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Index selection as a key in the selection process for pigs

Oleksandr Kodak*, Henrietta Nagyné Kiszlinger, Farkas János, György Kövér, Nagy István

Kaposvár University, Faculty of Agricultural and Environmental Sciences, H-7400 Kaposvár, Guba S. 40.

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Farrowing records of the Duroc, Hampshire and Pietrain breed were analysed by means of a three-trait repeatability animal model. The examined traits were number of piglets born alive (NBA), number of weaned piglets (NWE) and litter weight at weaning (LWWE). Heritability estimates were 0.10, 0.08 and 0.12 for NBA, NWE and LWWE, respectively. The ratios of the permanent environmental variance to the phenotypic variance were 0.08, 0.05 and 0.03 for NBA, NWE and LWWE, respectively. Using the estimated breeding values a desired index was constructed in order to improve each trait by one additive genetic standard deviation. NWE and NBA have a high correlation and range within breeds from 0.87 to 0.91, but LWWE had poor to moderate correlation with NBA and NWE (0.13 to 0.59). Animals ranking based on index showed better genetic merit for Duroc breed and the index scores ranged from 49.77 to 186.56. In the case of Hampshire and Pietrain breeds somewhat lower index scores (30.92 to 165.97) were observed. The estimated genetic trend for NBA was highest for the Pietrain breed (0.02), but for Duroc and Hampshire breeds the estimates were zero and negative (-0.01). For NWE the estimated genetic trends were practically zero for Duroc and Pietrain breeds and it was 0.02 for Pietrain. LWWE showed highest genetic trend for Duroc breed (0.17) but it was lower (0.09) for Pietrain and and negative (-0.24) for Hampshire.

Keywords: pig, selection, breeding value, desired gain index, aggregate genotype

1 Introduction

In the Hungarian pig breeding sector performance test of pigs is mainly based on field tests. Kaposvár University has been close partner of Hungarian Pig Breeders Association for many years and together they are responsible for collecting information and developing breeding programme for many different farms across Hungary.

Based on the measurements collected in the course of the field tests the future generations' performance can be predicted. Among other traits field test measurements involve number of piglets born alive (NBA), number of weaned piglets (NWE) and litter weight at weaning (LWWE). The nucleus pig farms in Hungary perform their selection process based on Best Linear Unbiased Prediction (BLUP) methodology where the prediction of breeding values is taking into account environmental factors and performances of relatives. It has to be noted that at present breeding value prediction for reproduction traits is limited to the Hungarian Large White and Hungarian Landrace breeds. In the framework of the field tests, the breeding value prediction for the other pig breeds (Pietrain, Duroc and Hampshire) is targeting only average daily gain and lean meat percentage (Hungarian Pig Breeders Association). Besides all pig breeds are selected based on progeny test for feed conversion ratio and for the weight of the valuable cuts (Hungarian Pig Breeders Association).

In our research, the objective was to construct BLUP indexes applying the so-called desired gain index (Brascamp, 1984). Derivation of a selection index to estimate the breeding value of an individual for

* **Corresponding Author:** Oleksandr Kodak. Kaposvár University, Faculty of Agricultural and Environmental Sciences, 7400, Kaposvár, Guba Sandor 40, Hungary. E-mail: oleksandr.kodak@ke.hu

various traits can be realised by definition of an aggregate genotype with the advantage of avoiding the necessity of calculating economic weights while estimating index-weighing factors.

The aim of this study was to evaluate the efficiency of the possible extension of the selection for the reproduction traits also for paternal pig breeds.

2 Material and methods

2.1 Data collection

Hungarian Pig Breeders' Association provided farrowing data information collected between 2001 and 2018 on 21 herds and three breeds, namely Duroc, Hampshire and Pietrain. Number of farrowing records were 8,806. Total number of pigs in the pedigree file was 22,170 covering 11 generations. Number of herds, sows and farrowing records are summarised in Table 1.

