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GENOTYPE BY PARITY INTERACTIONS WERE NOT FOUND FOR GROWTH IN AUSTRALIAN PIGS

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SUMMARY

Growth is known to be lower for gilt progeny in comparison to progeny from multiparous sows. Information about the effects of dam parity on other performance traits is often limited. The aim of this study was to quantify the effects of dam parity on performance traits and to evaluate genotype by parity interactions for growth rate of pigs. Dam parity had strongest effects on growth. Estimates of growth were 14 to 22 g/day lower in gilt progeny in comparison to progeny from older sows. Feed intake and feed conversion ratio were -0.023 to -0.066 units lower for progeny from older sows in comparison to gilt progeny. Dam parity had no biological importance for backfat and muscle depth. Growth was defined as a different trait for progeny from the first to the fifth parity of dams for analyses of genotype by parity interactions. Heritabilities varied from 0.13 to 0.20 for the three growth traits. Maternal genetic effects were low and slightly higher for progeny from older sows (0.047). Genotype by parity interactions for growth of pigs were not found based on high estimates of genetic correlations between different growth traits (range:0.83 to 0.98) and current selection practices that define growth as the same trait for progeny from different dam parities can be continued based on the results of this study.

INTRODUCTION

Progeny of gilts grow more slowly than progeny from older sows (Standal, 1973). This fact has long been known in pig industries although scientific studies quantifying this effect are sparse. Recently, Hermesch and Li (2013) showed that the reduction in growth rate of pigs from gilt litters varied between herds. Growth rate of gilt progeny was 6.7 to 21.1 g/d lower than progeny growth from third-parity litters. The exact reasons for this variation in the reduction of growth rate of gilt progeny between herds are unknown.

The gap in performance of gilt progeny relative to progeny of older sows may widen if the implications of continued selection are not fully understood in regard to optimal gilt management on farms. Selective breeding continues to focus on improving efficient lean meat growth and reproductive performance of sows. This selection emphasis affects characteristics of sows and genetic improvement of growth and backfat will lead to larger and leaner sows. For example, associations between estimated breeding values and sow characteristics estimated by Hermesch *et al*. (2010) indicate that sows have the genetic potential to be 30 kg heavier every 10 years as a result of genetic improvement of progeny growth of about 100 g/day over 10 years. Downward selection of backfat of 5 mm in progeny implied that sows had the genetic potential to be 7.5 mm leaner. These genetic associations, however, are often not fully expressed due to management of gilts and sows. For example, feed intake may be restricted in gilts and sows reducing the weight of gilts and sows relative to the genetic potential for weight gain in breeding females. Gilts are now considerably heavier and leaner at mating and first farrowing due to selection, and may be less able to support the lean meat growth potential of their progeny. It was the aim of this study to investigate the effects of dam parity on performance of progeny and to estimate genotype by parity interactions for growth.

MATERIALS AND METHODS

Data. Performance of progeny were recorded from 2000 to 2015. These data were combined with information about reproductive performance of sows. Editing procedures focused on good cross-classification of effects and completeness of litter and sow characteristics for progeny performance. Only progeny from the first 6 parities of sows were considered. These conditions were fulfilled for 262,193 pigs in total which were recorded in two locations and included male and female pigs from 6 genetic lines. Pigs were recorded at an average age of 151.90 (± 8.94) days and an average body weight of 91.21 (± 13.05) kg to obtain information about average daily gain (ADG), fat depth (FD) and muscle depth (MD).

A proportion of pigs were tested for daily feed intake (DFI) using electronic feeders. Feed intake records collected from 2003 to 2010 were included in the analyses. Entire-male pigs entered electronic feeders at an average age of 120.60 (± 5.47) days and a body weight of 70.92 (± 8.01) kg. The test period was 35.75 (± 2.54) days long and pigs were fed *ad libitum*. Additional traits available for these pigs were average daily gain prior to test (ADG1) and growth rate during test (ADG2) as well as DFI and feed conversion ratio (FCR). Records exceeding 3 standard deviations from the mean were deleted for all traits.

Analysis. The GLM (SAS 2014) procedure was used to derive the fixed effect model for each trait and to estimate least squares means for the effect of dam parity on performance traits. Dam parity, which had 5 levels because parity 5 and 6 were combined into 1 level, was added as an additional fixed effect to the base model for each trait. The base model included line and contemporary group based on week of birth at each location for all traits. Sex was fitted for ADG, FD and MD only because other traits were only available for entire males. Backfat and MD were adjusted for the weight at recording which was fitted as a linear and quadratic covariate. Weight of pigs at start of test to record DFI was only significant for DFI as a linear and quadratic covariate.

