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Estimation of Breed Effects on Litter Traits at Birth in Yorkshire and Landrace Pigs

Chittima KANTANAMALAKUL[1,2], Panwadee SOPANNARATH[1] and Sornthep TUMWASORN[1]

[1]Department of Animal Science, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand
[2]School of Agricultural Extension and Cooperatives, Sukhothai Thammathirat Open University, Pakkred, Nonthaburi 11120, Thailand

ABSTRACT

The purpose of this study was to estimate breed effects on litter traits at birth in the Yorkshire and Landrace breeds at a commercial swine farm in central Thailand. A total of 14,097 litters from 2002 to 2006 were analyzed using a GLM procedure. The least squares means analysis showed that the mating group between Landrace sows and Yorkshire boars had a significantly ($P < 0.05$) larger number of live piglets, of heavier weight than purebred piglets. The crossbreeding between the Yorkshire and Landrace breeds resulted in a lower number of mummified and stillborn piglets. Estimation of breed effects found that the effect of the Landrace sows was highly significant ($P < 0.01$) on the total number of piglets born, number of piglets born alive, number of mummified piglets and litter weight. The breed effect of the Landrace boars was significant ($P < 0.05$) on the total number of piglets born and highly significant ($P < 0.01$) on the number of mummified piglets. Heterozygosity coefficient of piglets was highly significant ($P < 0.01$) increasing the number of piglets born alive (0.30 pigs/litter) and litter weight (0.23 kilograms/litter) while decreasing the number of stillborn piglets (0.16 pigs/litter).

Keywords: Pig, litter traits, breed effects

INTRODUCTION

Crossbreeding is a useful tool for increasing the efficiency of swine production. Full benefits from crossbreeding can be gained by careful selection among and combination of available breeds. The systematic and well-planned crossbreeding programs enable farmers to take advantage of heterosis and breed differences. Heterosis is the superiority of crossbred animals over the average of their purebred counterparts. Desirable characteristics of different breeds can be utilized if some breeds can be identified as good paternal and maternal breeds. Males from paternal breeds with superior growth and carcass that are mated to females from maternal breeds with superior reproduction and mothering ability can take advantage of the strengths of both breeds while minimizing some of weaknesses [1].

Heterosis tends to be large for traits with low heritability such as litter size, litter weaning weight and pig survival rate [2]. Growth traits are moderately heritable but also can be improved by suitable crossbreeding [3,4]. Carcass traits are highly heritable and show little heterosis [5,6]. Choice of breeds for systematic crossbreeding programs should be based on the average differences between breeds. The genetic composition of breeds and the frequency of desirable gene combinations do change over time [7]. Therefore, the evaluation of crossbreeding research results should include the magnitude of additive effects and heterosis that provide information regarding the potential impact one may expect to produce by choosing the breeds and the manner of combining them in a crossbreeding program [8].

The purpose of this study was to estimate the breed effect of sows and boars including the effect of heterozygosity in piglets on litter traits at birth of Yorkshire and Landrace pigs raised in central Thailand.

MATERIALS AND METHODS

Data description

Data used in this study were collected from a commercial swine farm in central Thailand. A total of 14,097 records of litter traits from 1,670 Yorkshire and Landrace sows were analyzed. The data was obtained during 2002 to 2006. Traits of interest were the total number of piglets born (TB), number of piglets born alive (BA), number of mummified piglets (MM), number of stillborn piglets (SB) and litter weight born alive (LWBA). The total number of piglets born was the sum of number of piglets born alive, number of mummified piglets and number of stillborn piglets. The definition of a mummified piglet in this study was a piglet found dead before the sow at farrowing and a stillborn piglet was a piglet found dead behind the sow at or immediately after farrowing. Breeds of sow, boar and piglet, parity, housing for sow and farrowing dates were recorded. Breeds of sow and boar were purebred Yorkshire and Landrace breeds while breeds of piglets were purebred and crossbred. Parities were grouped into 9 classes (1, 2, 3, 4, 5, 6, 7, 8 and 9 - 16). Four-month farrowing periods were grouped into 3 seasons: the summer season from March to June, rainy season from July to October and winter season from November to February [9].

Farm Management

The breeding stock was either obtained from replacement herds or aboard. The gilts with teat numbers more than 14 teats and young boars were performance tested from 10 to 22 weeks of age by body weighing. They were selected on the estimated breeding value for total number of piglets born. Replacement gilts were mated at a minimum age of 32 weeks and on the second observed estrous or later. The mating design was two-breeds involving the Yorkshire and Landrace breeds. Purebred boars were mated to purebred females via artificial insemination to produce purebred and crossbred piglets. All mating groups (Y x Y, LR x LR, Y x LR and LR x Y) were mated at random. Sows were culled on the eighth parity or after according to their reproductive performance (total number of piglets born < 12 pigs per litter).

