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EVALUATION OF CONNECTEDNESS BETWEEN THE MANAGEMENT UNITS OF LANDRACE BREED OF PIGS IN CROATIA

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ABSTRACT

Connectedness between the Landrace pig herds in Croatia was evaluated on field test records (4,930) from 2005 to 2008. The aim was to assess connectedness using the connectedness rating (CR) method among large scale farms and family farms (as one group). In addition, reliability of breeding values was calculated for separate and joint genetic evaluation of animals in large scale farms and family farms. The last herd-year-season levels in each farm were defined as management units for the evaluation of CR. The range of CR values between management units was from 0.004 to 0.035, while the averages of CR by management units ranged from 0.013 to 0.024. The highest CR (0.035) was found between the large scale farm D and a group of family farms. Average reliability was in range between 0.21 for farm B to 0.29 for farm A in separate analyses and between 0.31 on farm B to 0.38 on farm D and family farms in joint analysis of all farms. Low level of connectedness and limited increase in reliability do not support use of joint genetic evaluation results across all management units in Croatian breeding programme. Artificial insemination should be used as an instrument of increasing connectedness between pig herds in the Croatian national pig breeding programme.

Key words: pigs / breeds / Landrace / management units / connectedness / connectedness rating method/ Croatia

1 INTRODUCTION

Pig production within the National breeding program in Croatia is organized through two different concepts. The first concept is based on large scale farms, which are characterized by a relatively large number of sows and intensive production with the latest technological and management achievements. The second concept is based on family farms characterized by a variable number of sows per farm, very variable intensity of production, and often out-dated management and organizational solutions. Since 2004, best linear unbiased prediction (BLUP) has been used for genetic evaluation of boars and gilts in Croatia (Vincek *et al*., 2003). Evaluations have been developed separately for every single large scale farm and jointly for all family farms, due to the lack of information about genetic links between management units. Centres for artificial insemination are the main distributers of boar semen for large scale farms in Croatia, as well as for family farms. However, some large scale farms and family farms conduct their own selection of gilts and boars, so the expected degree of connectedness for such herds with other herds is low.

Genetic links (connectedness) between management units are of great importance for reliable genetic evaluation. Higher degree of connectedness between management units reduces prediction error variance (PEV) of difference in estimated breeding values (EBV) and therefore increases the reliability of comparison between selection candidates from different management units. Lewis *et al.* (2005) measured connectedness in sheep through PEV of breeding values and showed that the joint analysis of (almost) dis-connected management units did not markedly decrease PEV in comparison to the separate analysis of connected management units

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even though the increase in number of included phenotype records was substantial.

Several approaches of assessing the connectedness among management units have been proposed in the past decades (e.g., Foulley *et al.*, 1992; Kennedy and Trus, 1993; Laloe *et al.*, 1996). Kennedy and Trus (1993) described in detail the effect of connectedness on the reliability of comparisons of EBV. Since computation of PEV of difference in EBV is computational intensive they proposed three alternative methods for measuring connectedness: gene flow, drift variance, and variance of management unit effect estimates. The last method had the highest correlation with the PEV of difference in EBV. Since computing the average PEV of all pair wise EBV differences between animals for every possible pair of herds is computationally demanding and time consuming, Mathur *et al.* (1998, 2002) extended the work of Kennedy and Trus (1993) by introducing a connectedness rating, which is essentially a correlation between management unit effect estimates. They used this criterion to measure connectedness among pig herds in Canada.

Connectedness between management units can be most efficiently created by using a set of common sires, likely via semen. Therefore, artificial insemination has not only an important role in modern pig production for spreading genetic progress among herds within breeding programmes (e.g., Sun et *al.,* 2008) but also to create genetic links between herds. Centres for artificial insemination are the main distributers of boar semen on large scale farms in Croatia, as well as on family farms. However, some large scale farms and family farms conduct their own selection of gilts and boars, so the expected degree of connectedness for such herds with other herds is low.

Genetic links between management units have still not been analysed for herds in the National breeding program in Croatia. Therefore, the aim of this study was to analyse connectedness between management units (large scale farms and family farms) in population of Landrace pigs under Croatian breeding program using gilt field test records for backfat thickness.

2 MATERIAL AND METHODS

Data records from field test in gilts from 2005 to 2008 on four large scale farms and 56 family farms were provided by the Croatian Agricultural Agency. Altogether 4,930 records for gilts of Landrace breed were collected. About 5% of records were excluded during data filtering (missing and non-logical values). The final number of records per management unit is shown in Table 1.