Table 1 Farrowing records from 2001 to 2018

Breed	Herds	Sows	Number of farrowing
Total	21	2,843	8,806
Duroc	10	1,294	3,796
Hampshire	7	381	1,246
Pietrain	16	1,168	3,764

2.2 Animal model

Best Linear Unbiased Prediction (BLUP) and Restricted maximum likelihood (REML) methodologies were used to estimate genetic parameters and breeding values. A three-trait repeatability animal model was constructed. In Table 2 the model structure is given. Traits involved in the model were number of piglets born alive (NBA), number of weaned piglets (NWE) and litter weight at weaning (LWWE). The PEST (Groeneveld, 1990) and VCE 6 (Groeneveld et al., 2008) software were used to estimate genetic parameters and predict breeding values. In Table 3 descriptive statistics of the measured traits are summarized.

Table 2 The structure of the applied animal model

Model	Traits	Factors (Type)						
		Animal	PE	FYM	WYM	Breed	Herd	Parity
		(A)	(R)	(F)	(F)	(F)	(F)	(F)
	NBA	X	X	X		X	X	X
	NEW	X	X		X	X	X	X
	LWWE	X	X		X	X	X	X

NBA - number of piglets born alive; NWE - number of weaned piglets; LWWE - litter weight at weaning; PE - permanent environmental effect; FYM - farrowing year-month; WYM - weaning year-month; A - additive genetic effect; R - random effect; F - fixed effect.

Based on the predicted breeding values, aggregate breeding values were also calculated using a desired gain index applying the MIX software (Nath et al., 2002). When constructing the index the objective was to improve all traits by one additive genetic standard deviation.

Selection index scores were trasformed to get index mean of 100 and standard deviation of 20.

Table 3 Descriptive statistics of the measured traits

Breed	Trait	Mean	SD	Maximum	Minimum
Duroc	NBA	9.27	2.45	16	1
	NWE	8.35	1.83	14	2
	LWWE, kg	54.14	16	110	14
Hampshire	NBA	9.15	2.38	16	2
	NWE	8.76	2.23	14	2
	LWWE, kg	61.45	17.17	103	15
Pietrain	NBA	9.19	2.43	16	1
	NWE	8.79	2.1	14	2
	LWWE, kg	54.81	15.58	110	14

NBA - number of piglets born alive; NWE - number of weaned piglets; LWWE - litter weight at weaning.

3 Results and discussion

3.1 Heritability, permanent environmental impact, index weighting factors and genetic correlation

In Table 4 the estimated heritabilities and their standard errors are presented. Heritability estimates were low for all traits. Irgang et al. (1994) reported higher heritability for NBA of Duroc breed, like in the case of Skorupski et al. (1996), with a value of 0.16. Hamann et al. (2004) and Chen et al. (2003) reported heritability of 0.08 and 0.09 for NBA of Hampshire and Duroc, respectively. Concerning NWE, heritability was 0.05 for Hampshire and 0.07 for Duroc. LWWE in the study of Chen et al. (2003) showed smaller heritability for Duroc and Hampshire, with values of 0.07 and 0.08, respectively.

Table 4 Genetic parameters of the invetigated traits

h^2			PE		
NBA	NWE	LWWE	NBA	NWE	LWWE
0.10 ± 0.01	0.08 ± 0.01	0.12 ± 0.01	0.08 ± 0.01	0.05 ± 0.01	0.03 ± 0.01

h^2 - heritability; PE - ratio of the permanent environmental variance to the phenotypic variance; NBA - number of piglets born alive; NWE - number of weaned piglets; LWWE - litter weight at weaning.

Permanent environmental effects (Table 4) accounted for small proportions of the phenotypic variance for all traits. Skorupski et al. (1996) reported smaller PE for NBA in Duroc, with a value of 0.05. Chen et al. (2003) reported about the same PE for NBA in Hampshire and Duroc (0.06 and 0.08, respectively). The same PE was obtained for NWE in both breeds, with a value of 0.04. However, in case of LWWE, Chen et al. (2003) estimated higher values for both breeds (Duroc = 0.07; Hampshire = 0.06).

