Statistical Analysis of Stillbirths in Different Genotypes of Sows*

M. X. Chu**
Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing 100094, P. R. China

ABSTRACT : Statistical analysis was conducted on sow stillbirth traits of three genotypes with 2,400 litters including the Erhualian, Large White and the F_1 cross of these two breeds. Number of stillborn piglets per litter in the Erhualian, Large White and the F_1 averaged 0.85, 0.31 and 0.70, and percentage born alive averaged 95.0%, 97.0% and 95.5%, respectively. Erhualian sows with a greater litter size also had a higher stillbirth rate. Results of analysis of variance indicated that genotype, parity, farrowing year×farrowing season interaction and total number born had highly significant effects on both number of stillborn piglets per litter and percentage born alive in sows (p<0.0001). Farrowing year had no significant effect on number of stillborn piglets per litter (p>0.05), and highly significant effect on percentage born alive (p<0.01). Farrowing season had highly significant effects on both number of stillborn piglets per litter and percentage born alive (p<0.01). From parity one to parity ten, least squares means for number of stillborn piglets per litter progressively increased with increasing parity and least squares means for percentage born alive progressively decreased with increasing parity. Sows that farrowed in winter had the highest number of stillborn piglets per litter and the lowest percentage born alive, sows that farrowed in autumn had the lowest number of stillborn piglets per litter and the highest percentage born alive. With increasing total number born, least squares means for number of stillborn piglets per litter markedly increased and least squares means for percentage born alive markedly decreased. Results from analysis of paternal half sibs indicated that the heritabilities for number of stillborn piglets per litter and percentage born alive were 0.110 and 0.124, and the genetic, phenotypic and environmental correlations between them were -0.989, -0.951 and -0.948, respectively. These results indicated that number of stillborn piglets per litter and percentage born alive were traits with the similar genetic background. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 10 : 1475-1478)***

Key Words : Sow, Stillbirth, Environmental Effect, Genetic Parameter

INTRODUCTION

Improving sow productivity is a major way to raise the economic efficiency of pig production systems (Yen et al., 1987). Stillbirths constitute a major source of economic loss for the producer as well as an ethical problem (Leenhouwers et al., 1999). Risk factors for stillbirths in swine farms are parity, breed, sow body condition, use of oxytocin during parturition, obstetric intervention through vaginal palpation, farrowing duration, mummified fetuses, total litter size and litter birth weight (Lucia et al., 2002).

The objectives of the present study were to evaluate the effect of genotype, parity, farrowing year, farrowing season and total number born on sow stillbirth traits and to estimate genetic parameters for sow stillbirth traits.

MATERIALS AND METHODS

Data

Data on piglets from 2,400 litters, born from 1999 to 2002 at Changshu Livestock and Poultry Experimental Farm, Jiangsu Province, P. R. China, were used in the present study. No cross fostering was used in the herd. Data consisted of litters from three genotypes including 981 purebred Erhualian litters (M1); 847 purebred Large White litters (M2); and 572 Large White×Erhualian F_1 litters (M3). For each litter, the ear mark, breed, parity, sire, farrowing date, total number of piglets born per litter (TNB), number of piglets born alive per litter (NBA), and mating sire (ear mark, breed) of the dam were recorded. Number of stillborn piglets per litter (NSB) was calculated as NSB = TNB-NBA and percentage born alive (PBA) was PBA = (NBA/TNB)× 100%.

Years 1999 through 2002 were regarded as four farrowing years. The parity number was divided into four groups: first, second, third to sixth, and seventh through tenth. Seasons were three-month groups starting with March through May as season one (Spring), June through August as season two (Summer), September through November as season three (Autumn) and December through February as season four (Winter). Total number born was divided into five groups: 1 to 5 piglets as class one, 6 to 10 piglets as class two, 11 to 15 piglets as class three, 16 to 20 piglets as class four, 21 piglets and upwards as class five. The division of parity and season was the same as Yen et al. (1987).