There were three houses for sows to stay during gestation and lactation. The difference among houses was that the roof of the third house had aluminium sheeting as insulation while the other houses did not have insulation. All houses were open buildings and allowed one labor per house. Each sow was kept in an individual stall during mating and in individual farrowing pens during farrowing and lactation period. The boar was kept in an individual pen in an evaporating cooling system building. Boars and sows were fed of the same composition at all stages of the reproductive cycle. The feed contained approximately 16 % crude protein and 13 MJ of digestible energy per kilogram as-fed basis. Boars were fed 2 kilogram per day. Sows were given the limit-fed at 2 kilogram per day during gestation and were given *ad libitum* access to the same diet during lactation.

Statistical analysis

Data were analyzed by the SAS program [10]. Descriptive statistics were obtained by the MEANS procedure. Fixed effects and covariates as shown in **Table 1** were examined for their significance in univariate models using a GLM procedure. The multiple comparisons of traits between different mating groups were obtained through the LSMEANS statement in the GLM procedure. The statistical models were,

a) Total number of piglets born and number of piglets born alive

$$y_{ilklm} = \mu + m_i + p_j + h_k + f_l + e_{ijklm}$$

b) Number of mummified piglets and number of stillborn piglets

$$y_{ilklm} = \mu + m_i + p_j + h_k + f_l + b_1(tb - \overline{tb}) + e_{ijklm}$$

c) Litter weight born alive

$$y_{ilklm} = \mu + m_i + p_j + h_k + f_l + b_2(ba - \overline{ba}) + e_{ijklm}$$

where

y_{ijklm}	is the observed value
μ	is the overall means
m_i	is the fixed effect of i^{th} mating group (i = YxY, LRxLR, YxLR, LRxY)
p_j	is the fixed effect of j^{th} parity (j = 1, 2, 3,…, ≥ 9)
h_k	is the fixed effect of k^{th} house (k = 1, 2, 3)
f_l	is the fixed effect of combination of l^{th} farrowing year-season (season = summer, rainy, winter; year = 2002, 2003, 2004, 2005, 2006)
b_1	is the regression coefficient of y_{ijklm} on total number of piglets born (TB)
b_2	is the regression coefficient of y_{ijklm} on number of piglets born alive (BA)
e_{ijklm}	is random error (~ NID (0, σ^2_e))

Table 1 Fixed effects and covariates included in the statistical models.

Fixed effect/covariate	Trait				
	TB	BA	MM	SB	LWBA
Mating group	√	√	√	√	√
Parity	√	√	√	√	√
Housing	√	√	√	√	√
Year x season at farrowing	√	√	√	√	√
TB	-	-	√	√	-
BA	-	-	-	-	√

TB = total number of piglets born, BA = number of piglets born alive, MM = number of mummified piglets, SB = number of stillborn piglets, LWBA = litter weight born alive
√ = this effect was included in the analysis
- = this effect was excluded from the analysis

Estimation of breed effects on litter traits followed that conducted by Koger *et al* [11] and Kahi *et al* [12]. The breed effects of sows and boars were estimated from coefficients of expected breed content in the sows (x_1) and in the boars (x_2). The heterozygosity coefficients were estimated from heterozygosity in the piglets (x_3) that were set values for F_1 crossing at 1 and purebreds at zero. The coefficients of expected breed content and heterozygosity are shown in **Table 2**.

There were three models for the estimation of breed effects. These models included component effects and factors affecting traits except mating group. The models used are as follows:

a) Total number of piglets born and number of piglets born alive

$$y_{ilkl} = \mu + p_i + h_j + f_k + a_1x_1 + a_2x_2 + hx_3 + e_{ijkl}$$

b) Number of mummified piglets and number of stillborn piglets

$$y_{ilkl} = \mu + p_i + h_j + f_k + b_1(tb - \overline{tb}) + a_1x_1 + a_2x_2 + hx_3 + e_{ijkl}$$

c) Litter weight born alive

$$y_{ilkl} = \mu + p_i + h_j + f_k + b_2(ba - \overline{ba}) + a_1x_1 + a_2x_2 + hx_3 + e_{ijkl}$$

where,

y_{ijkl} is the observed value
μ is the overall means
p_i is the fixed effect of ith parity (i = 1, 2, 3,…, ≥ 9)
h_j is the fixed effect of jth house (j = 1, 2, 3)
f_k is the fixed effect of combination of kth farrowing year-season (season = summer, rainy, winter; year = 2002, 2003, 2004, 2005, 2006)
b_1 is the regression coefficient of y_{ijkl} on total number of piglets born (TB)
b_2 is the regression coefficient of y_{ijkl} on number of piglets born alive (BA)
a_1, a_2 are the sow and boar breed effects of expected breed content (x_1, x_2) received from the Landrace breed
h is the heterozygosity coefficient of expected heterozygosity in the piglet (x_3)
e_{ijkl} is random error (~ NID (0, σ^2_e))

Table 2 The expected breed contents (x_1 and x_2) and expected heterozygosity (x_3).

