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Genetic parameters and breeding value stability estimated from a joint evaluation of purebred and crossbred sows for litter weight at weaning

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ABSTRACT

Authors analysed genetic parameters and breeding value stability in Hungarian Large White (HLW), Hungarian Landrace (HL) pigs and their reciprocal cross (F_1) for litter weight at weaning adjusted to 28 days of age. Data was collected by the legal predecessor of the National Food Chain Safety Office between 2001 and 2010. Data preparation was carried out using SAS 9.1.3 software. The litter weight records of the purebred and crossbred pigs were considered as separate traits. Genetic parameters were estimated by REML method using the VCE 6 software applying two-trait repeatability model. The total number of animal in the pedigree was 138 969. Heritability estimates were low for each breed and the cross. Corresponding values are 0.13 (0.004), 0.10 (0.004) and 0.13 (0.003) and 0.12 (0.002) for HLW, HL and F_1 from the two datasets, respectively. Magnitudes of permanent environmental effect were 0.008 for HLW and <0.001 for HL and F_1. Genetic correlations between purebred and crossbred performances were 0.23 (0.04) from the dataset HLW-F_1, and 0.03 (0.008) from the dataset HL-F_1. Breeding value stability was low regarding both methods. Number of common representatives from rankings of purebred and crossbred breeding value did not reach the 40 from 100 animals in either breed. The differences between average crossbred breeding values reached a maximum value of 3.47 kg in HLW and 3.16 kg in HL.
(Keywords: genetic correlation, purebred breeding value, crossbred breeding value, litter weight)

INTRODUCTION

In pig breeding reproduction traits are crucial for economical piglet production. Traits related to reproduction generally show low heritability which emphasises the importance of the accuracy of selection decisions. According to the current Hungarian Pig Performance Testing Code breeding value estimation for reproductive traits is accomplished using a two trait repeatability model. These two traits are the number of piglets born alive and the litter weight at weaning adjusted to 28 days of age. However, the model does not account for purebred and crossbred performance as different traits; breed of sows is included in the model as fixed effect. Regarding them as separate traits as suggested by *Wei and van der Werf* (1994), however, reveals that variance components and therefore also genetic parameters are different for purebreds and crossbreds.

The international literature provides predominately purebred heritabilities (*Chen et al.*, 2003, h^2: 0.07-0.08; *Fernandez et al*., 2008, h^2: 0.16; *Ziedina et al*., 2011, h^2: 0.17; *Dube et al*., 2012, h^2: 0.06). *Chansomboon et al*. (2010) analyzed the data obtained on Large White Thailand piglets weaned between 26 and 30 days of age, and they obtained much lower value compared to our estimate (h^2: 0.05). The highest heritability (0.27) was estimated by *Ajayi and Akinokun* (2013) for Nigerian Indigenous pigs, however, without information on the age of weaning. Purebred and crossbred comparison was made by *Nakavisut et al.* (2005) who investigated litter weight at 3 weeks of age separately for purebreds and a three-way cross, and obtained corresponding heritabilities of 0.10 and 0.13, respectively. No difference could be shown in the study of *Ehlers et al*. (2005) in this regard (h^2: 0.15 both for purebreds and crossbreds).

Genetic correlation between purebred and crossbred performance is an indicator that should be taken into account when making selection decisions about parents of the crossbred offspring. If genetic correlation between purebred and crossbred performance is high, change of the sow's position in the ranking based on crossbred breeding value compared to purebred breeding value is not expected to be substantial. On the contrary, if genetic correlation is low to medium, change of sow's position may be remarkable. *Nakavisut et al.* (2005) estimated genetic correlation of 0.33 between purebreds and crossbreds. On the contrary, *Nguyen and Nguyen* (2011) obtained r_{pc} 0.48 and 0.78 for Landrace and reciprocal cross of Yorkshire and Landrace, and for Yorkshire and reciprocal cross of Yorkshire and Landrace, respectively. *Nagyné Kiszlinger et al*. (2013) investigated, relating to this problem, the number of piglets born alive, and estimated genetic correlations of 0.82 and 0.93, but so far no corresponding values regarding litter weight has been estimated for the Hungarian Large White and Landrace population. Thus, aim of present study was to estimate purebred and crossbred genetic parameters and breeding value stability for the trait litter weight at weaning adjusted to 28 days.

