Original Article

Genetic Associations between Stillbirth, Total Number of Piglets Born and Gestation Length in a Commercial Pig Farm

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Abstract

Data of purebred Landrace, Large White and their crossbreds taken from a commercial swine farm located in the north-eastern part of Thailand were used to evaluate the genetic associations of stillbirth with the total number of piglets born and gestation length. The analyses were base on 28,275 litters born from 2002 to 2006. Analysis was carried out with a multivariate animal model using average information REML procedures. Heritability estimates for stillbirth, the total number of piglets born and gestation length were 0.03±0.01, 0.03±0.01 and 0.16±0.01, respectively. The genetic correlation between the total number of piglets born and stillbirth was positive. The genetic correlation between the total number of piglets born and gestation length was negative. However, the genetic correlation between stillbirth and gestation length was not significantly different from zero. The correlation observed indicated that increasing the total number of piglets born through selection could result in more stillbirths and a shortened gestation length.

Keywords: genetic association, gestation length, total number of piglets born, sow, stillbirth

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บทคัดย่อ

ความสัมพันธ์ทางพันธุกรรมระหว่างลักษณะลูกตายแรกคลอด จำนวนลูกเกิดทั้งหมด และระยะเวลาในการอุ้มท้อง ในฟาร์มที่เลี้ยงสุกรแบบการค้าแห่งหนึ่ง

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ข้อมูลของสุกรพันธุ์แลนด์เรซ ลาร์จไวท์ และสุกรลูกผสมระหว่างพันธุ์แลนด์เรซและลาร์จไวท์ จากฟาร์มที่เลี้ยงสุกรแบบการค้าแห่งหนึ่งในภาคตะวันออกเฉียงเหนือของประเทศไทย ถูกใช้ในการประเมินความสัมพันธ์ทางพันธุกรรมระหว่างลักษณะลูกตายแรกคลอดกับจำนวนลูกเกิดทั้งหมด และระยะเวลาในการอุ้มท้องของแม่สุกร ทำการวิเคราะห์โดยใช้ข้อมูลของลูกสุกรที่คลอดตั้งแต่ปี พ.ศ. 2545 ถึง พ.ศ. 2549 จำนวน 28,275 ครอก วิเคราะห์โดยใช้แบบหุ่น multivariate animal model ด้วยวิธี average information REML ค่าอัตราพันธุกรรมของลักษณะลูกตายแรกคลอด จำนวนลูกเกิดทั้งหมด และระยะเวลาในการอุ้มท้อง มีค่าเท่ากับ 0.03±0.01, 0.03±0.01 และ 0.16±0.01 ตามลำดับ ค่าสหสัมพันธ์ทางพันธุกรรมระหว่างลักษณะจำนวนลูกเกิดทั้งหมดและลูกตายแรกคลอดมีค่าเป็นบวก ค่าสหสัมพันธ์ทางพันธุกรรมระหว่างลักษณะจำนวนลูกเกิดทั้งหมดและระยะเวลาในการอุ้มท้องมีค่าเป็นลบ อย่างไรก็ตามค่าสหสัมพันธ์ทางพันธุกรรมระหว่างลักษณะลูกตายแรกคลอดและระยะเวลาในการอุ้มท้องไม่มีนัยสำคัญทางสถิติ ผลจากค่าสหสัมพันธ์ทางพันธุกรรมแสดงให้เห็นว่า การคัดเลือกเพื่อเพิ่มจำนวนลูกเกิดทั้งหมดจะมีผลทำให้จำนวนลูกตายแรกคลอดเพิ่มขึ้น และระยะเวลาในการอุ้มท้องลดลง

คำสำคัญ: ความสัมพันธ์ทางพันธุกรรม ระยะเวลาในการอุ้มท้อง จำนวนลูกเกิดทั้งหมด แม่สุกร ลูกตายแรกคลอด

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Introduction

To date, the breeding objective in commercial swine herds is focused on increasing the total number of piglets born. Many researchers have reported the effectiveness of selection on litter size (Lamberson et al., 1991; Knap et al., 1993; Hanenberg et al., 2001). However, the selection on litter size leads to an increase in piglet mortality (Johnson et al., 1999) and a decrease in gestation length (Hanenberg et al., 2001). In addition, gestation length also influences the number of stillbirths, increasing the number of stillbirths at a short gestation length (Leenhouwers et al., 1999). Higher stillbirth has been found in later parities, which appear to be associated with a larger litter size, prolonged farrowing and a decline in the quality of uterus (Leenhouwers et al., 1999; Knol et al., 2002; Damgaard et al., 2003). Hence, selection on dam lines should consider the genetic correlation between the components of reproduction and mortality in pigs (Johnson et al., 1999; Rydhmer, 2000). It is, therefore, important to know the genetic determination of stillbirth and its relationship with the total number of piglets born and gestation length to guide the effectiveness of selection on litter size. The aim of this study was to evaluate the genetic parameters associated with stillbirth.