Breed[1]			Breed content[2]		Heterozygosity (x_3)[3]
Sow	**Boar**	**Piglet**	**Sow (x_1)**	**Boar (x_2)**	
Y	Y	Y x Y	0	0	0
	LR	Y x LR	0	1	1
LR	Y	LR x Y	1	0	1
	LR	LR x LR	1	1	0

[1]Y = Yorkshire, LR = Landrace
[2]x_1 = proportion of the Landrace breed in the sow, x_1 = proportion of the Landrace breed in the boar
[3]x_3 = proportion of heterozygosity in the piglet

RESULTS AND DISCUSSION

Descriptive Statistic

Descriptive statistics of the traits analyzed in this study are given in **Table 3**. The overall means on TB, BA, MM, SB and LWBA were found to be 11.06, 9.87, 0.39 and 0.81 pigs, respectively and 15.77 kilograms. The mean value of SB in this study was higher than those were reported by Tantasuparuk *et al* [9] and Imboonta [13]. The high number of stillborn piglets might be related to the breeding goal of this farm that aimed to improve litter size as Johnson *et al* [14] concluded that selection on litter size also showed an increase in the number of stillborn piglets.

Table 3 Number of records, mean, standard deviation (SD), minimum (Min) and maximum (Max) of litter traits.

Trait	No. of records	Mean	SD	Min	Max
TB (pigs)	14,097	11.06	2.84	1	26
BA (pigs)	14,097	9.87	3.11	1	20
MM (pigs)	14,097	0.39	1.34	0	17
SB (pigs)	14,097	0.81	1.35	0	14
LWBA (kilograms)	13,708	15.77	4.50	1	30

TB = total number of piglets born, BA = number of piglets born alive, MM = number of mummified piglets, SB = number of stillborn piglets, LWBA = litter weight born alive

Fixed Effect Testing

The levels of significance for fixed effects and covariates are summarized in **Table 4**. The effects of the mating group, parity, housing and a combination of farrowing season and year were highly significant ($P < 0.01$) for TB, BA, MM, SB and LWBA. The TB and BA increased with parity number 1 to 5 and declined afterwards. These findings agreed with previous studies [9,15]. According to Ten Napel *et al* [16], selection for production and reproduction traits may lead to a limited feed intake capacity, reduced body reserves at first farrowing and increased milk production. In addition, primiparous sows have attained only 40 to 50 % of their final mature size at the time of first conception [17]. Hence they must simultaneously produce milk for the first litter and continue to grow. This study showed low SB in the second and the third parity which agreed with report of Imboonta [13] while MM was low between the fourth and the seventh parity. Litter sizes at birth of sows living in house number 3 were less than others while SB was high. These findings might be the effect of differences in environmental conditions within the houses and farmer’s skills. The largest litters were found from sows farrowed in the summer season (March to June). These sows were mated during the winter season where the ambient temperature was lower. Gourdine *et al* [18] reported that sows did not suffer from heat stress at lower temperatures. Furthermore, Quiniou and Noblet [19] confirmed that sows would consume less feed intake in the summer season.

In this study it was found that TB had a highly significant effect on MM and SB ($P < 0.01$) while BA was highly significant ($P < 0.01$) for LWBA.

Table 4 The levels of significance for fixed effects and covariates.

Effect and covariate	Trait				
	TB	**BA**	**MM**	**SB**	**LWBA**
Mating group	**	**	**	**	**
Parity	**	**	**	**	**
Housing	**	**	**	**	**
Year x season at farrowing	**	**	**	**	**
TB	-	-	**	**	-
BA	-	-	-	-	**

TB = total number of piglets born, BA = number of piglets born alive, MM = number of mummified piglets, SB = number of stillborn piglets, LWBA = litter weight born alive
** = $P < 0.01$
- = this effect was excluded from the analysis

Least squares means for traits

Least squares means of all traits and the significant ($P < 0.05$) differences between mating groups are shown in **Table 5**. The mating type between the Landrace sows with the Yorkshire boars had significantly ($P < 0.05$) more BA and LWBA than others. The crossbred litters from the Yorkshire and Landrace breeds showed significantly ($P < 0.05$) lower numbers of piglets died by mummification and stillbirth than the purebred Landrace litters. These indicated the advantages for single cross litters over purebred litters on a greater litter size at birth. These findings were in accordance with earlier studies [20-26].

