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GENETIC ANALYSES OF SOW LONGEVITY TRAITS, AGE AT FIRST FARROWING AND FIRST-LITTER CHARACTERISTICS

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SUMMARY

Sow longevity is a vital trait in the pig production sector because of its economic and welfare importance. However, this trait is recorded late in a sow's life and early selection criteria associated with sow longevity are beneficial for genetic improvement of sow longevity. The aim of this study was to estimate genetic parameters of sow longevity and other sow reproduction traits. Data included 14,284 purebred sows recorded from 1996 to 2016 in 7 commercial herds across Australia. Traits describing sow longevity included the number of maximum parities reached, length of productive lifetime in days, total number of piglets born alive per sow over her lifetime, and stayability from parity 1 to parity 4. Further traits considered were number of piglets born alive (litter size) and average piglet birth weight (both recorded in the first litter), and age at first farrowing. Sow longevity traits were genetically the same traits and had low heritabilities (0.07 to 0.13). Genetic correlations were lowly negative between sow longevity and age at first farrowing (-0.13 to -0.22), and between sow longevity and average piglet birth weight (-0.19 to -0.26). First litter size had positive genetic correlations with sow longevity traits (0.49 to 0.65). This study showed favourable genetic correlations of the traits first litter size and age at first farrowing with sow longevity, suggesting that these two traits could be suitable genetic indicators for sow longevity.

INTRODUCTION

Improving sow longevity is important not only for welfare but also for economic reasons, as it will enhance the proportion of sows in higher production phases and reduce the number of replacement gilts (Hoge and Bates 2011). Sow longevity has been defined in different ways over time, but a broad definition is the ability of a sow to live a long and healthy life while producing good quality litters. Traits that define sow longevity include the length of productive lifetime, the maximum number of parities a sow reached, total number of piglets born alive per sow, and stayability up to parity 4. However, genetic improvement of these sow longevity traits is a slow process, since they can only be assessed when a sow has had the chance to reach a certain number of parities. To enable earlier genetic selection for sow longevity, there is a need to select other traits that are good indicators of sow longevity and that can be measured earlier in a sow's life. Previous studies have shown significant effects of the age at first farrowing on sow longevity traits (Serenius *et al.* 2008; Engblom *et al.* 2016), but genetic correlations were low and somewhat variable ranging from -0.21 to -0.03. First-litter characteristics, including litter size and average piglet birth weight, could be indicators for sow longevity as well, but inconclusive results have been found so far (e.g. Tholen *et al.* 1996; Hoge and Bates 2011; Engblom *et al.* 2016). Therefore, genetic relationships between sow longevity and age at first farrowing and first-litter traits need further quantification. The aim of this study was to estimate genetic parameters of sow longevity, age at first farrowing, and first-litter characteristics.

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MATERIALS AND METHODS

Animals and data. Pedigree and phenotypic data were available from 7 commercial sow herds in Australia. Only sows that had at least 1 parity record were included in the dataset. Purebred sows born between 1996 and 2016 were included in the analysis, so all sows had the chance to reach at least parity 4. This resulted in 14,284 records of Large White sows.

Traits. Four traits were defined for sow longevity including: maximum number of parities, length of productive lifetime in days (calculated from first farrowing until last weaning), total number of piglets born alive per sow during her lifetime, and stayability from parity 1 to parity 4, as a binary trait. Data were not censored for the trait stayability 1-4 because only records of sows that had the opportunity to reach 4 parities were included. Three early reproduction traits were identified: age of the sow at first farrowing in days, the number of piglets born alive at first farrowing (first litter size), and average piglet birth weight at first farrowing in grams based on piglets born alive recorded within 24 hours after farrowing.

Statistical Analyses. For all traits, fixed effects were defined as the herd-year-season interaction, and the only random effect fitted was animal. There were no repeated records for traits, and year and season were based on the first farrowing of each sow. Parameter estimates were obtained using linear mixed models under an animal model with ASReml (Gilmour *et al.* 2014), for all traits except stayability 1-4. This trait was analysed as a binary trait using a generalized mixed linear animal model with the logistic link function. Further, stayability 1-4 was also analysed as a continuous trait on the linear scale. Genetic and phenotypic correlations between the traits were estimated with use of a series of bivariate animal models, using the same fixed effects as for the univariate models. Bivariate analyses involving the trait stayability 1-4 were carried out on the linear scale.