Statistical analysis

The mathematical model used to estimate the effects of genotype, parity, farrowing year, farrowing season and total number born on sow stillbirth traits was as follows:

$$y_{ijklmn} = \mu + M_i + P_j + Y_k + S_l + (Y \times S)_{kl} + N_m + e_{ijklmn}$$

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** Corresponding Author: M. X. Chu. Tel: +86-10-62816001, Fax: +86-10-62895351, E-mail: mxchu@263.net
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Table 1. Phenotypic values for stillbirth traits by genotype

Genotype	No. of litters	Mean±standard deviation		
		TNB	NSB	PBA
Erhualian (♂)× Erhualian (♀)	981	15.90±3.35	0.85±1.66	95.0%±0.089
Large White (♂)× Large White (♀)	847	9.85±2.65	0.31±0.84	97.0%±0.067
Large White (♂)× Erhualian (♀)	572	15.15±3.31	0.70±1.46	95.5%±0.083
Average		13.59±4.14	0.62±1.41	95.8%±0.081

TNB = Total number of piglets born per litter, NSB = Number of stillborn piglets per litter. PBA = Percentage born alive.

Table 2. Phenotypic values for stillbirth traits by parity of the dam

Parity	No. of litters	Mean±standard deviation	
		NSB	PBA
1	408	0.26±0.72	0.975±0.063
2	328	0.25±0.70	0.978±0.048
3	321	0.57±1.22	0.963±0.069
4	300	0.60±1.31	0.960±0.071
5	254	0.75±1.60	0.953±0.095
6	238	0.77±1.24	0.948±0.078
7	176	1.27±1.93	0.922±0.115
8	150	0.90±1.96	0.946±0.099
9	124	0.90±1.98	0.944±0.102
10	101	0.92±2.07	0.945±0.100

NSB = Number of stillborn piglets per litter, PBA = Percentage born alive.

where y_{ijklmn} is the phenotypic value for a given trait; μ is the overall mean; M_i is the fixed effect of the i^{th} genotype (i = 1, 2, 3); P_j is the fixed effect of the j^{th} parity group (j = 1, 2, 3, 4); Y_k is the fixed effect of the k^{th} farrowing year (k = 1, 2, 3, 4); S_l is the fixed effect of the l^{th} farrowing season (l = 1, 2, 3, 4); $(Y\times S)_{kl}$ is the interaction effect between farrowing year and farrowing season; N_m is the fixed effect of the m^{th} total number born group (m = 1, 2, 3, 4, 5); e_{ijklmn} is the random residual effect of each observation. Calculations were achieved using Proc GLM of SAS (Ver 8).

Genetic parameters were estimated from paternal half sib analysis using the mixed model least-squares and maximum likelihood computer program PC-2 Version (Harvey, 1990).

RESULTS AND ANALYSES

Phenotypic values for sow stillbirth traits

Phenotypic values for stillbirth traits by genotype and parity are shown in Table 1 and 2, respectively.

From Table 1 it could be seen that as the consanguinity of Erhualian pig increased, NSB progressively increased and PBA progressively decreased. Stillbirth rate per litter [(NSB/TNB)×100%] in the Erhualian, Large White and the F_1 averaged 5.3%, 3.1% and 4.6%, respectively. Erhualian sows with a greater litter size also had a higher stillbirth rate.

Table 2 shows that NSB progressively increased with increasing parity, PBA progressively decreased with increasing parity, from the first parity to the seventh parity. Both NSB and PBA remained almost constant from the eighth parity to the tenth parity. These results are very important for determining potential culling strategies. Increased stillbirths at later parities are often observed and may be related to excessive fatness of older sows, pathological changes in the reproductive tract and poorer uterine muscle tone, all leading to a less efficient parturition process (English et al., 1984). Moeller et al. (2004) reported that NSB in the first parity was a little higher than that in the second parity, which was consistent with the relationship observed in the present study. This may be caused by narrow birth canals in younger females (Pejsak, 1984). The major cause of intrapartum stillbirths is asphyxiation during delivery (Pejsak, 1984). Various attempts have been made to increase the efficiency of the parturition process. English et al. (1984) pointed out, one simple approach to this end in commercial practice is to cull sows timeously since older sows take longer to farrow and have a higher incidence of intrapartum stillbirths.