Genotype by parity interactions were evaluated for growth which was defined as a separate trait for progeny from each parity (ADG-P1 to ADG-P5). Variance and covariance components were estimated with ASReml (Gilmour *et al*. 2009) in univariate and bivariate analyses fitting an animal model. Additional random effects fitted in univariate analyses were maternal genetic and permanent environmental effects of dams. For bivariate analyses, only additive genetic and permanent environmental effects of dams were fitted because estimates of maternal genetic effects were low and partially confounded with permanent environmental effects of sows. Further, the residual covariance was fixed at zero because growth traits were recorded on different animals and it was not possible to estimate residual and subsequently phenotypic correlations.

RESULTS AND DISCUSSION

Effects of dam parity. Estimates of growth for gilt progeny were 22 g/day lower in comparison to progeny from second and third parity sows (Table 1). This difference in growth was reduced to 17 and 14 g/day between progeny from gilts versus progeny of fourth and fifth-parity sows. Further analyses showed that growth of gilt progeny in comparison to progeny from the second to third parity was 16 to 18 g/day lower in 2004 and 2009 for ADG, while the difference increased to 26 to 32 g/day in 2013 to 2015 (for details see Hermesch, 2015). In comparison, growth of gilt progeny was 5 to 20 g/day lower than growth of progeny from third-parity sows in the 9 herds investigated by Hermesch and Li (2013).

Early growth is expected to be more strongly affected by characteristics of the dam. Growth prior to test (ADG1) was affected by dam parity, which conversely had no significant effect on growth during the test period (ADG2) (P values, Table 1). Dam parity affected DFI and FCR significantly and gilt progeny had inferior performances in these traits. Progeny from multiparous sows ate -0.025 to -0.066 kg less feed per day than gilt progeny and had a better FCR (difference of -0.015 to -0.058

kg/kg). However, these differences in performance of gilt progeny to progeny from older sows were not observed in a second independent herd analysed by Hermesch (2015). The effects of dam parity on performance traits should be investigated for each population because estimates of dam-parity effects on growth of progeny were variable between herds and over time.

Table 1. Number of observations (*n*), means and standard deviations (SD) as well as predicted differences between first and subsequent parities for performance traits observed in progeny.

Trait	*n*	Mean	SD	Parity 2	Parity 3	Parity 4	Parity 5/6	P value
ADG (g/d)	261,919	600	77	22	22	17	14	< 0.0001
ADG1 (g/d)	7,679	588	62	18	16	13	13	< 0.0001
ADG2 (g/d)	7,679	860	197	1	7	-5	-7	0.41
DFI (kg)	7,537	2.44	0.47	-0.025	-0.044	-0.045	-0.066	0.0003
FCR	7,537	2.06	0.43	-0.013	-0.058	-0.023	-0.050	0.004
BF (mm)	215,066	10.2	2.29	-0.14	-0.13	-0.12	-0.13	< 0.0001
MD (mm)	214,172	43.4	5.87	-0.09	0.24	1.08	0.71	< 0.0001

Abbreviations: ADG: average daily gain, ADG1: ADG until 70 kg prior to feed-intake test, ADG2: ADG during feed-intake test, DFI: daily feed intake, FCR: feed conversion ratio, BF: backfat, MD: muscle depth.

Genetic parameters. Heritability estimates for growth were 0.16 for progeny from 3 parities in comparison to estimates of 0.13 (± 0.01) and 0.20 (± 0.02) for ADG-P3 and ADG-P5 (Table 2). Maternal genetic effects were consistent for ADG-P1 to ADG-P4 and slightly higher for ADG-P5 (0.047 ± 0.013). Common litter effects were higher for ADG-P1 to ADG-P3 (0.09 and 0.10) in comparison to lower estimates of 0.07 and 0.04 for ADG-P4 and ADG-P5. Heritability estimates and common litter effect estimates obtained in this study for different growth traits were within the range of estimates presented by Hermesch and Jones (2012) for overall growth based on subsets of the data used in the current study. Inclusion of maternal genetic effects as an additional random effect decreased heritability estimates by 0.01 for all traits. Meanwhile, the permanent environmental effect of the dam was reduced by the magnitude of estimate of the maternal genetic effect for each growth trait, demonstrating high sampling correlations between these 2 random effects for these growth traits. These changes in variances between models indicate that data structure were not sufficient to disentangle these two maternal effects when traits were defined separately for each dam parity. However, maternal genetic effects are generally low for growth in pigs (e.g. Johnson *et al.* 2002) and estimates of variance components for the 5 growth traits followed expectations.