RESULTS AND DISCUSSION

Descriptive statistics for all traits are displayed in Table 1. Sows had 4.09 parities on average, corresponding with a productive lifetime of 480.5 days during which they farrowed 46.9 live piglets. The relatively large coefficients of variation (CV) found for the sow longevity traits can be explained by the fact that there were several extreme values in the data. Skewness of the data was reflected in the minimum and maximum values of the different traits which depended mainly on management decisions. High variation in sow longevity traits has been found in previous studies (e.g. Serenius *et al.* 2008; Hoge and Bates 2011). Nonetheless, the SD and CV for age at first farrowing were small, especially compared to the other traits. This probably reflects management decisions. Age at first farrowing is strictly managed by selecting gilts in a short age range at puberty or mating, which therefore decreases the variability of age at first farrowing in sows.

Table 1. Descriptive statistics of the traits with the number of observations (N), the standard deviations (SD) of the means, coefficients of variation in % (CV), and the minimum and maximum values of each trait

Trait*	N	SD	CV (%)	Min	Max
MNP	14284	2.47	60.29	1	13
LPL (days)	14284	363.65	75.69	2	1744
TNBA	14284	31.90	68.04	1	165
STAY14	13920	0.50	93.98	0	1
AFF (days)	14284	21.31	6.2	264	417
LS	14284	3.02	29.29	1	22
PBWT (g)	7782	242.30	18.68	600	3000

**MNP=Maximum number of parities; LPL=Length of productive lifetime; TNBA=Total number of piglets born alive per sow per lifetime; STAY14=Stayability 1-4; AFF=Age at first farrowing in days; LS=first litter size including only live-born piglets; PBWT=Average piglet birth weight in grams in the first litter.*

Heritability estimates for the sow longevity traits ranged from 0.07 to 0.13 (Table 2). Genetic gain in these traits is expected to be slow, not only due to low genetic variance but also due to late expression of the traits. These estimates for the sow longevity traits were in agreement with previous estimates presented in literature which ranged from 0.02 to 0.22 (Serenius *et al.* 2008; Engblom *et al.* 2016). Heritability for stayability 1-4 estimated on the logistic and the linear scale were 0.09 and 0.07, respectively, which is in agreement with previous findings of Tholen *et al.* (1996) who found heritabilities of 0.08 and 0.09 for this stayability trait using a linear model. Estimates from both a logistic and linear scale are presented. The logistic scale takes the non-normal distribution of this binary trait into account. However, a linear model may be used in genetic evaluation systems.

Age at first farrowing had a heritability estimate of 0.10 ± 0.01, which was within the range of heritabilities (0.04 to 0.10) estimated in previous studies (e.g. Serenius *et al.* 2008; Engblom *et al.* 2016). However, the result in this study may be partly affected by the low variation in age at first farrowing resulting from management strategies. Further, the heritabilities for first litter size of 0.07 ± 0.01 and for average piglet birth weight of 0.19 ± 0.02 corresponded with previous findings in literature as well (Tholen *et al.* 1996; Engblom *et al.* 2016).

Table 2. Heritability estimates (h^2) with standard errors (SE), phenotypic variance (V_p), additive genetic variance (V_a) and residual variance components (V_e) per trait

Trait*	h^2 ± SE	V_p	V_a	V_e
MNP	0.10 ± 0.01	5.46	0.57	4.89
LPL (d)	0.10 ± 0.01	118830	12205.60	106627
TNBA	0.13 ± 0.01	937.85	124.00	813.85
STAY14[1] (logistic)	0.09 ±0.001	3.60	0.31	3.29
STAY14 (linear)	0.07 ± 0.01	0.23	0.016	0.22
AFF (d)	0.10 ± 0.01	293.88	29.50	264.38
LS	0.07 ± 0.01	8.74	0.57	8.17
PBWT (g)	0.19 ± 0.02	55500	10743	7782

**For abbreviations see Table 1; [1]Genetic estimates for stayability 1-4 were derived on both a logistic and linear scale.*

Sow longevity traits were genetically the same traits with high genetic correlations between them (range: 0.95 to 0.99). This is reflected in similar genetic and phenotypic correlations of the sow longevity traits with the other sow reproduction traits investigated (Table 3). For the first-litter traits, the correlations were all found to be positive between litter size and the sow longevity traits, with genetic correlations ranging from 0.49 to 0.65. For the trait average piglet birth weight, the genetic correlations with the sow longevity traits were all negative, ranging from -0.19 to -0.26. The genetic correlations between age at first farrowing and the sow longevity traits were negative as well, ranging from -0.13 to -0.22.