Table 3. Analysis of variance for sow stillbirth traits

Source of variation	df	Prob>F	
		NSB	PBA
Genotype	2	0.0001	0.0001
Parity	3	0.0001	0.0001
Farrowing year	3	0.1895	0.0030
Farrowing season	3	0.0043	0.0094
Farrowing year×farrowing season	9	0.0001	0.0001
Total number born	4	0.0001	0.0001
Residual	2,375		

NSB = Number of stillborn piglets per litter. PBA = Percentage born alive.

Variance analysis

Results of analysis of variance for sow stillbirth traits are summarized in Table 3.

From Table 3 it could be seen that genotype, parity, farrowing year×farrowing season interaction and total number born had highly significant effects on both NSB and PBA in sows ($p<0.0001$). Farrowing year had no significant effect on NSB ($p>0.05$), and highly significant effect on PBA ($p<0.01$). Farrowing season had highly significant effects on both NSB and PBA ($p<0.01$).

Analysis of the main effects for sow stillbirth traits

Least squares means (LSM)±standard error of the main

Table 4. Least squares means±standard error of the main effects for sow stillbirth traits

Main effect	No. of litters	Least squares means±standard error	
		NSB	PBA
Erhualian (♂)×Erhualian (♀)	981	1.07±0.08	0.944±0.006
Large White (♂)×Large White (♀)	847	1.05±0.08	0.944±0.006
Large White (♂)×Erhualian (♀)	572	1.04±0.06	0.944±0.006
First parity	408	0.96±0.09	0.949±0.006
Second parity	328	0.81±0.08	0.960±0.005
Third to sixth parity	1,113	1.05±0.06	0.943±0.006
Seventh through tenth parity	551	1.40±0.07	0.924±0.005
Farrowing year 1999	617	1.13±0.06	0.943±0.006
Farrowing year 2000	593	1.15±0.09	0.936±0.006
Farrowing year 2001	567	1.09±0.07	0.938±0.006
Farrowing year 2002	623	0.85±0.09	0.959±0.006
Farrowing season: March through May	677	1.06±0.08	0.944±0.006
Farrowing season: June through August	510	1.08±0.07	0.942±0.006
Farrowing season: September through November	617	0.92±0.06	0.952±0.006
Farrowing season: December through February	596	1.16±0.09	0.937±0.006
Total number born: 1 to 5 piglets	68	0.04±0.18	0.994±0.013
Total number born: 6 to 10 piglets	607	0.18±0.09	0.978±0.007
Total number born: 11 to 15 piglets	1,073	0.38±0.07	0.970±0.004
Total number born: 16 to 20 piglets	617	0.83±0.06	0.951±0.005
Total number born: 21 piglets and upwards	35	3.86±0.17	0.826±0.012

NSB = Number of stillborn piglets per litter. PBA = Percentage born alive.

effects for sow stillbirth traits are presented in Table 4.

From Table 4 it could be seen that: (1) Least squares means of the most main effects for sow stillbirth traits were highly significant ($p<0.0001$). (2) There were no significant genotype differences in least squares means for sow stillbirth traits ($p>0.05$). (3) From parity one to parity ten, least squares means for NSB progressively increased with increasing parity and least squares means for PBA progressively decreased with increasing parity. The optimum values for both NSB and PBA were reached in the second parity in the present study. (4) Sows that farrowed in winter had the highest NSB and the lowest PBA, sows that farrowed in autumn had the lowest NSB and the highest PBA. (5) Least squares means for NSB markedly increased with increasing total number born, indicating the positive phenotypic correlation existed between them. Least squares means for PBA markedly decreased with increasing total number born, indicating the negative phenotypic correlation existed between them.