Materials and Methods

Animals used in this study were raised in a standard farm registered with the Department of Livestock Development, Ministry of Agriculture and Cooperatives, Thailand. Data used in this study were collected from a commercial farm located in the north-eastern part of Thailand and taken between 2002 and 2006. Data on Landrace (LR), Large White (LW) and their crosses were used to evaluate genetic parameters of stillbirth, the total number of piglets born and gestation length. Reciprocal crosses between LR and LW were 50LR (LR-sire and LW-dam) and 50LW (LW-sire and LR-dam). Crosses of 50LR or 50LW with LR-sire and LW-sire were 75LR and 75LW, respectively. Gilts were selected on the basis of their phenotypic results (average daily gain and feed conversion ratio) and also considered from individual breeding value sow productivity (BVSP). The BVSP was calculated from the number of parity, the adjusted live born litter size and the adjusted 21-day litter weight according to the formula of the Pigchamp program (PigCHAMP, 1996).

Sows were kept in evaporative cooling system buildings throughout their reproduction cycles. Gilts and sows received sufficient feed both in quantity and quality according to NRC (Subcommittee on Swine nutrition, 1998). Water was available to all animals at all times. Estrus detection was performed twice daily, at 09:00 and 15:00. The gilts and sows were artificially inseminated three and two times per estrus, respectively, every 12 hours. Sows were moved to a farrowing house one week before the expected farrowing date. Sows were supervised day and night around parturition. In case of dystocia, manual extraction of the piglets was performed but it was not recorded. New born piglets were processed once a day. The total number of piglets born (TB) and stillbirths (SB) were recorded at this handling. Some cross-fostering was performed within the first day of birth. The lactation period was approximately 21 days. The total number of piglets born included piglets born alive, stillbirths and mummies. Stillbirth in this study was classified by visual appearance. Stillbirths were recorded as such when they were found dead and wet or covered with placenta behind the sows. Gestation length (GL) was recorded as the farrowing date minus the mating date. GL in this study was between 106 to 148 days and GL >125 days were excluded from the analyses, due to their low frequency (24 records). Data pertaining to previous lactation length less than 8 days and greater than 28 days were excluded. Owing to the fact that sows weaned too early after farrowing might have some health problem, sows nursing piglets longer than 28 day were foster sows. After editing, the final data consisted of 28,725 reproductive records of 6,955 sows. Animals in the pedigree file contained 709 boars and 12,922 sows.

Fixed effect: For genetic analyses, the breeds of sow were classified into 6 groups: LR, LW, 50LR (50%LR-50%LW), 50LW (50%LW-50%LR), 75LR (75%LR-25%LW), and 75LW (75%LW-25%LR). Parities were divided into 6 classes (1, 2, 3, 4, 5 and 6 to 11). The number of TB were divided into 2 groups (1 to 11 pigs and ≥12 pigs). Previous lactation length was divided into 3 groups (8 to 17, 18 to 24 and 24 to 28 days). From the initial analyses, previous lactation length did not affect TB and SB. Thus, previous lactation length was not included in the final model.

Statistical analyses: Initially, several fixed effects and covariates were examined for their significance ($p<0.05$) in the univariate models using ordinary least squares. From these general linear models, fixed effects with a significant influence were included in the final model. The statistical model was $\boldsymbol{y=Xb+Wp+Za+e}$, where, $\boldsymbol{y}$ is the vector of observations of the studied traits (3 traits simultaneously, i.e. TB, SB, GL); $\boldsymbol{X}$, $\boldsymbol{W}$ and $\boldsymbol{Z}$ are the known incidence matrices for fixed and random effects; $\boldsymbol{b}$ is the vector of fixed effects; $\boldsymbol{p}$ is the vector of permanent environmental effects; $\boldsymbol{a}$ is the vector of additive genetic effects and $\boldsymbol{e}$ is the vector of residuals. The (co)variance matrices of random effect factors in $\boldsymbol{p}$, $\boldsymbol{a}$ and $\boldsymbol{e}$ were assumed to be