Backfat thickness was analysed using the following statistical model:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z}_l\mathbf{l} + \mathbf{Z}_a\mathbf{a} + \mathbf{e}\,, \qquad (1)$$

where **y** is the vector of phenotype observations for backfat thickness, **b** is a vector of unknown parameters for fixed effects (herd-year-season), **l** and **a** are vectors of unknown parameters for common litter environment and additive genetic (animal) effect, and **e** is a vector of residuals, while **X**, $\mathbf{Z}_l$, and $\mathbf{Z}_a$ are design matrices linking phenotype records with corresponding parameters. Model assumptions were:

$$\mathbf{E} = \mathbf{Xb},\ \ \mathbf{l} \sim N(\mathbf{0}, \mathbf{I}\sigma^2_l),\ \ a \sim N(\mathbf{0}, \mathbf{A}\sigma^2_a),\ \ e \sim N(\mathbf{0}, \mathbf{I}\sigma^2_e), \qquad (2)$$

where **A** is the numerator relationship matrix. The mixed model equations (MME) for the corresponding model (1) are:

$$\begin{bmatrix} \mathbf{X}^T\mathbf{X} & \mathbf{X}^T\mathbf{Z}_l & \mathbf{X}^T\mathbf{Z}_a \\ \mathbf{Z}_l^T\mathbf{X} & \mathbf{Z}_l^T\mathbf{Z}_l + \mathbf{I}\sigma_e^2\sigma_l^{-2} & \mathbf{Z}_l^T\mathbf{Z}_a \\ \mathbf{Z}_a^T\mathbf{X} & \mathbf{Z}_a^T\mathbf{Z}_l & \mathbf{Z}_a^T\mathbf{Z}_a + \mathbf{A}^{-1}\sigma_e^2\sigma_a^{-2} \end{bmatrix} \begin{bmatrix} \mathbf{h} \\ \mathbf{l} \\ \mathbf{a} \end{bmatrix} = \begin{bmatrix} \mathbf{X}^T\mathbf{y} \\ \mathbf{Z}_l'\mathbf{y} \\ \mathbf{Z}_a'\mathbf{y} \end{bmatrix} \qquad (3)$$

By setting $\mathbf{W} = [\mathbf{X}\ \mathbf{Z}_l\ \mathbf{Z}_a]$ and $\mathbf{m}^T = [\mathbf{h}^T\ \mathbf{l}^T\ \mathbf{a}^T]$ the MME can be rewritten as:

$$\mathbf{W'W\,m} = \mathbf{W'y}. \qquad (4)$$

Table 1: *Number of records by management units (A-D – large scale farms and F – a group of family farms)*

Farm	N
A	1,042
B	476
C	846
D	741
F	1,825
Total	4,930

The above system was solved using the PEST program (Groeneveld *et al.*, 1990) in order to obtain estimated breeding values (EBV) and prediction error variances (PEV). Variance components were obtained in previous studies and were equal to 0.81 for between litter variance, 1.63 for additive genetic variance and 1.34 for residual variance. Reliability of breeding values (r^2) was calculated as (e.g., Mrode, 2005):

$$r^2 = 1 - (\mathrm{PEV} / \sigma^2_a). \qquad (5)$$

To evaluate connectedness between pig management units, connectedness rating criterion (Mathur *et al.*,

1998) was used. The connectedness rating (CR) between herds *i* and *j* is defined formulas a correlation between estimates and for herd *i* and herd *j*, respectively, obtained from solving the MME (3):

$$CR = \frac{\mathrm{cov}(\hat{h}_i, \hat{h}_j)}{\sqrt{\mathrm{var}(\hat{h}_i)\mathrm{var}(\hat{h}_j)}}. \quad (6)$$

The calculation of the variances and covariances in (4) requires the elements of the inverse of the coefficient matrix of mixed model equation corresponding to the herd effects. Due to the computational complexity of obtaining the complete inverse directly for large data sets, Mathur *et al*. (2002) used the following equalities:

$$\mathbf{W}^T\mathbf{W}\ (\mathbf{W}^T\mathbf{W})^{-1} = \mathbf{I} \quad (7)$$

and

$$\mathbf{W}^T\mathbf{W}\ (\mathbf{W}^T\mathbf{W})_i^{-1} = \mathbf{I}_i \quad (8)$$

where $(\mathbf{W}^T\mathbf{W})_i^{-1}$ is a part of coefficient matrix $\mathbf{W}^T\mathbf{W}$ with all the values set to zero except for the block that involves management units *i*, and $\mathbf{I}_i$ is an identity matrix with nonzero diagonal values only for the corresponding management units *i.* By solving the above system of equations (7) the required elements for the calculation of CR can be obtained (5). This was done using the program for calculating CR (Mathur *et al.*, 1998). The average CR between one management unit and all other management units can be defined as the average of CR with all other herds in analysis.