Table 5 Least squares means and standard errors for traits in four mating groups.

Mating group[1]		Trait[2]				
Sow	**Boar**	**TB (pigs)**	**BA (pigs)**	**MM (pigs)**	**SB (pigs)**	**LWBA (kg)**
Pure breed :						
Y	Y	10.40 ± 0.11^{c}	9.23 ± 0.12^{d}	0.34 ± 0.05^{b}	0.93 ± 0.05^{ab}	14.99 ± 0.10^{c}
LR	LR	11.47 ± 0.10^{a}	9.80 ± 0.11^{b}	0.60 ± 0.05^{a}	1.01 ± 0.05^{a}	15.94 ± 0.08^{b}
Two-breed :						
LR	Y	11.37 ± 0.04^{a}	10.13 ± 0.04^{a}	0.39 ± 0.02^{b}	0.80 ± 0.02^{b}	16.20 ± 0.03^{a}
Y	LR	10.66 ± 0.05^{b}	9.50 ± 0.05^{c}	0.39 ± 0.02^{b}	0.83 ± 0.02^{b}	15.18 ± 0.04^{c}

[1]Y = Yorkshire, LR = Landrace
[2]TB = total number of piglets born, BA = number of piglets born alive, MM = number of mummified piglets, SB = number of stillborn piglets, LWBA = litter weight born alive
[a,b,c,d] Least squares means without a letter in common are significantly different ($P < 0.05$).

Estimation of breed effect

The results of estimates of sow and boar breed effects and heterozygosity coefficient are shown in **Table 6**.

Sow breed effect Sow breed effects were highly significant ($P < 0.01$) for TB, BA, MM and LWBA. It indicated that the Landrace sows were superior to Yorkshire sows for almost traits except MM. According to Wu *et al* [27] and Borges *et al* [28], a greater occurrence of mummified foetuses in large litters was commonly attributed to insufficient uterine space to maintain the development and survival of foetuses. Hence, the Landrace breed with higher prolificacy (litter size) has a higher risk of foetal losses by mummification than the Yorkshire breed. The effect of the sow was estimated to be 0.61 pigs for BA and 0.98 kilograms for LWBA in agreement with reference values (−2.23 to 2.61 pigs for BA and −2.97 to 4.84 kilograms for LWBA [29-31]). The effect of the sow was generally small and found to be not significant for number of stillborn piglets.

Boar breed effect The boar breed had a major impact ($P < 0.05$) on TB with a value of 0.18 pigs. A highly significant ($P < 0.01$) effect was also found on MM. The results indicated the superiority on TB of the Landrace boars. On the other hand, BA, SB and LWBA of Landrace boars and the Yorkshire boars were not different. These might be due to the high standard errors of traits. In addition, the successful pregnancy was the delivery of a large number of viable piglets of satisfactory birth weight. There was a tremendous variability in sows in achieving this aim such as uterine space, hormones, disease, dietary requirements and the environment of the sows.

Heterozygosity coefficient The purpose of estimation of the heterozygosity coefficient in this study was to find out the effect of heterozygosity in piglets on the litter performance of the sow. The estimate of the heterozygosity coefficient was not the same as the estimated individual heterosis of each sow as reported in other studies

[26,29-32] which showed the heterosis effect to range from 0.31 to 2.60 pigs for BA and 0.28 to 3.73 kilograms for LWBA. The results in this study showed that heterozygosity in piglets had a significant ($P < 0.05$) influence on MM and had a highly significant ($P < 0.01$) influence on BA, SB and LWBA. The coefficient values of these corresponding traits per litter were found to be −0.08 pigs, 0.30 pigs, −0.16 pigs and 0.23 kilograms, respectively.

Table 6 Estimates and standard errors of breed effects and heterozygosity coefficient.