$$var\begin{bmatrix} p \\ a \\ e \end{bmatrix} = \begin{bmatrix} P\otimes A & 0 & 0 \\ 0 & G\otimes A & 0 \\ 0 & 0 & R\otimes I \end{bmatrix}$$

where $\boldsymbol{A}$ is the additive genetic relationship matrix between animals; $\boldsymbol{I}$ is the identity matrix; and $\boldsymbol{P}$, $\boldsymbol{G}$ and $\boldsymbol{R}$ are the (co)variance matrices for the vectors $\boldsymbol{P}$, $\boldsymbol{a}$ and $\boldsymbol{e}$, respectively.

Fixed effects of breed groups and parities were included in all models. The model for TB and GL included non genetic-effects of contemporary groups (mating year-month), whereas the model for SB included a combination of farrowing year-month. Fixed effects of the number of TB were included in the model for SB and GL. Covariate effects of GL were included in the model for SB and covariate effects of AF were also included in both TB and SB models. Fixed effects included in the statistical models for analyses of TB, SB and GL are summarized in Table 1. The (co)variance components were estimated with AI-REML (Johnson and Thompson, 1995), using the ASREML package (Gilmour et al., 2001).

Results

Descriptive statistics: The number of records, mean, standard deviation and range of studied traits are shown in Table 2. In 57.34% of litters, no piglets were stillbirths (SB=0) and in 38.93% of litters, there were 1 to 3 stillbirths per litter. Stillbirths were 7.06% of total number of piglets born.

Means and standard deviations of TB and SB classified by GL are shown in Table 3. The results showed that sows with a high TB had shorter GL than sows with a low TB. For example, sows with 11.38±0.04 pigs/litter had 4 days shorter GL than sows with 10.69±0.04 pigs/litter. Sows with the mean value of GL (117 days) had the lowest SB, compared to sows with a shorter or longer GL than 117 days.

Table 1 Fixed effects included in the statistical models for analyses of total number of piglets born (TB), stillbirths (SB) and gestation length (GL)

Trait	Fixed effects[1]						
	Effects					Covariate	
	Br	YMM	YMF	Pr	TB	GL	AF
TB	*	*	-	*	-	-	*
SB	*	-	*	*	*	*	*
GL	*	*	-	*	*	-	-

[1]Br: breed of sows (LR, LW, 50LR, 50LW, 75LR, and 75LW), YMM: year-month at mating, YMF: year-month at farrowing, Pr: parity (1, 2, 3, 4, 5, and 6 to 11), TB: total number of piglets born (<12 and ≥12 piglets), GL: gestation length, AF: age at farrowing, -: The effect was excluded from the analysis *$p<0.05$

Table 2 Number of records, mean, standard deviation (SD) and range of studied traits

Trait[1]	No. of records	Mean	SD	Range
TB (pigs/litter)	28,725	11.50	2.35	1 to 23
SB (pigs/litter)	28,725	0.78	1.23	0 to 16
GL (days)	28,725	116.96	1.68	106 to 125

[1]TB: total number of piglets born, SB: stillbirths, GL: gestation length

Table 3 Means and standard deviations of total number of piglets born (TB) and stillbirths (SB) classified by gestation length (GL)

GL (days)	No. of records	Trait	
		TB (pigs/litter)	SB (pigs/litter)
≤ 114	1,517	11.42±0.06[a]	0.98±0.03[a]
115	3,373	11.38±0.04[a]	0.80±0.02[bc]
116	6,561	11.22±0.03[b]	0.74±0.02[cd]
117	7,525	11.10±0.03[c]	0.71±0.01[d]
118	5,104	10.92±0.03[d]	0.78±0.02[c]
119	2,911	10.69±0.04[e]	0.84±0.02[b]
≥ 120	1,734	10.29±0.06[f]	0.95±0.03[a]

[a-f] Means in the same column with different superscript differ (p<0.05)

