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Genetic parameters of direct and ratio traits of Hungarian pig populations

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Abstract

Genetic parameters of several growth and carcass traits were estimated for the Hungarian Large White and Hungarian Landrace pig breeds and for their cross (F_1). The objective of the analysis was to compare the direct (days of station test, consumed feed, valuable cuts and age) and ratio/composite (meat quality score, net daily gain, feed conversion, proportion of valuable cuts, carcass fat content, lean meat percentage and average daily gain) traits, which were collected in the course of station and field tests. The analysis was based on the national database (1997-2003) using univariate and bivariate animal models. Estimated heritabilities for station test traits ranged between 0.34-0.58 (except for meat quality score, where the heritability was low) and exceeded that of the field test traits (0.18-0.23). Relative importance of random litter effects was low for the station test traits (0.05-0.29) but moderate for the field test traits (0.22-0.48). The unfavourable genetic correlation between lean meat percentage and meat quality score is worth mentioning. In both performance tests the direct and ratio test counterparts showed similar heritabilities and their genetic correlation were close to unity (0.74-0.95). Based on these results selection on either the direct or on the ratio traits would possibly result similar selection response.
Key words: swine, genetic parameters, direct traits, ratio traits

Introduction

Meat production, more specifically pork production continuously aims to satisfy the consumers' demands. Although these demands are likely to change over long periods, during the last two decades consumers primarily showed preference for lean meat. Producing lean pork cannot be easily realised as a 70kg swine carcass may contain 25-35% fat. Beside other factors (like restricted feeding) the solution for reducing fat includes genetic selection, and once genetic improvement is attained it is permanent. Genetic selection may target several traits. Selection in Hungarian pig breeding is based on data from field and station tests, respectively and the collected traits can be sorted into two groups. Part of the traits are directly measurable while rest of the traits can be calculated using the measurements of direct traits. The objective of the study was to estimate the genetic parameters of all the measured and calculated traits using the data of Hungarian pig populations collected in the course of various (field and station) tests. Thus from the estimated heritabilities and genetic correlations it can be determined if the direct or the indirect traits show more advantageous features on which selection should be based.

Material and Methods

The genetic analysis was conducted on the data collected by the National Institute for Agricultural Quality Control of Hungary between 1997 – 2003, in the course of the field and station tests respectively. The analysed genotypes were the Hungarian Large White (LW), the Hungarian Landrace breeds (LR), and their cross (F_1).

Field test (own performance test)
In the field test ultrasonic (SONOMARK 100) measurements are taken from boars and gilts between 80 and 110kg at the fat depth between the 3rd and 4th lumbar vertebrae (8cm laterally from the spinal chord), fat depth between the 3rd and 4th ribs (6cm laterally from the spinal chord) and

the loin muscle area between the 3rd and 4th ribs (6cm laterally from the spinal chord). Using these measurements lean meat percentage values (LMP) are calculated. Age (AGE) and body weight (with an accuracy of 1 kg) of the animals are recorded at the same time from which their average daily gain (ADG) are also calculated. All healthy animals in a litter are tested on the farm except for those sent to the station. Gilts are kept in groups up to 25 pigs while boars are raised in smaller groups up to 15 on an *ad libitum* feeding regime.

Station test (progeny test)
For the purpose of the station test a castrate and a female from the same litter are sent to the station between the age of 65-77 days. Body weight of the animals at the age of 65 days should be at least 17 kg but not greater than 32 kg. After some preliminary adaptation period the test begins at the age of 80 days (body weight at this age is at least 23 kg) and ends with reaching the final weight of 105 kg. Days of test (DOT), total amount of feed consumed during the test (FEED) and valuable cuts (VC) (neck, shoulder, loin and ham) are directly measured from which net daily gain (NDG), feed conversion ratio (FCR) proportion of valuable cuts (VC%) are calculated. Meat quality scores (MQ) are also recorded. Moreover body weight is measured at the beginning and at the end of the test with an accuracy of 1 kg. Animals are fed *ad libitum* and penned individually. Number of measurements for the examined genotypes are presented in table 1.