Effect[1]	**Trait**[2]				
	TB (pigs)	**BA (pigs)**	**MM (pigs)**	**SB (pigs)**	**LWBA (kg)**
a_1	0.89 ± 0.08**	0.61 ± 0.08**	0.13 ± 0.04**	0.02 ± 0.04	0.98 ± 0.07**
a_2	0.18 ± 0.08*	−0.03 ± 0.08	0.12 ± 0.04**	0.06 ± 0.04	−0.03 ± 0.07
h	0.08 ± 0.09	0.30 ± 0.09**	−0.08 ± 0.04*	−0.16 ± 0.04**	0.23 ± 0.07**

[1]a_1= Landrace sow breed, a_2 = Landrace boar breed, h = heterozygosity coefficient
[2]TB = number of total piglets born, BA = number of piglets born alive, MM = number of mummified piglets, SB = number of stillborn piglets and LWBA = litter weight born alive
* $P < 0.05$, ** $P < 0.01$

CONCLUSIONS

This study of crossbreeding utilizing the Yorkshire and Landrace breeds showed that sow breed significantly affected the total number of piglets born, number of piglets born alive and weight of all piglets born alive. The Landrace sows had better performance than the Yorkshire sows for these traits. The most significant boar breed effect ($P < 0.05$) was found in the total number of piglets born meaning that the Landrace boars had 0.18 born more pigs per litter than the Yorkshire boars. The highly significant heterozygosity coefficients ($P < 0.01$) indicated that crossing between the Yorkshire boars and the Landrace sows would yield larger litters, heavier pigs and lower piglet mortality.

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บทคัดย่อ

จิตติมา กันตนามัลลกุล[1,2] พรรณวดี โสพรรณรัตน์[1] และ ศรเทพ ธัมวาสร[1]

การประมาณค่าอิทธิพลเนื่องจากพันธุ์ต่อลักษณะครอกเมื่อคลอดในสุกรพันธุ์ยอร์คเชียร์และแลนด์เรซ

การศึกษาในครั้งนี้เพื่อประมาณค่าอิทธิพลเนื่องจากพันธุ์ต่อลักษณะครอกเมื่อคลอดในสุกรพันธุ์ยอร์คเชียร์และแลนด์เรซ ซึ่งเลี้ยง ณ ฟาร์มเอกชนแห่งหนึ่งในภาคกลางของประเทศไทย มีจำนวนข้อมูลทั้งหมด 14,097 ครอก ระหว่าง พ.ศ. 2545 ถึง 2549 จากการวิเคราะห์ค่าเฉลี่ยลิสสแควร์ของลักษณะครอกพบว่า การผสมข้ามระหว่างแม่พันธุ์แลนด์เรซและพ่อพันธุ์ยอร์คเชียร์ทำให้มีจำนวนลูกสุกรมีชีวิตต่อครอกและน้ำหนักลูกสุกรมีชีวิตต่อครอก มากกว่ากลุ่มอื่นอย่างมีนัยสำคัญทางสถิติ ($P < 0.05$) และการผสมข้ามระหว่างพันธุ์ทั้งสองส่งผลให้จำนวนมัมมี่และจำนวนลูกสุกรตายแรกคลอดลดลง จากการประมาณค่าอิทธิพลเนื่องจากพันธุ์พบว่า อิทธิพลเนื่องจากพันธุ์ในแม่พันธุ์แลนด์เรซมีผลต่อจำนวนลูกสุกรทั้งหมดต่อครอก จำนวนลูกสุกรมีชีวิตต่อครอก จำนวนมัมมี่ และน้ำหนักลูกสุกรมีชีวิตต่อครอก อย่างมีนัยสำคัญยิ่งทางสถิติ ($P < 0.01$) อิทธิพลเนื่องจากพันธุ์ในพ่อพันธุ์แลนด์เรซมีผลต่อจำนวนลูกสุกรทั้งหมดต่อครอกอย่างมีนัยสำคัญทางสถิติ ($P < 0.05$) และจำนวนมัมมี่อย่างมีนัยสำคัญยิ่งทางสถิติ ($P < 0.01$) และค่าสัมประสิทธิ์ของเฮทเทอโรไซโกซิตีในลูกส่งผลให้ลูกสุกรมีชีวิตเพิ่มขึ้น (0.30 ตัว/ครอก) และน้ำหนักลูกสุกรมีชีวิตเพิ่มขึ้น (0.23 กิโลกรัม/ครอก) ขณะที่ลูกสุกรตายแรกคลอดลดลง (0.16 ตัว/ครอก) อย่างมีนัยสำคัญยิ่งทางสถิติ ($P < 0.01$)

[1] ภาควิชาสัตวบาล คณะเกษตร มหาวิทยาลัยเกษตรศาสตร์ อำเภอกำแพงแสน จังหวัดนครปฐม 73140

[2] สาขาวิชาส่งเสริมการเกษตรและสหกรณ์ มหาวิทยาลัยสุโขทัยธรรมาธิราช อำเภอปากเกร็ด จังหวัดนนทบุรี 11120