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The Connectedness on Large White and Landrace in Regional Joint Breeding System in Beijing

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Abstract: Connectedness between herds plays a very important role in cross-herd genetic evaluation in pig breeding. The connectedness between herds in Beijing region was evaluated to assess the efficiency of regional joint breeding system in China. In current study, data on age at 100 kg in Large White and Landrace were collected and Connectedness Rating (CR) method was employed to measure the connectedness between herds. Results showed that most herds have genetic connection with other herds. There were 17 and 10 herds, out of totally 19 and 13 herds of Large White and Landrace, respectively were connected with at least one other herd within breed. However, the average CR in Beijing was relatively low (0-4.80%), the strong connectedness only existed among few herds; therefore, regional cross-herd genetic evaluation by far is not practicable. More intense efforts are needed to establish and enhance the connectedness between herds by means of extensive use of Artificial Insemination (AI), together with promotion of other activities on breed registration, performance test, etc.

Key words: Connectedness rating, cross-herd genetic evaluation, joint breeding system, breed registration, performance test, efficiency

INTRODUCTION

The joint evaluation by combining performance data from all available herds had been proved effective in pig breeding and carried out widely. Based on this system, the comparison of genetic evaluation among different herds will be more reasonable. However, the accuracy of this cross-herd evaluation could be very much affected by the connectedness between herds. The higher connectedness between herds, the more accurate the comparison of estimate breeding values cross-herds will be (Zhang *et al*., 2004).

Currently, several methods have been developed to measure the degree of connectedness. Foulley *et al*. (1990, 1992) presented a Connectedness Index (CI). Laloe (1993) introduced the concept of generalized Coefficient of Determination (CD). Fries (1998) proposed a very simple measurement of connectedness using the number of direct genetic links between herds such as common sires and dams used while it ignored the indirect links and the links derived from common environment, usually resulting in the underestimation of connectedness. Kennedy and Trus (1993) argued that the most appropriate measure of connectedness would be the average Prediction Error Variance (PEV) of differences in EBVs between animals, since the objective of measuring connectedness was to obtain an indication of the accuracy as well as the bias of comparisons between EBVs in different herds.

Laloe *et al*. (1996) further made a comprehensive comparison of PEV with CI and CD and suggested that CD could be a better option to assess the connectedness as it combining aspects of genetic variability and PEV. While the calculation of PEV and CD required the inverse corresponding to the animal effects in the coefficient matrix of the Mixed Model Equations (MME).

This matrix is usually huge and its inverse is very difficult to be handled even with high performance computer. To solve this encumbrance, Mathur *et al*. (1998, 2002) presented Connectedness Rating (CR), expressed as the correlation between the estimates of herd effects to estimate connectedness. CR had been proved strongly related to PEV and less depended on herd size and

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variation and can be easily calculated (Mathur *et al*., 2002). This method has been routinely used in the national swine genetic evaluation in Canada. In China, a national swine improvement program had been carried out since 1998, aiming to set up regional joint breeding system first and then expand to a nation-wide system. The connectedness among herds is a touchstone to evaluate the effectiveness of the joint swine breeding system in China to determine the feasibility of regional and national cross-herd genetic evaluation.

In current study, data of breeding herds from a representative region in China where the joint swine breeding system has been established since 1999 were collected to analyze the degree of connectedness among herds.

MATERIALS AND METHODS

Data: The records on age at 100 kg of Large White and Landrace from different herds in Beijing were collected. With a criterion of minimum 100 records in each herd, 29988 records in total were left including 22841 records from 19 Large White herds and 7147 records from 13 Landrace herds, respectively. The birth year of pigs spread between 1999 and 2009.

Model: The linear animal model used to analyze the data sets for each breed was as followed:

$$y = Xh + Za + e \quad (1)$$

Where:

y = A vector containing age at 100 kg
h = A vector of fixed herd effects with a design matrix X
a = A vector of random animal additive genetic effects with a design matrix Z
e = A vector of residual errors.

The expectation and variance of the random variables are as followed:

$$E\begin{bmatrix} a \\ e \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix},\ Var\begin{bmatrix} a \\ e \end{bmatrix} = \begin{bmatrix} A\sigma_a^2 & 0 \\ 0 & I\sigma_e^2 \end{bmatrix} \quad (2)$$

where, σ^2_a and σ^2_e represent additive genetic variance and residual variance, respectively and A the numerator relationship matrix derived from pedigree. The Mixed Model Equations (MME) used to solve for h, a and e given A, X, y and Z are:

$$\begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}k \end{bmatrix}\begin{bmatrix} \hat{h} \\ \hat{a} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

where, $k = \sigma^2_e/\sigma^2_a$. For analyzing the connectedness, only the coefficient matrix on the left hand-side is needed.