Fixed effect

Breed effect: Least square means and standard error for TB, SB and GL classified by breeds are presented in Table 4. Large White sows had a significantly higher TB than LR sows (p<0.05). The differences in TB among 50LR, 50LW and 75LW sows were not significant, but the TB from these sows were significantly higher than the TB from 75LR sows (p<0.05). In comparison of purebred and crossbred sows for TB, we found that 50LR, 50LW and 75LW sows had a significantly higher TB than purebred sows (LR and LW) (p<0.05). The total number of piglets born of 75LR sows significantly differed from LR sows (p<0.05), however, no significant difference was observed between 75LR and LW litters. There was neither significant difference between SB of purebred nor among SB of crossbreeds. On the other hand, 50LW and 75LR had significantly lower SB than purebred sows (p<0.05). Landrace sows were pregnant 0.51 days longer than LW sows (p<0.05). Crossbred 75LR sows had significantly longer GL than the other crossbreeds (p<0.05). In the comparison between purebreds and crossbreeds, the results showed that LR sows had the longest GL whereas the GL of LW sows were not different from those of crossbred sows except 75LR sows.

***Parity effect*:** Least square means and standard errors of TB, SB and GL classified by parity are presented in Table 5. The total number of piglets born increased as the parity increased from parity 1 to 4 and thereafter TB stayed constantly in the following parity and decreased again in parity 6. SB in the first parity was the highest one but was not significantly different from parity 6. From the present data, the gestation period in the first parity was significantly longer than that in the next parities.

Total number of piglets born effect: Total number of piglets born significantly influenced SB and GL. Sows with a large litter size (≥ 12 pigs/litter) had 0.85 stillbirths/litter (p<0.05) more than sows with a small litter (<12 pigs/litter). The corresponding values for large and small litter sows were 1.28±0.01 and 0.43±0.01 stillbirths/litter, respectively. Small litter sows gestated 0.24 d longer (p<0.05) than large litter sows. Since their GL were 117.0 and 116.76 days, respectively.

Table 4 Least square means and standard errors of total number of piglets born (TB), stillbirths (SB) and gestation length (GL) classified by breeds

Breed[1]			No. of records	Traits		
Sows	Sire	Dam		TB (pigs/litter)	SB (pigs/litter)	GL (days)
LR	LR	LR	2,402	10.44±0.05[c]	0.90±0.02[ab]	117.22±0.03[a]
LW	LW	LW	2,298	10.76±0.05[b]	0.90±0.02[a]	116.71±0.03[c]
50LR	LR	LW	7,617	11.15±0.03[a]	0.84±0.02[bc]	116.77±0.02[c]
50LW	LW	LR	8,345	11.20±0.03[a]	0.83±0.01[c]	116.72±0.02[c]
75LR	LR	50LR or 50LW	2,838	10.74±0.05[b]	0.80±0.02[c]	117.02±0.03[b]
75LW	LW	50LR or 50LW	5,225	11.15±0.03[a]	0.85±0.02[ac]	116.74±0.02[c]

[1]LR: Landrace, LW: Large White, 50LR: 50% LR–50% LW, 50LW: 50% LW–50%LR, 75LR: 75% LR–25% LW, 75LW: 25% LR–75% LW
[a–c] Least square means in the same column with different superscript differ (p<0.05)

Table 5 Least square means and standard errors of total number of piglets born (TB), stillbirths (SB) and gestation length (GL) classified by parity

Parity	No. of records	Trait		
		TB (pigs/litter)	SB (pigs/litter)	GL (days)
1	6,175	9.96±0.08[e]	1.06±0.04[a]	117.38±0.02[a]
2	5,325	10.67±0.05[d]	0.81±0.03[bc]	116.86±0.02[b]
3	4,689	11.10±0.04[c]	0.77±0.02[c]	116.73±0.02[c]
4	3,910	11.27±0.04[ab]	0.77±0.02[c]	116.73±0.03[c]
5	3,211	11.29±0.06[a]	0.80±0.03[c]	116.72±0.03[c]
≥ 6	5,415	11.15±0.10[bc]	0.91±0.05[ab]	116.76±0.02[c]

[a – e] Least square means in the same column with different superscript differ (p<0.05)

Genetic parameters: Heritabilities (h^2), permanent environmental variances in proportion to total variances (c^2) and repeatabilities (r) of the studied traits are presented in Table 6. Heritabilities for TB and SB were relatively low. Heritability for GL was moderate. Permanent environmental variances in proportion to total variances for these traits were low. Repeatabilities for TB and SB were low, whereas the repeatability for GL was moderate. The ratio of permanent environmental variances (c^2) of TB and SB was higher than the ratio of additive variances (h^2). On the other hand, the ratio of permanent environmental variance of GL was lower than the ratio of additive variance.