MATERIAL AND METHODS

Genetic parameters

The analysis was based on the data collected by the legal predecessor of the National Food Chain Safety Office (NÉBIH) in the course of field test conducted between 2001 and 2010. The analyzed breeds were the Hungarian Large White (HLW), the Hungarian Landrace (HL) and their reciprocal cross (F_1). The purebred and crossbred pigs were kept partly in the same herds. The number of farrowing ranged from 1 to 17. The analyzed trait was litter weight adjusted for 28 days. For the data preparation the SAS (*SAS Institute Inc*., 2004) software was applied. The data was divided in two datasets. The first dataset contained HLW and F_1 records, the second Hl and F_1 records, respectively. The analyzed records of the purebred and crossbred pigs were considered as separate traits, thus the data table contained separate columns for purebred and crossbred performance. Purebred animals, having no performance in crossbred trait, were assigned a zero for crossbred performance, and in return, crossbred animals, having no record for purebred performance, were assigned a zero for purebred performance. Genetic parameters were estimated separately by REML method using the PEST (*Groeneveld*, 1990) (only for data coding) and VCE6 software (*Groeneveld et al*., 2008) applying two-trait repeatability model. The structure of repeatability model was the following:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} W_1 & 0 \\ 0 & W_2 \end{bmatrix} \begin{bmatrix} pe_1 \\ pe_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

where y_1 = vector of observations for the purebred litter weight, y_2 = vector of observations for the crossbred litter weight b_1 = vector of fixed effect for the purebred litter weight, b_2 = vector of fixed effect for the crossbred litter weight, a_1 = vector of random animal effects for the purebred litter weight, a_1 = vector of random animal effects for the crossbred litter weight, pe_1 = vector of random effects for the purebred litter weight, pe_1 = vector of random effects for the crossbred litter weight and X_1, X_2, Z_1, Z_2, W_1 and W_2 are incidence matrices relating records of purebred and crossbred litter weight to fixed effects, random animal effects and random permanent environmental effects, respectively. Model information is shown in *Table 1*.

Table 1

Effects considered in the model and their levels

Effect	*Type*	*Levels*		*Traits*	
		1–20[1]	4–20[2]	lw28–1[3]/lw28–4[4]	lw28–20[5]
Number of farrowing	F	17	17	x	x
Herd	F	126	112	x	x
Litter size	C	1	1	x	x
Weaning year-month	F	111	111	x	x
Permanent environment	R	95345	63263	x	x
Animal	A	138969	138969	x	x

[1]Hungarian Large White and the cross; [2]Hungarian Landrace and the cross; [3]litter weight adjusted for 28 days for Hungarian Large White (only in model 1); [4] litter weight adjusted for 28 days for Hungarian Landrace (only in model 2); [5]litter weight adjusted for 28 days for the cross (in both models)

The total number of animals in the pedigree was 138969.

Differences between breeds and cross were tested using GLM procedure of SAS software (*SAS Institute Inc.*, 2004).

Breeding value stability

For estimating breeding value stability, two approaches were applied. In the first approach purebred pigs were ranked based on their purebred, and on their crossbred breeding values separately for every year. From each ranking only the best 100 animals were considered, and the number of pigs being present in both datasets.

In the second approach first purebred pigs were ranked based on their crossbred breeding values, and the best 100 animals were kept. Then pigs were ranked based on their purebred breeding values, and again the highest ranked animals were kept. Crossbred breeding values were assigned to these latter pigs. After calculating the average values of both crossbred rankings across the years, differences between them were calculated.

RESULTS AND DISCUSSION

Descriptive statistics

Descriptive statistics of the litter weight adjusted for 28 days are shown in *Table 2*. Statistical analysis reveals the superiority of the Hungarian Landrace sows. The large variation coefficient may be caused by in the differences in farm management between herds, and in the variability of the litter size considered as covariant effect in the model. It ranged between 2 and 16 with an average value of 9.

Table 2

Descriptive statistics for litter weight adjusted for 28 days, kg

	N	*Min.*	*Max.*	*Mean*	*SD*	*CV%*
HLW[1]	164 884	9.3	192.3	77.7 b	14.7	19.6
HL[2]	55 238	17.6	151.3	75.6 a	12.8	16.9
F_1	161 154	11.7	169.7	75.5 a	13.6	15.1

[1]Hungarian Large White; [2]Hungarian Landrace, Means with different letters are significantly different, $p<0.05$.

Heritability, permanent environmental effect and genetic correlations

The heritability of traits relating to reproduction is generally low. Accordingly, our estimates for each breed and cross are in the lower range (*Table 3*). Our findings are in rough accordance with those found in the literature, although other authors mostly referred to 21 days litter weight (*Chen et al.*, 2003; *Fernandez et al*., 2008; *Ziedina et al*., 2011; *Dube et al*., 2012). Regarding age at weaning, the analysis of *Chansomboon et al*. (2010) is closer to ours and they obtained much lower value compared to our estimate.

No substantial differences were found between the estimates of purebred and crossbred animals similar to the results of *Nakavisut et al.* (2005) and *Ehlers et al*. (2005).