Table 1. Number of measurements for the Hungarian Large White, Hungarian Landrace breeds and their cross (F_1)

Genotype	Field test	Station test
Hungarian Large White	111006	8168
Hungarian Landrace	55703	3391
F_1	247347	14587

Statistical analysis
The statistical analysis consisted of two consecutive steps. The first step was testing for the significance of the various environmental factors (fixed effects) conducting least squares analyses using the GLM procedure of the SAS package (SAS Institute Inc., 1999) leaving only significant factors in the models. The second step was the estimation of the heritabilities of the individual traits and their genetic correlations. The method used to obtain the (co)variance components was the appropriate variation of the animal model using the PEST (Groeneveld, 1990) and VCE 4 (Groeneveld, 1998) softwares based on the BLUP and REML methods.

The heritability estimates of AGE, LMP, ADG, DOT, FEED, VC, NDG, FCR, VC%, MQ were obtained by using the following univariate linear model:

$$\boldsymbol{y} = \boldsymbol{Xb} + \boldsymbol{Za} + \boldsymbol{e}$$

where
y = vector of observations, **b** = vector of fixed effects, **a** = vector of random animal effects, **e** = vector of random residual effects, **X** and **Z** are incidence matrices relating records to fixed and random animal effects, respectively.

Expected values of **a** and **e** were E(**a**) = E(**e**) = 0. The variance-covariance structure assumed to be V(**a**) = $A\sigma^2 a$, V(**e**) = $I\sigma^2 e$, and cov(**a,e**) = Cov(**e,a**) = 0, where A is the numerator relationship matrix. Also cov(**y,a**) = $ZAI\sigma^2 a$.
Genetic correlations were estimated among AGE, LMP, DOT, FEED, VC, MQ, among ADG, NDG, FCR, VC% and between AGE-ADG, DOT-NDG, FEED-FCR and VC-VC%. Due to the size of the datasets and the relatively low computing capacity genetic correlations could only be estimated using bivariate models.
The applied models are summarised in table 2.

Table 2. The applied models of the traits

Factor	Type	AGE[1]	LMP[2]	ADG[3]	DOT[4]	FEED[5]	VC[6]	NDG[7]	FCR[8]	VC%[9]	MQ[10]
weight	C[11]	x	x	-	x	x	x	-	-	-	x
herd	F[12]	x	x	x	x	x	x	x	x	x	x
sex	F	x	x	x	x	x	x	x	x	x	x
Year-month	F	x	x	x	x	x	x	x	x	x	x
station	F	-	-	-	x	x	x	x	x	x	x
litter	R[13]	x	x	x	x	x	x	x	x	x	x
animal	A[14]	x	x	x	x	x	x	x	x	x	x

[1]AGE, age; [2]LMP, lean meat percentage; [3]ADG, average daily gain; [4]DOT, days of test; [5]FEED, total amount of feed consumed during the test; [6]VC, valuable cuts; [7]NDG, net average daily gain; [8]FCR, feed conversion ratio; [9]VC%, proportion of valuable cuts; [10]MQ, meat quality score; [11]C, covariate; [12]F, fixed effect; [13]R, random effect; [14]A, additive genetic effect

Results and discussion

Estimated heritabilities for the field and station test traits are presented in table 3. Station test heritabilities exceeded that of the field test traits except for meat quality score where low heritability estimates were found. In Hungary meat quality score is calculated from several parameters (pH_1, pH_2, GÖFO, subjective score) from which the subjective score might be prone to error and may result incorrect scores (Groeneveld et al., 1996). Published heritability estimates of separate meat quality score parameters were low or moderately low (0.10-0.30) (Knapp et al., 1997; Lo et al., 1992; Hovenier et al., 1992). These findings suggest that although meat quality is internationally considered an important trait its definition may not be optimal. Valuable cuts and proportion of valuable cuts both showed moderately high heritabilities and were in accordance with the reported estimates of others (Hofer et al., 1992; Groeneveld et al., 1998; Groeneveld and Pescovicova, 1999; Wolf et al., 2001). The other traits measured in the station test (DOT, FEED, NDG, FCR) showed moderate heritabilities and were similar to the findings of Chen et al. (2002); Ducos et al. (1992); Zhang et al. (2000); (DOT); Groeneveld et al. (1996) (FEED); but were higher than reported by Hermesch et al. (2000); Hofer et al., (1992); Mrode and Kennedy (1993) (NDG, FCR).