Table 6 Heritabilities (h^2), permanent environmental variances in proportion to total variances (c^2) and repeatabilities (r) of the studied traits

Trait[1]	h^2 ± S.E.	c^2 ± S.E.	r ± S.E.
TB	0.03±0.01	0.05±0.01	0.08±0.01
SB	0.03±0.01	0.04±0.01	0.07±0.01
GL	0.16±0.01	0.08±0.01	0.24±0.01

[1]TB: total number of piglets born, SB: stillbirths, GL: gestation length

Estimated genetic and phenotypic correlations between TB, SB and GL are presented in Table 7. Genetic correlations ranged from low to moderate and had small standard errors. Phenotypic correlation between TB and SB was unfavorable, i.e. sows with a larger litter size had higher SB. Litter size of sows had significant and negative phenotypic correlation with GL, but its magnitude was low. There was no significant association between GL and SB.

Table 7 Genetic (above the diagonal) and phenotypic (below the diagonal) correlations between TB, SB and GL

Traits[1]	TB	SB	GL
TB		0.49 ± 0. 12	-0.29 ± 0.10
SB	0.36 ± 0.01[2]		-0.04 ± 0.11
GL	-0.10 ± 0.01	0.01 ± 0.01	

[1]TB: total number of piglets born, SB: stillbirth, GL: gestation length, [2]value±standard error

Discussion

The mean values of TB and SB are in accordance with the ranges of 10.03 to 11.4 pigs/litter for TB and 0.21 to 0.9 pigs/litter for SB from previous studies (Serenius et al., 2004; Imboonta et al., 2007; Rydhmer et al., 2008). The estimated mean for GL is in line with the result of Serenius et al. (2004) who reported that the GL of LR and LW sows was 116.5 and 117.0 days, respectively. However, gestation length in this study was longer than the finding of Rydhmer et al. (2008) and Hanenberg et al. (2001) which range from 115.2 to 115.9 days. One of the reasons that the estimate of GL differs from those of other studies might be the genetic background of the sows. Sows in the present study consisted of purebreds and crossbreeds whereas sows in the studies of Rydhmer et al. (2008) and Hanenberg et al. (2001) were purebreds, i.e. Swedish Yorkshire and Dutch Landrace, respectively.

The mean of TB across GL shows that the larger the litter is the shorter the GL becomes, which is in agreement with Rydhmer et al. (2008) and Sasaki and Koketsu (2007). Small numbers of TB have a small amount of placenta and in consequence a low level of estrogen hormone and longer GL (Dziuk, 1991). The finding of this study confirms this statement. The result revealed that sows with low TB gestated longer than sows with high TB. The lowest SB at GL of 117 days is interesting, but the reason for this is not known.

There was no significant difference between the TB of 50LR and 50LW. Thus, the advantage of heterosis can be done using both LR and LW as dams or sire to produce two-breed cross sows. On the other hand, 75LW produced more TB than 75LR. Owing to the genetics of LW in this population, LW has superior genetics for TB than LR and LW share more genetics in 75LW. The crossbred sows (50LR, 50LW and 75LW) had more TB than purebred sows due to the effect of heterosis.

There was no significant difference between the SB of LR and LW. This is in agreement with previous reports (Leenhouwer et al., 1999; Tantasuparuk et al., 2000). There also was no significant difference between SB of 50LR and 50LW. The result indicates that the reciprocal crosses between LR and LW (50LR, 50LW) did not alter SB. This is in line with the finding of Kantanamalakul et al. (2007) that reciprocal crosses between LR and Yorkshire did not give a different number of SB per litter. The breed differences were significant between purebreds and crossbreeds, i.e. 75LR and 50LW. One reason for the lower SB in crossbred sows than in purebred sows might be the effect of heterosis. This is in agreement with Kantanamalakul et al. (2007), who reported that crossbred sows had 0.16 stillbirths/litter lower than purebred sows.

This study showed the longer the GL and the smaller the TB in LR sows compared to LW sows. The results confirm the study of Tummaruk et al. (2001), who reported that LR sows had a longer GL during first pregnancy (116.0 versus 115.6 days) than Yorkshire sows since LR sows gave less TB than Yorkshire sows. The longest GL of 75LR compared to other crossbred sows was partly due to the highest genetic proportion of LR breed, in consideration that LR had the longest GL in this population. The difference between GL of crossbreeds and LR was significant. Crossbreeds gestated 0.20 to 0.51 days shorter than LR. This result is consistent with the report of Cassady et al. (2002) who reported that reciprocal cross between LW and LR had 0.56 days shorter than purebreds.