Genetic parameters for sow stillbirth traits

Results from the paternal half sib analysis indicated that the heritability for NSB was 0.110 and 0.124 for PBA. The genetic and phenotypic correlations between NSB and TNB were -0.212 and 0.354. The genetic and phenotypic correlations between PBA and TNB were 0.411 and -0.245. The genetic, phenotypic and environmental correlations between NSB and PBA were -0.989, -0.951 and -0.948, respectively. These results indicated that NSB and PBA were traits with the similar genetic background.

DISCUSSION

Sow stillbirth traits

In the present study, NSB in the Erhualian, Large White and the F_1 averaged 0.85, 0.31 and 0.70, and stillbirth rate per litter averaged 5.3%, 3.1% and 4.6%, respectively. In surveys and investigations of piglet mortality conducted through the world, stillbirth losses have varied from 4% to 8% while losses in recorded herds in UK amount to 5.4% (English et al., 1984). Spicer et al. (1986) reported stillbirth loss was 5.4% on a large intensive piggery. Haley et al. (1990) reported that NSB in the first parity in Meishan× Meishan, Large White×Large White and Large White (♂) ×Meishan (♀) averaged 0.64, 0.41 and 0.39, and NSB in the second parity averaged 1.22, 0.45 and 0.53, respectively. McLaren et al. (1990) reported that mean±standard deviation for NSB in purebred Meishan and US Yorkshire was 0.62±0.86 and 0.25±0.55, the stillbirth rate was 5.0% and 3.4%, respectively. Bidanel et al. (1989) and Bidanel (1993) found higher stillbirth rates in the Meishan breed compared with the Large White breed. Leenhouwers et al. (1999) reported for 7,817 litters analyzed in The Netherlands, the average TNB was 10.77 piglets, including an average of 0.57 stillborn piglets per litter, and the stillbirth rate was 5.3%. Vazquez et al. (1994) reported that means of PBA for parity 1, parity 2, parity 3-4, parity 5-8, parity >8 in Iberian sows were 0.973, 0.969, 0.977, 0.954 and 0.988, respectively. Grandinson et al. (2002) reported for 11,016 Yorkshire piglets from 1,046 first parity litters in

Sweden, the average TNB was 10.54 piglets, including an average of 0.64 stillborn piglets per litter, the stillbirth rate was 6.0%. These results imply that the optimum parity should be determined for different pig breeds in production practice to achieve the optimum production efficiency.

Factors affecting sow stillbirths

Effects of genotype, parity, year and season : Haley et al. (1990) and Leenhouwers et al. (1999) reported that both genotype and parity had significant effects on NSB. Vazquez et al. (1994) reported that the effects of parity and year were significant for PBA ($p<0.01$, $p<0.0001$, respectively) in Iberian sows in Spain, and the seasonal effect was not significant for PBA ($p>0.29$). Iberian sows that farrowed in winter had the highest PBA. Means for PBA in spring, summer, autumn and winter were 0.978, 0.949, 0.978 and 0.981, respectively. Lucia et al. (2002) reported that litters from sows of parity four or greater had 2.2 times higher odds of stillborn occurrence than litters from parity 2 to 3 females. Petry et al. (2004) reported that genotype had a highly significant effect on NSB ($p<0.01$). Moeller et al. (2004) reported that both maternal line and parity had highly significant effects on NSB ($p<0.01$).

Effect of total number born : Total number born had highly significant effect on both NSB and PBA ($p<0.0001$) in the present study. Spicer et al. (1986) reported that increased litter size resulted in an increased percentage of stillborn piglets and mummified fetuses. Leenhouwers et al. (1999) reported that NSB was significantly influenced by TNB ($p<0.001$) and NSB increased with increasing TNB. Lucia et al. (2002) reported that litters having 12 or more pigs had 2 times higher odds of a stillborn piglet than smaller litters. Petry et al. (2004) and Moeller et al. (2004) reported that increased litter size resulted in high incidence of stillborn and mummified piglets ($p<0.01$). Ruiz-Flores et al. (2001) reported that the phenotypic correlation between NSB and TNB was 0.33, which was consistent with the relationship observed in the present study. An increased stillbirth rate with increasing TNB could be explained by uterine environment late in gestation and/or extended length of parturition due to a larger number of fetuses farrowed.

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