Table 3. Heritability estimates of the field and station test traits

	Hungarian Large White	Hungarian Landrace	F_1
Age	0.23±0.02	0.23±0.05	0.23±0.03
Lean meat percentage	0.23±0.02	0.28±0.04	0.25±0.02
Average daily gain	0.20±0.03	0.18±0.04	0.23±0.02
Days of test	0.34±0.02	0.35±0.06	0.40±0.01
Consumed feed	0.37±0.01	0.48±0.05	0.42±0.01
Valuable cuts	0.54±0.02	0.65±0.03	0.58±0.02
Net daily gain	0.36±0.01	0.35±0.05	0.40±0.02
Feed conversion ratio	0.37±0.02	0.35±0.04	0.42±0.02
Proportion of valuable cuts	0.54±0.02	0.69±0.03	0.60±0.01
Meat quality score	0.10±0.02	0.15±0.03	0.18±0.02

From the field test traits AGE and ADG showed low heritabilities that were in good agreement with the findings of other authors (Bereskin, 1987; Groeneveld et al., 1998; Hovenier et al., 1992; Pescovicova et al., 1999). LMP also showed low heritability but the received values were perhaps lower than expected as others reported moderately high heritability estimates (Sonesson et al., 1998; 0.41; Knapp et al., 1997; 0.40-0.53; Hovenier et al., 1992; 0.63) for the same trait.

Estimated random litter effects for the field and station test traits are presented in table 4. The relative importance of this effect was less in the station test than in the field test traits. VC, VC%, FCR and MQ showed negligible random litter effects but the size of this effect for DOT, FEED and NDG were also low or moderately low, similarly to Ducos et al. (1992); Hofer et al. (1992) Groeneveld et al. (1998); Groeneveld and Pescovicova (1999); Zhang et al. (2000); Chen et al. (2002). On the contrary in the field test traits the relative importance of random litter effects was either reached (LMP) or exceeded (AGE) that of the additive genetic effects. Bereskin reported similar results for AGE but for LMP low random litter effects were published by Knapp et al. (1997) and Groeneveld et al. (1998). Our results may be caused by imprecise ultrasonic scanning. Precision might be improved if the operators' code would be included in the applied models. The genetic correlation coefficients were only estimated in the Hungarian Large White and Hungarian Landrace breeds and were presented separately for the direct (tables 5-6) and ratio traits (tables 7-8) and between the direct and ratio trait equivalents (table 9).

Table 4. Relative importance of random litter effects (proportion of the total variance) of the field and station test traits

	Hungarian Large White	Hungarian Landrace	F1
Age	0.48±0.01	0.46±0.02	0.49±0.02
Lean meat percentage	0.20±0.02	0.25±0.02	0.21±0.01
Average daily gain	0.29±0.02	0.33±0.01	0.40±0.01
Days of test	0.11±0.01	0.14±0.02	0.12±0.01
Consumed feed	0.29±0.01	0.22±0.02	0.26±0.01
Valuable cuts	0.05±0.02	0.01±0.02	0.02±0.01
Net daily gain	0.21±0.01	0.23±0.02	0.16±0.02
Feed conversion ratio	0.05±0.01	0.02±0.01	0.06±0.02
Proportion of valuable cuts	0.04±0.01	0.01±0.01	0.09±0.01
Meat quality score	0.07±0.01	0.08±0.02	0.05±0.02