The total number of piglets born increased with parity number. The result is consistent with earlier reports. For example, litter sizes of LR and Yorkshire sows in Sweden increased as parity increased and decreased after parity 6 (Tummaruk et al., 2000) and TB of crossbred sows (LR x Yorkshire) increased with parity number and met the plateau in parity 4 and 5 and decreased from then on (Suriyasomboon et al., 2006). The increase in litter size is possibly caused by the increase in the ovulation rate and uterine capacity of the sows (Gama and Johnson, 1993). The decrease in litter size again in later parity might be caused by the increase in embryonic death in higher parity sows (Hughes and Varley, 1980).

First parity sows had the highest SB, and these result conforms to many studies (Leenhouwers et al., 1999; Canario et al., 2006). Intrapartum death is often caused by prolonged farrowing which results from the too narrow reproductive tract of primiparous sows (Pejsak, 1984). In addition, high numbers of SB were found in older parity sows. Similar results were obtained by Tantasuparuk et al. (2000), who reported that parity 7 and older LR sows gave more SB than younger parity sows. According to some authors, sows will give more SB when they attain parity 3 to more than parity 6 (Leenhouwers et al., 1999; Borges et al., 2005; Canario et al., 2006). That more piglets died in litters of multiparous sows than in those of primiparous ones may be causatively linked with the excessive fatness of old sows and with the fact that groups of muscles responsible for normal parturition are much weaker in such animals (English and Morrison, 1984; Pejsak, 1984).

First-parity sows had the longest gestation length. Thereafter, gestation length decreased as parity number increased and was stable from parity 3. However, the results of the current study do not support the previous research of Sasaki and Koketsu (2007), who found no difference in GL among the parity groups except for a slight difference (0.09 d) between the second and third parity.

Stillbirths were lower in sows with small litters compared to sows with litters of equal or more than 12. This result is in agreement with previous research (Leenhouwers et al., 1999; Lucia et al., 2002; Borges et al., 2005). Sows giving more SB as litter size increased might be caused by the longer period of parturition and induced asphyxia in piglets and caused SB (Herpin et al., 2001).

Sows with litters of equal or more than 12 had a shorter gestation length than sows with a small litter. This is in agreement with Leigh (1981), who found that the regression coefficient of the gestation period on litter size was -0.38 day. Our result is also in accordance with the observation of Rydhmer et al. (2008) and Sasaki and Koketsu (2007), who reported that sows with a higher TB had shorter GL. This might be caused by the large placenta of the large litter sows producing a high level of estrogen. Estrogen is hormone that causes the starting of parturition, thus the more the estrogen the shorter the GL (Dziuk, 1991).

The heritability estimate of TB in this study was low and consistent with the heritabilities (0.03 to 0.07) reported by Imboonta et al. (2007). Other research reported higher heritability estimates of 0.11 (Rothschild and Bidanel, 1998) and 0.10 to 0.16 (Roehe and Kennedy, 1995). In the same way, the heritability estimate of SB was low and consistent with the heritabilities (0.03 to 0.04) reported by Imboonta et al. (2007), but lower than the estimate of 0.11 that was reported by Serenius et al. (2004). The heritability for GL is moderate and consistent with the estimate of 0.19 that was reported by Rydhmer et al. (2008). Estimates for gestation length found in the literature varies from around 0.25 to 0.37 (Hanenberg et al., 2001; Knol, 2001; Serenius et al., 2004), which is higher than the estimate for GL in this study.

The proportion of permanent environmental variances to total variances for TB in the literature ranges between 0.045 and 0.090 (Lamberson et al., 1991; Hanenberg et al., 2001; Knol, 2001; Imboonta et al., 2007) and for GL varies from 0.072 to 0.116 (Hanenberg et al., 2001; Knol, 2001). The estimates from this study fall in between these values. The estimate of permanent environmental effect for SB was lower than the estimates of 0.06 and 0.09 from the studies of Hanenberg et al. (2001) and Knol (2001) respectively. Comparing the estimates of heritability and permanent environmental effect, TB and SB were more influenced by permanent environmental effect than by additive genetic effects, whereas GL was dominantly influenced by additive genetic effect.