Table 2. Number of observations (*n*), heritabilities (h^2, with standard errors (se)), maternal genetic (m^2) and permanent environmental effect of dam (c^2) as well as phenotypic variance (Vp) for average daily gain (ADG) of progeny from the first (ADG-P1) to the fifth (ADG-P5) parity of dams.

Trait	*n*	h^2 (se)	m^2 (se)	c^2(se)	Vp
ADG-P1	100,662	0.16 (0.01)	0.024 (0.005)	0.10 (0.005)	4811
ADG-P2	72,298	0.16 (0.01)	0.025 (0.006)	0.09 (0.006)	5022
ADG-P3	44,430	0.13 (0.01)	0.021 (0.008)	0.10 (0.009)	4898
ADG-P4	25,732	0.16 (0.02)	0.029 (0.014)	0.07 (0.014)	4885
ADG-P5	24,320	0.20 (0.02)	0.047 (0.014)	0.04 (0.013)	4826

Estimates of genetic correlations were high, ranging from 0.83 to 0.98 between traits (Table 3). Genetic correlations tended to decrease as the difference in parities increased for definitions of growth traits. Overall, these estimates indicate that a genotype by parity interaction can be ignored in pig breeding programs as is currently the case. No estimates of genotype by parity interactions were found in the literature. A comparable investigation may be the analyses of genotype by sex interactions because sex of pigs is another systematic effect for performance traits. This interaction was investigate by Crump *et al.* (1997), who found no significant genotype by sex interactions. The magnitude of genotype by environment interactions depends on the difference between environments that genotypes experience. Differences in environments provided by dams to progeny in different parities were not large enough for the detection of genotype by parity interactions.

Table 3. Genetic correlations (above diagonal, with standard errors (se)) and correlations due to permanent environmental effect of dam (below diagonal) for average daily gain (ADG) of progeny from the first (ADG-P1) to the fifth (ADG-P5) parity of dams.

Trait	ADG-P1	ADG-P2	ADG-P3	ADG-P4	ADG-P5
ADG-P1		0.94 (0.02)	0.96 (0.03)	0.93 (0.04)	0.83 (0.04)
ADG-P2	0.25 (0.03)		0.98(0.03)	0.97 (0.04)	0.90 (0.04)
ADG-P3	0.26 (0.04)	0.25 (0.04)		n.e.[1]	0.93 (0.05)
ADG-P4	0.24 (0.06)	0.23 (0.06)	n.e.[1]		0.89 (0.05)
ADG-P5	0.26 (0.07)	0.34 (0.06)	0.40 (0.06)	0.31 (0.08)	

[1] Correlations could not be estimated

CONCLUSIONS

Dam parity had the greatest effect on growth. Gilt progeny grew more slowly than progeny from older sows and differences were larger in more recent years. Further, a higher DFI and higher FCR was observed for gilt progeny in the current population. Estimates of dam-parity effects on performance of progeny were variable and this effect should be evaluated on farms to ensure management of gilts and sows is optimal for each genotype. No genotype by parity interactions were found for growth and current selection practices for growth can be continued.

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REFERENCES

Crump R.E., Haley C.S., Thompson R. and Mercer J. (1997) *J. Anim. Sci.* **65**: 275.

Gilmour A.R., Gogel B.J., Cullis B.R. and Thompson R. (2009) 'ASReml User Guide Release 3.0.' VSN International Ltd, Hemel Hempstead, HP1 1ES, UK.

Hermesch S. (2015) Final Report for Australian Pork Limited, Project 2014/458.

Hermesch S., Jones R.M., Bunter K.L. and Gilbert H. (2010) 9th WCGALP, paper 292

Hermesch S. and Jones R.M. (2012) *Animal* **6**: 1904.

Hermesch S. and Li L. (2013) In 'Manipulating pig production XIV. Proceedings of the 14th Biennial Conference of the Australiasian Pig Science Association', p. 53, editors J.R. Pluske and J.M. Pluske.

Johnson Z.B., Chewning J.J. and Nugent R.A. 3rd (2002) *J. Anim. Sci*. **80**: 1470.

SAS (2014). Base SAS® '9.4 Procedures Guide: Statistical Procedures, Third Edition'. SAS Institute, Cary, NC, USA.

Standal N. (1973) *Acta Agr. Scand.* **23**: 225.