Table 5. Estimated genetic correlation coefficients of the direct (field and station) traits in the Hungarian Large White breed

FEED[1]	DOT[2]	VC[3]	MQ[4]	AGE[5]	LMP[6]	
	0.62±0.02	0.00±0.04	-0.06±0.13	0.68±0.04	0.03±0.04	FEED1
		-0.38±0.06	-0.29±0.11	0.51±0.03	-0.06±0.02	DOT2
			0.18±0.20	0.02±0.02	0.34±0.02	VC3
				-0.02±0.21	**-0.28**±0.16	MQ4
					0.04±0.04	AGE5
						LMP6

[1]FEED, total amount of feed consumed during the test; [2]DOT, days of test; [3]VC, valuable cuts; [4]MQ, meat quality score; [5]AGE, age; [6]LMP, lean meat percentage

Table 6. Estimated genetic correlation coefficients of the direct (field and station) traits in the Hungarian Landrace breed

FEED[1]	DOT[2]	VC[3]	MQ[4]	AGE[5]	LMP[6]	
	0.79±0.03	-0.03±0.05	0.09±0.18	0.64±0.07	-0.07±0.04	FEED1
		-0.22±0.04	0.12±0.16	0.54±0.05	-0.08±0.06	DOT2
			-0.35±0.23	0.07±0.06	0.40±0.05	VC3
				-0.19±0.25	**-0.44**±0.19	MQ4
					0.10±0.07	AGE5
						LMP6

[1]FEED, total amount of feed consumed during the test; [2]DOT, days of test; [3]VC, valuable cuts; [4]MQ, meat quality score; [5]AGE, age; [6]LMP, lean meat percentage

From the results the moderately high and negative genetic correlation between MQ and LMP has to be emphasised. The received association is unfavourable as the selection on LMP decreases MQ. The existence of this unfavourable genetic correlation was justified by other authors (Cameron, 1990; De Vries et al., 1994).

Table 7. Estimated genetic correlation coefficients of the ratio (field and station) traits in the Hungarian Large White breed

NDG[1]	FCR[2]	VC%[3]	ADG[4]	
	-0.40±0.03	0.09±0.03	0.60±0.03	NDG[1]
		-0.47±0.04	-0.25±0.04	FCR[2]
			0.10±0.05	VC%[3]
				ADG[4]

[1]NDG, net average daily gain; [2]FCR, feed conversion ratio; [3]VC%, proportion of valuable cuts; [4]ADG, average daily gain

Table 8. Estimated genetic correlation coefficients of the ratio (field and station) traits in the Hungarian Landrace breed

NDG[1]	FCR[2]	VC%[3]	ADG[4]	
	-0.39±0.06	0.12±0.05	0.66±0.05	NDG[1]
		-0.40±0.05	-0.19±0.05	FCR[2]
			0.00±0.04	VC%[3]
				ADG[4]

[1]NDG, net average daily gain; [2]FCR, feed conversion ratio; [3]VC%, proportion of valuable cuts; [4]ADG, average daily gain

Table 9. Estimated genetic correlation coefficients between the direct and ratio trait equivalents in the Hungarian Large White breed

DOT[1]-NDG[2]	FEED[3]-FCR[4]	VC[5]-VC%[6]	AGE[7]-ADG[8]	Genotype
-0.92±0.01	0.86±0.02	0.89±0.01	-0.79±0.03	Large White
-0.95±0.01	0.83±0.03	0.90±0.01	-0.74±0.04	Landrace

[1]DOT, days of test; [2]NDG, net average daily gain; [3]FEED, total amount of feed consumed during the test; [4]FCR, feed conversion ratio; [5]VC, valuable cuts; [6]VC%, proportion of valuable cuts; [7]AGE, age [8]ADG, average daily gain

Conclusions

The heritability and random litter effect estimates of direct and ratio trait were similar. Moreover the genetic correlation coefficients between the direct and ratio trait equivalents were close to unity. The selection response is therefore not expected to be different based either on the direct or on the ratio traits.

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