The low repeatability values for TB and SB indicated that correlations among parities are low, therefore, TB or SB in first parity tell nothing about the number of TB or SB in the following parities. Repeatability estimate of GL is moderate, thus, there is moderate correlation between GL of first parity and those of the following parities and GL of first parity can be used for predicting the GL of later parities. The repeatability in GL for our population (0.24) seemed lower than the previous study (0.50) for crossbred sows (Sasaki and Koketsu, 2007). The difference may be explained as the difference between crossbred sows and mixed between crossbred and purebred sows in this study, and induced farrowing practices in that study.

The estimated genetic correlation between TB and SB was unfavorable. The result indicated that selection for large litters increase the number of stillbirths. This is in line with the finding of Hanenberg et al. (2001), Serenius et al. (2004) and Canario et al. (2006) who reported the genetic correlations of 0.29 to 0.60, 0.30 to 0.51 and 0.58, respectively. Genetic correlation between TB and GL was negative in this study. In accordance with the study of Hanenberg et al. (2001) and Rydhmer et al. (2008), large litter size is genetically correlated with a short gestation period, i.e. genetic correlations are -0.2 and -0.14, respectively.

Conclusion

The number of stillbirths was influenced by breed of sow, parity number and the total number of piglets born. Crossbred sows (50LR and 75LR) produced fewer SB than purebred sows. First parity sows gave more SB than later parities and SB increased in sows after parity 6. Sows with large litter (more than 12 pigs/litter) produced more SB than small litter sows. Crossbred sows produced larger litters, fewer stillbirths and gestated for a shorter time than purebred sows. Heritabilities for TB and SB were near zero (0.03 and 0.03) and was moderate (0.16) for GL. Repeatabilities for TB and SB were low (0.08 and 0.07) and was moderate (0.24) for GL. Genetic correlations indicated that selection for larger TB will increase SB and decrease GL.

References

Borges, V.F., Bernardi, M.L., Bortolozzo, F.P. and Wentz, I. 2005. Risk factors for stillbirth and foetal mummification in four Brazilian swine herds. Prev Vet Med. 70: 165-176.

Canario, L., Cantoni, E., Le Bihan, E., Caritez, J.C., Billon, Y., Bidanel, J.P. and Foulley, J.L. 2006. Between-breed variability of stillbirth and its relationship with sow and piglet characteristics. J Anim Sci. 84: 3185-3196.

Cassady, J.P., Young, L.D. and Leymaster, K.A. 2002. Heterosis and recombination effects on pig reproductive traits. J Anim Sci. 80: 2303-2315.

Damgaard, L.H., Rydhmer, L., Lovendahl, P. and Grandinson, K. 2003. Genetic parameters for within-litter variation in piglet birth weight and change in within-litter variation during suckling. J Anim Sci. 81: 604-610.

Dziuk, P. 1991. Reproduction in the pig. In: Reproduction in domestic animals. P.T. Cupps (ed). Academic Press, New York. 471-489.

English, P.R. and Morrison, V. 1984. Causes and prevention of piglet mortality. Pig News Inf. 5: 369-376.

Gama, L.L. and Johnson, R.K. 1993. Changes in ovulation rate, uterine capacity, uterine dimensions, and parity effects with selection for litter size in swine. J Anim Sci. 71: 608-617.

Gilmour, A.R., Cullis, B.R., Welham, S.J. and Thompson, R. 2001. ASREML reference manual., NSW Agriculture, Australia. 217 pp.

Hanenberg, E.H.A.T., Knol, E.F. and Merks, J.W.M. 2001. Estimates of genetic parameters for reproduction traits at different parities in Dutch Landrace pigs. Livest Prod Sci. 69: 179-186.

Herpin, P., Hulin, J.C., Le Dividich, J. and Fillaut, M. 2001. Effect of oxygen inhalation at birth on the reduction of early postnatal mortality in pigs. J Anim Sci. 79: 5-10.

Hughes, P. and Varley, M. 1980. Reproduction in the pig. 1st ed. Butterworth & Co (Publishers) Ltd, Lodon. 241 pp.

Imboonta, N., Rydhmer, L. and Tumwasorn, S. 2007. Genetic parameters for reproduction and production traits of Landrace sows in Thailand. J Anim Sci. 85: 53-59.

Johnson, D.L. and Thompson, R. 1995. Restricted maximum likelihood estimation of variance components for univariate animal models using sparse matrix techniques and average information. J Dairy Sci. 78: 449-456.

Johnson, R.K., Nielsen, M.K. and Casey, D.S. 1999. Responses in ovulation rate, embryonal survival, and litter traits in swine to 14 generations of selection to increase litter size. J Anim Sci. 77: 541-557.