3 RESULTS AND DISCUSSION

Connectedness ratings between the latest herd-year-season classes in data set are shown in Table 2. The use of herd-year-season classes instead of herd classes enables the analysis of the latest status regarding the connectedness. The highest connectedness rating was noticed between farm D and family farms (CR = 0.035), while the lowest value of connectedness rating was found between farms D and A (CR = 0.004).

Table 2: *Connectedness rating between pig management units for Landrace pigs*

Management units	A	B	C	D
B	0.011			
C	0.021	0.031		
D	0.004	0.007	0.012	
F (family farms)	0.019	0.016	0.027	0.035

Large scale farms in Croatia have intensive and usually isolated systems without direct exchange of genetic material with other farms. However, observed genetic links between some farms, especially B and C, are a due to using the semen of common sires from the centres for artificial insemination, and not due to the direct transfer of genetic material from one farm to another. Centres for artificial insemination are the main distributors of imported genetic material in Croatia and therefore, there is possibility of using the same semen on two or more management units. Connectedness between farms C and D with family farms is on the other hand also due to the transfer of young breeding animal from the farms C and D to family farms – a common practice for family farms. While analysing field test data from the Canadian national swine database, Mathur *et al*. (1998) recommended that for backfat thickness the average CR between a certain management units and all other units should be 3% to ensure reasonably reliable comparison of EBV between management units. According to this criterion, genetic evaluation results in Croatia should not be compared across all management units, because there average connectedness ratings were never higher than 3% (Table 3).

Table 3: *Average and maximum connectedness rating between management units*

Management units	Average	Maximum
A	0.014	0.021
B	0.016	0.031
C	0.023	0.031
D	0.023	0.035
F (family farms)	0.024	0.035

Reliability of EBVs depends on the amount of information and level of connectedness. In the case of well connected herds, reliability of EBV is higher when joint evaluation is done, due to increase in the number of phenotype records included in evaluation. However, if herds are poorly connected no increase in reliability is expected as information between from one management unit does not contribute to other management units – due to lack of genetic links. Average reliability in analysis of our data was between 0.21 to 0.29 when separate analyses were done (Table 4). The lowest average reliability was found for farm B, while group of family farms had the highest average. When joint genetic evaluation was performed, the increase of average reliability was found in all management units. However, the observed increase was mod-

Table 4: *Average reliability of prediction in management units*

Management units	N	Reliability		
		Separate analysis	Joint analysis	Difference
A	1,042	0.28	0.37	0.09
B	476	0.21	0.31	0.10
C	846	0.26	0.33	0.07
D	741	0.27	0.38	0.11
F (family farms)	1,825	0.29	0.38	0.09

erate. This increase indicates that there are some genetic links between management units, but there is a need to strengthen these links.

Although artificial insemination represents reasonable source of genetic material in Croatian breeding programme, it is necessary to improve system in order to increase connectedness between management units and to use semen of a larger number of common boars on more management units. In order to achieve higher level of connectedness among herds, some breeders should allow access to semen of their boars. However, inadequate organization of artificial insemination might be a barrier to increase level of connectedness. Also, some large scale farms, and especially family farms, still do not use artificial insemination to a large extent. Large scale farms buy semen from centres for artificial insemination, but they also perform their own selection, and this genetic progress is not transferred/shared between them. To increase connectedness between management units, and consequently reliability of EBVs, it is necessary to extend the use of common boars with high breeding values through artificial insemination. Due to lack of connectedness between management units and a small increase in the reliability of EBVs, results of a joint genetic evaluation can not be used across all management units but only within, with potential exception between large scale farm D and family farms. In additions to connectedness the amount and quality of data should be improved as well.

4 CONCLUSIONS

The range of values of CR between management units within the National breeding programme in Croatia was between 0.004 and 0.035. The connectedness rating was the highest between farm D and family farms. Results from the genetic evaluation across all farms should be used with care or mainly within managements units because average connectedness rating was less then 3% for all management units. Reliability of prediction of breeding values increased in all management units when joint evaluation was done, but the increase was moderate. In order to increase connectedness between management units, organization of artificial insemination should be improved and intensified. Future work should implicate evaluation of connectedness in other maternal and terminal breeds of pigs in the Croatian National pig breeding programme. Also, connectedness should be evaluated within the group of family farms.

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