For permanent environmental effect (variation accounted for PE) (*table 3*.) we estimated negligible values across all three genotypes suggesting its low significance for litter weight. *Ehlers et al.* (2005) reported similar estimates both for purebred (<0.001) and crossbred pigs (0.002). *Fernandez et al.* (2008) obtained one order of magnitude greater value (0.02).

Genetic correlations between purebred and crossbred performances (*Table 3*.) proved to be low from each dataset. Difference between our estimates, however, is surprisingly high. It could probably be explained by the phenomenon that Hungarian Large White pigs contribute more to the litter weight performance. Unfortunately there is little information in the literature in this regard. Both *Nakavisut et al.* (2005) and *Nguyen and Nguyen* (2011) estimated higher values for this trait. Low genetic correlations suggest that purebred and crossbred litter weight performances are different traits.

Table 3

Heritability (h^2), permanent environmental effect for litter weight adjusted to 28 days (pe) and genetic correlations between purebred and crossbred performance (r_{pc}) with standard errors in brackets

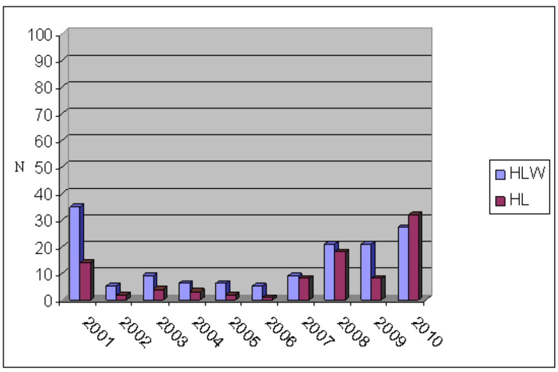
	HLW[1]	*HL*[2]	*F_1*	*HLW-F_1*	*HL-F_1*
h^2	0.13 (0.004)	0.10 (0.004)	0.13 (0.003)* 0.12 (0.002)**		
r_{pc}				0.23 (0.04)	0.03 (0.008)
pe	0.008 (0.003)	<0.001 (<0.001)	<0.001 (<0.001) * <0.001 (<0.001) **		

[1]Hungarian Large White; [2]Hungarian Landrace
*from dataset HLW-F_1,**from dataset HL-F_1

Breeding value stability
Breeding value stability roughly follows the genetic correlation between purebred and crossbred performances, and this is confirmed in present study. Numbers of common representatives from the two rankings (*Figure 1*) were low for all the years analyzed. Our overall estimate is higher for Hungarian Large White pigs as it was that for genetic correlation for this breed. To our best understanding there is no adequate result in the literature to compare our findings to. Low values mean that pigs ranked on the top based on purebred breeding values may be inferior based on crossbred breeding values, thus selection decision would be more appropriate considering both purebred and crossbred breeding values.

Figure 1

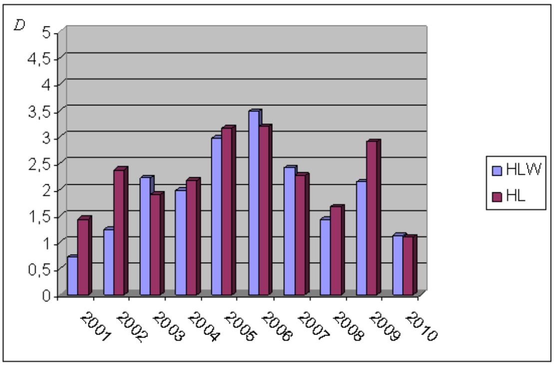
Numbers (N) of common representatives of the highest ranked purebred sows from purebred and crossbred ranking across the years expressing the breeding value stability



The results of the second approach of evaluating breeding value stability are shown in *Figure 2*.

Figure 2

Differences (D) between the average crossbred breeding values of the highest ranked purebred sows across the years expressing the breeding value stability, kg



Similar to the previous method it is an indirect way to show the strength of association between the purebred and the crossbred performance. The lower the difference between the averages of the crossbred breeding values from the two rankings the closer are purebred and crossbred performances to one another. Both *Figure 1* and *Figure 2* prove the weak association between purebred and crossbred performances with a lower breeding value stability in the middle years of the analyzed period of time.

CONCLUSIONS

The low genetic correlations and estimates for breeding value stability for litter weight adjusted to 28 days of age reveal that purebred and crossbred performance should be treated as separate traits. If the aim of breeding is to produce only purebred piglets, it is enough to consider purebred information, however, for producing crossbred piglets, both purebred and crossbred information should de taken into account when selecting the parents of the next generation. As reproduction traits are difficult to improve exploitation of crossbred breeding value would be useful.

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