Kantanamalakul, C., Sopannarath, P. and Tumwasorn, S. 2007. Estimation of breed effects on litter traits at birth in Yorkshire and Landrace pigs. Walailak J Sci & Tech. 4: 175-186.

Knap, P.W., van Alst, G.J.M., Versteeg, J.G. and Kanis, E. 1993. Realised genetic improvement of litter size in Dutch pig herdbook breeding. Pig News Inf. 14: 119N-121N.

Knol, E.F. 2001. Genetic aspects of piglet survival. Ph.D. Dissertation, Wageningen University, Wageningen, The Natherlands. 122 pp.

Knol, E.F., Leenhouwers, J.I. and van der Lende, T. 2002. Genetic aspects of piglet survival. Livest Prod Sci. 78: 47-55.

Lamberson, W.R., Johnson, R.K., Zimmerman, D.R. and Long, T.E. 1991. Direct responses to selection for increased litter size, decreased age at puberty, or random selection following selection for ovulation rate in swine. J Anim Sci. 69: 3129-3143.

Leenhouwers, J. I., van der Lende, T. and Knol, E. F. 1999. Analysis of stillbirth in different lines of pig. Livest Prod Sci. 57: 243-253.

Leigh, A. 1981. Factors affecting the gestation period of pigs in Nigeria. Trop Anim Hlth Prod. 13: 87-93.

Lucia, T., Corra, M.N., Deschamps, J.C., Bianchi, I., Donin, M.A., Machado, A.C., Meincke, W. and Matheus, J.E.M. 2002. Risk factors for stillbirths in two swine farms in the south of Brazil. Prev Vet Med. 53: 285-292.

Pejsak, Z. 1984. Some pharmacological methods to reduce intrapatum death of piglets. Pig News Inf. 5: 35-37.

PigCHAMP. 1996. Pigchamp reports manual. University of Minnesota. St. Paul.

Roehe, R. and Kennedy, B.W. 1995. Estimation of genetic-parameters for litter size in Canadian Yorkshire and Landrace swine with each parity of farrowing treated as a different trait. J Anim Sci. 73: 2959-2970.

Rothschild, M.F. and Bidanel, J.P. 1998. Biology and genetics of reproduction. In: The genetics of the pig. M.F. Rothschild and A. Ruvinsky (eds.). University Press, Cambridge. 313-344.

Rydhmer, L. 2000. Genetics of sow reproduction, including puberty, oestrus, pregnancy, farrowing and lactation. Livest Prod Sci. 66: 1-12.

Rydhmer, L., Lundeheim, N. and Canario, L. 2008. Genetic correlations between gestation length, piglet survival and early growth. Lives Sci. 115: 287-293.

Sasaki, Y. and Koketsu, Y. 2007. Variability and repeatability in gestation length related to litter performance in female pigs on commercial farms. Theriogenology 68: 123-127.

Serenius, T., Sevon-Aimonen, M.L., Kause, A., Mantysaari, E.A. and Maki-Tanila, A. 2004. Selection potential of different prolificacy traits in the Finnish Landrace and Large White populations. Acta Agr Scand a-An. 54: 36-43.

Subcommittee on Swine Nutrition, Committee on Animal Nutrition and National Research Council. 1998. Nutrient Requirements of Swine: 10th revised ed. The National Academies Press.

Suriyasomboon, A., Lundeheim, N., Kunavongkrit, A. and Einarsson, S. 2006. Effect of temperature and humidity on reproductive performance of crossbred sows in Thailand. Theriogenology 65: 606-628.

Tantasuparuk, W., Lundeheim, N., Dalin, A.M., Kunavongkrit, A. and Einarsson, S. 2000. Reproductive performance of purebred Landrace and Yorkshire sows in Thailand with special reference to seasonal influence and parity number. Theriogenology 54: 481-496.

Tummaruk, P., Lundeheim, N., Einarsson, S. and Dalin, A.M. 2000. Reproductive performance of purebred Swedish Landrace and Swedish Yorkshire sows: I. Seasonal variation and parity influence. Acta Agr Scand a-An. 50: 205-216.

Tummaruk, P., Lundeheim, N., Einarsson, S. and Dalin, A.M. 2001. Effect of birth litter size, birth parity number, growth rate, backfat thickness and age at first mating of gilts on their reproductive performance as sows. Anim Reprod Sci. 66: 225-237.