Calculation of Connectedness Ratings (CR): Following arguments as presented by Mathur *et al*. (1998), CR is defined as the correlation between the estimates of herd effects. The CR between herd i and herd j is calculated as:

$$CR_{ij} = \frac{\text{cov}(\hat{h}_{ij})}{\sqrt{\text{var}(\hat{h}_i)\text{var}(\hat{h}_j)}} \quad (3)$$

where, $\hat{h}_i$ and $\hat{h}_j$ represent the estimated effects of herd i and herd j, respectively obtained from the MME.

$$\text{var}(\hat{h}_i),\ \text{var}(\hat{h}_j) \text{ and } \text{cov}(\hat{h}_{ij})$$

represent the variance and covariance of herd effects. The average CR for one herd is defined as the average of its CRs with all other herds.

The calculation of the variances and covariances requires the elements of the inverse of the coefficient matrix of MME corresponding to the herd effects. It is very difficult to obtain the inverse directly when the data set is large. Hence, Mathur *et al*. (1998, 2002) proposed the following procedure: Since,

$$W'W(W'W)^{-1} = I$$

Therefore,

$$W'W(W'W)_i^{-1} = I_i$$

Where W'W is the coefficient matrix of MME, I is an identity matrix, $(W'W)_i$ is a vector of corresponding to herd i and I_i is a vector of W'W the identity matrix corresponding to herd I. Solving Eq. 4 for herd i and herd j separately, the required elements for calculation of the variances and covariances in Eq. 3 can be obtained.

Usually the calculation of CR is complex using the procedure recommended by Mathur *et al*. (1998) because it needs the connection of several programs published at the website of the Canadian Center for Swine Improvement (http://www.ccsi.ca/connectedness).

And now, the new version of software package DMU (Madsen *et al*., 2010) can easily handle this difficulty, the calculation of CR is the byproduct of module DMU4 in DMU. Therefore, DMU was employed to calculate CR in current study.

RESULTS AND DISCUSSION

The average CR values for Large White and Landrace were shows in Table 1 and 2, respectively. Only the herds with an average CR greater than zero were given as they were connected with at least one other herd. In Large White, of the 19 herds analyzed there were 17 herds with average CR>0, the number of herds connected ranges from 4-16 and herd BJHD1 was connected with the highest number of other herds. The highest CR (46.9%) is found between herd BJHD1 and BJHD2. In addition, relative strong connections were also observed in 10 pairs of herds with their CR>10%.

Compared to Large White, the connectedness in Landrace was weak in general. Of the 13 herds analyzed, there were 10 herds with average CR greater than 0, the number of herds connected ranges from 2-6 and herd BBSCB was connected with the highest number of other herds.

The highest CR (38.4%) was also observed between herd BJHD1 and BJHD2 as in the case of Large White. Only quite few pairs of herds are found relative strong connections with CR>10%.

It was shown in Table 1 and 2 that herd BJHD1 and BJHD2 were mostly connected in both Large White and Landrace. A further analysis revealed that these two herds shared 56% common sires in Large White with 62.3% of their progeny in BJHD1 and 31.4% in BJHD2 and 43.0% common sires in Landrace with 33.4% of their progeny in BJHD1 and 59.8% in BJHD2. These two herds belong to one breeding corporation, therefore it is possible and convenient to make genetic exchange.

Table 1: Connectedness rating (%) between herds of Large White in Beijing

Herd code	No. of herds connected	Connectedness rating (%) Average	Connectedness rating (%) Maximum	Most connected herd
BBSCB	8	1.8	18.4	BBSCR
BBSCN	13	1.3	11.7	BJTZ1
BBSCR	11	3.1	33.1	BJCP1
BJCP1	12	2.5	33.1	BBSCR
BJDX1	12	1.7	14.3	BJXD1
BJFS1	13	1.9	10.6	BJXD1
BJHD1	16	4.4	46.9	BJHD2
BJHD2	14	3.6	46.9	BJHD1
BJHD5	4	0.1	0.9	BJHD1
BJLM1	10	0.2	1.0	BJHD1
BJPG1	9	0.4	3.4	BJXD1
BJTZ1	14	2.5	13.9	BJXD1
BJXD1	14	4.8	19.5	BJXD2
BJXD2	15	2.0	19.5	BJXD1
BJXL1	7	0.1	0.4	BJXD1
BJZD2	13	0.4	2.1	BJXD1
BJZY1	15	3.5	19.7	BJHD1

Herd BAOF1 and BJMY1 are not listed as they were not connected with any other herd

It indicated that the more connection one herd had with other herds normally the higher average CR this herd obtained. For instance, BJHD1 was connected with 16 herds and its average CR reached 4.4% while BJHD5 was only connected with 4 herds, the value of its average CR was close 0.

