 5

Correlations between indices of same animal

	Correlation between indexes of		
	1st and 2nd measurement	2nd and 3rd measurement	1st and 3rd measurement
DL ♀	.79	.87	.75
DY ♀	.90	.87	.76
DL ♂	.85	—	—
DY ♂	.86	—	—

It is found that the repeatability of the index, for the sample on which it is based, is about .85 when the interval between successive measurements was 30 days. When the interval is doubled, the repeatability drops to about .75. These repeatability values are very high, so under the above mentioned assumption it does not seem necessary to measure the animals in farm testing more than once.

Since the scores are only slightly correlated, the repeatability of the scores also must be high. This was only checked for DY boars. The repeatability values for score 1 and 2 were .90 and .84 respectively, so in accordance with expectation.

However it must be emphasized that the repeatabilities may be over-estimated since they are derived from the same data that served to construct the scores and the performance index.

It will be desirable to recalculate the parameters of table 3 periodically, since these may change in course of time, especially as a result from genetic or environmental improvements in the populations.

Reçu pour publication en avril 1973.

ACKNOWLEDGEMENT

The author wishes to thank the Institute T. N. O. for Mathematics, Information processing and Statistics in Wageningen for their assistance in the statistical treatment of the data.

Also valuable suggestions of Mr. L. Ollivier and Dr. J. W. B. King regarding the manuscript are gratefully acknowledged.

RÉSUMÉ

TESTAGE EN FERME DES JEUNES REPRODUCTEURS PORCINS
I. — ÉLABORATION D'UN INDEX DE PERFORMANCES

Afin d'élaborer un index de performances utilisable dans le testage en ferme des jeunes porcs d'élevage, on a pris 2 ou 3 mesures sur des échantillons de truies et verrats *Landrace hollandais* et *Yorkshire hollandais*. La taille des échantillons variait de 150 à 286.

L'index choisi était une combinaison linéaire de deux indices : l'un pour le poids, l'autre pour l'épaisseur du lard dorsal.

L'indice pour le poids était basé sur la régression moyenne du poids, sur l'âge intra-animal et l'indice pour le gras dorsal sur la régression moyenne de l'épaisseur du gras dorsal sur le poids intra-animal.

L'échelle choisie pour l'index faisait que sa valeur pouvait varier entre 0 (mauvais) et 20 (très bon).

Pour faciliter son emploi, on avait tabulé les valeurs de l'index. Pour chaque classe d'âge, l'index correspondant se lisait dans la table en face de chaque combinaison de poids et d'épaisseur du lard dorsal. La répétabilité de l'index était de l'ordre de 0,85. On a conclu que, pour le testage en ferme, une seule mensuration suffisait.

REFERENCE

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