The relatively high positive genetic correlations between the sow longevity traits and first litter size were not expected compared to previous studies (e.g. Tholen *et al.* 1996; Engblom *et al.* 2016), with non-significant or even negative associations between first litter size and sow longevity traits. The results from this study showed that the first litter size could be a good selection criterion for sow longevity. Moreover, litter size is an important economic trait in commercial pig production systems, and sows with low first litter sizes are unlikely to be kept in the herd for subsequent parities. Even though genetic correlations were only found to be low to moderate between age at first farrowing and the sow longevity traits, all correlations did show negative associations. This implies that sows that farrow their first litter early in life have increased longevity. These results suggest that the trait, age at first farrowing may be incorporated as an indicator for sow longevity as well.

The average piglet birth weight was negatively correlated with sow longevity, suggesting that high piglet birth weights in the first litter are undesirable concerning the longevity of the sows. These correlations between average piglet birth weight and the sow longevity traits were slightly stronger than previous results (-0.02 and -0.15) found by Tholen *et al.* (1996). Further, negative correlations, both genetic and phenotypic, were estimated between the average piglet birth weight and the first litter size of -0.36 ± 0.09 and -0.45 ± 0.01, respectively. This indicates that there is a trade-off between litter size and average piglet birth weight in parity 1. As expected, since the uterine capacity of sows is limited and selecting sows only on litter size may reduce the average piglet birth weight, found in previous studies (e.g. Tholen *et al.* 1996). Even so, the strong positive genetic correlations found in this study between first litter size and sow longevity suggest that these sows were primarily selected on the number of piglets born alive, since this is an important production trait. Furthermore, autocorrelation between first litter size and subsequent litter sizes is expected, which influences retention to the next parity.

Table 3. Genetic and phenotypic (1st and 2nd row for each trait) correlations between the reproduction and the sow longevity traits, along with their standard errors (±SE)

Trait*	MNP	LPL	TNBA	STAY14[1]	AFF	LS
AFF	-0.16 ± 0.09	-0.14 ± 0.10	-0.13 ± 0.09	-0.22 ± 0.11		
	-0.07 ± 0.01	-0.07 ± 0.01	-0.06 ± 0.01	-0.06 ± 0.01		
LS	0.51 ± 0.10	0.53 ± 0.10	0.65 ± 0.08	0.49 ± 0.12	0.21 ± 0.11	
	0.16 ± 0.01	0.16 ± 0.01	0.27 ± 0.01	0.15 ± 0.01	0.05 ± 0.01	
PBWT	-0.20 ± 0.09	-0.19 ± 0.09	-0.26 ± 0.08	-0.26 ± 0.11	-0.15 ± 0.10	-0.36 ± 0.09
	-0.08 ± 0.01	-0.08 ± 0.01	-0.14 ± 0.01	-0.07 ± 0.01	0.07 ± 0.01	-0.45 ± 0.01

**For abbreviations see Table 1; [1]Correlations with stayability 1-4 were derived on the linear scale.*

When including age at first farrowing and first-litter characteristics as selection criteria for sow longevity, it should be taken into account that age at first farrowing is a highly managed period in pig production systems, and genetic variation in this trait is low. On a phenotypic level, gilts that are mated too early, are more prone to anoestrus after the first litter (e.g. Hoge and Bates 2011). In addition, sows with high litter size or high litter birth weights in parity 1 are exposed to high stress levels during gestation, farrowing, and subsequent lactation, which may lead to prolonged weaning to conception intervals (Tholen *et al.* 1996). It is likely that there is an optimum not only for first mating and farrowing age but also for first litter size and average piglet birth weight, and this should be taken into consideration for future research.

CONCLUSIONS

This study showed that first-litter characteristics had significant genetic associations with sow longevity. Both age of the sow at first farrowing and litter size are important selection criteria for sow longevity because these two traits can be measured earlier.

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