Mathur *et al*. (1998, 2002) recommended that for backfat and age at 100 kg, a minimum average CR of 3% would be required to ensure a reasonably accurate comparison of EBVs between herds. According to this criterion, the cross-herd genetic evaluation for Large White and Landrace in Beijing is not feasible at present while a quite few groups of herds within which the average CR of one herd with other herds was >3% could be grouped to implement cross-herd genetic evaluation. As shown in Table 3, there were 5 groups for Large White and 3 groups Landrace, respectively, Recommended for cross-herd genetic evaluation in Beijing.

Showed by current study, not all herds in Beijing could meet the requirement of minimum average CR of 3% and the joint genetic evaluation across Beijing is not practicable at this moment, however the genetic connectedness in Beijing had been improved compared to the result reported by Sun *et al*. (2009). They analyzed the field data on age at 100 kg from 36 herds in China, pigs were born between 1998 and 2005.

Sun *et al*. (2009) demonstrated that the genetic connectedness in Beijing was higher than those in other regions, the number of connected herds was 9 for Large White and 2 for Landrace, respectively. In current study, the genetic connectedness existed in 17 Large White herds and 10 Landrace herds after 4 years continuous effort in establishment of joint breeding system in Beijing.

The genetic connectedness between herds can be increased by following means: promoting cross-herd utilization of superior boars through extensively AI

Table 2: Connectedness rating (%) between herds of Landrace in Beijing

Herd code	No. of herds connected	Connectedness rating (%) Average	Connectedness rating (%) Maximum	Most connected herd
BBSCB	6	2.7	18.4	BBSCR
BBSCN	5	2.9	18.4	BJTZ1
BBSCR	4	3.1	25.7	BJCP1
BJCP1	4	2.5	25.7	BBSCR
BJTZ1	3	1.6	12.7	BBSCN
BJDX1	3	0.7	5.8	BJTZ1
BJHD1	2	3.2	38.4	BJHD2
BJHD2	2	3.2	38.4	BJHD1
BJHD5	2	0.1	0.5	BJHD1
BJZD2	3	0.1	0.5	BBSCR

Herd BJCZ1, BJLM1 and BJMY1 are not listed as they are not connected with any other herd

Table 3: Recommended pig farm groups for joint genetic evaluation in Beijing

Breed/group	1	2	3	4	5
Large white	BJDX1, BJFS1, BJHD1, BJHD2, BJTZ1, BJXD1, BJXD2, BJZY1	BBSCB, BBSCR, BJCP1	BJXD1, BJPG1	BBSCN, BBSCB	BBSCN BJTZ1
Landrace	BBSCB, BBSCN BBSCR, BJCP1	BJTZ1, BJDX1	BJHDI BJHD2		

system, exchanging boars across herds, strengthening connections between herds through central test station (Mathur *et al*., 2002; Mathur, 2005). Based on an extensive AI system, the connectedness can be improved by exchanging semen between herds or by forming a pool of superior AI boars and obtaining a sufficient proportion of progeny from these animals.

Although, boar station in China is still in initial stage, it has experienced a rapid development. There are three boar stations in Beijing by far since the first typical commercial one founded in 2001 which is also the first one in China. The covering rate of AI technique had been dramatically increased from 10% in 2002 to 73% in 2009. However, the semen from AI stations is more widely used in commercial farms while natural mating is more dominant in most of breeding farms as the closed breeding strategy still widely practiced in swine breeding in China. This situation held back the gene flow of superior boars and to build connectedness between herds.

In Beijing currently there are two swine performance test stations while the role of test stations in promoting connectedness between farms was limited due to the limited scale of test stations. The exchange of boars among closely connected herds was illustrated by Sun *et al*. (2009) and actually a quite high proportion of boars and sows in most herds in Beijing were mainly purchased from herd BJXD1, BJHD1, BBSCN and BBSCR. The frequent sales of boar and sow in fact played most important role in increasing genetic connectedness.

Although some achievements have been obtained, currently, the pig genetic improvement system was not completely contructed, lots of fundamental administration such as breed registration and performance test needed further improvement. There is long way to go in the improvement of connectedness in Beijing. Following schemes were suggested to be implemented in establishment of joint breeding system. To standardize pig registration to maintain the unique identification of pig through their lifetime, To enlarge field data of performance test to improve the accuracy of genetic evaluation, To make full use of test station in selecting top boars and to increase popularity of AI technique and To form a pool of superior AI boars and build a profit-sharing mechanism in stimulating the enthusiasm of breeders to participate the joint breeding system.

CONCLUSION

Current study showed that most herds have genetic connection with other herds, however the levels of average connectedness between pig breeding herds in Beijing were generally low, ranging from 0-4.8%. Regional cross-herd genetic evaluation in entire Beijing is not feasible at present. However cross-herd genetic evaluation can be conducted within groups containing herds with average connectedness rating >3%. In the further, great efforts are needed in extensive using of AI technique, implementing pig registration, enlarging scale of performance test, efficient using test station and forming a pool of superior AI boars to enhance the connectedness between herds and to increase the accuracy of cross-herd genetic evaluations.

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