Calculating the index coefficients satisfying the desired gains of one additive genetic standard deviation, the following index was constructed:

Index = 12.9199*ebv1 + 5.2524*ebv2 + 2.4661*ebv3,

where ebv1 is the estimated breeding value for number of piglets born alive, ebv2 is the estimated breeding value for number of weaned piglets, and ebv3 is the estimated breeding value for litter weight at weaning. As mentioned above, the calculated index scores were further modified in order to get index mean of 100 and standard deviation of 20. The reason for this conversion was to make the constructed index of this study comparable with indexes used by the Hungarian Pig Breeders Association (2017). At present the BLUP index of the Hungarian Large White and Hungarian Landrace breeds consists of NBA and litter weight at day 21. The main difference between the index of the present study and that of the Hungarian Pig Breeders Association (2017) is that the latter is based on

the calculation of the economic values. The genetic correlation (Pearson's correlation) analysis resulted in high correlation coefficients between indexes (aggregate genotype) and traits for all three breeds (Table 5). In particular, NWE and NBA have high correlation within breeds (from 0.87 to 0.91), but LWWE have very poor to moderate correlation with NBA and NWE (from 0.13 to 0.59), depending on the breed.

Table 5 Genetic correlations between the examined traits and the selection index

Breed	Trait	NWE	LWWE	Index
Duroc	NBA	0.87	0.13	0.71
	NWE		0.13	0.67
	LWWE			0.78
Hampshire	NBA	0.91	0.52	0.84
	NWE		0.59	0.86
	LWWE			0.89
Pietrain	NBA	0.88	0.37	0.82
	NWE		0.37	0.78
	LWWE			0.83

NBA - number of piglets born alive; NWE - number of weaned piglets; LWWE - litter weight at weaning.

3.2 Genetic trends and index by breed

After calculating the aggregate genotypes, Duroc showed the highest index values, ranging from 49.77 to 186.56. Compared to Duroc, the index values were somewhat lower for the Hamsphire and Pietrain breeds where the minimum and maximum index values were 30.92 and 165.97, respectively.

In Table 6 the estimated genetic trends are presented. In Duroc, significantly positive trends were detected only for LWWE, with 0.17 kg year^{-1}. The genetic trend of this trait in Hampshire was significant but negative (-0.24 kg year^{-1}), whereas for Pietrain the trend was significant and positive for NBA and NWE (0.02 and 0.02 piglets year^{-1}, respectively). Chen et al. (2003) reported a lower value in Duroc breed for LWWE (0.087 kg year^{-1}), but a positive value for Hampshire (0.007 kg year^{-1}). The positive and significant genetic trend in case of LWWE for Duroc breed can be explained by the increase in average daily gain during the suckling period. The LWWE for Hampshire breed was negative, possibly due to a constant non-significant decrease in number of piglets during birth and weaning. Concerning the Hungarian Large White, Hungarian Landrace and their cross, Nagy (2017) reported a very small positive genetic trend for NBA (0.01 piglets year^{-1}) and a small negative genetic trend for NWE (-0.04 piglets year^{-1}). These results were not favorable but it has to be noted that these pig breeds are simultaneously selected for growth and carcass traits (Hungarian Pig Breeders Association, 2017) where they showed higher efficiency. It has to be emphasised that at present the Duroc, Hampshire and Pietrain breeds are not selected for reproductive traits and thus the lack of positive trends are not surprising.

Table 6 Estimated genetic trends

Breed	NBA		NWE		LWWE	
	Pr>|t|	B	Pr>|t|	B	Pr>|t|	B
Duroc	0.61	0.003	0.6	-0.002	0.01	0.17
Hampshire	0.24	-0.01	0.33	-0.005	0.04	-0.24
Pietrain	0.008	0.02	0.001	0.02	0.22	0.09

NBA - number of piglets born alive; NWE - number of weaned piglets; LWWE - litter weight at weaning.

4 Conclusions

The desired gains index technique is a good tool for determining the economic importance of traits where the economic values cannot be determinded. Using the desired gain index method for the Duroc, Hampshire and Pietrain breeds would probably increase the annual genetic trends of the traits involved in the index.

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