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ASSOCIATIONS BETWEEN SOW BODY COMPOSITION, FEED INTAKE DURING LACTATION AND EARLY PIGLET GROWTH

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SUMMARY

The genetic and phenotypic associations between sow body composition, early piglet growth and lactation feed intake (LFI) recorded during the first lactation were estimated using data collected from two maternal lines (N~2500). Heritability estimates for lactation feed intake, average piglet birth weight (ABW) and total born (TB) were 0.16±0.04, 0.27±0.03 and 0.10±0.04; genetic correlations between LFI and ABW or TB were positive but not significantly different to zero. Heritabilities for sow weight and fat depths prior to farrowing and at weaning ranged from 0.27 to 0.37 (±0.05) and within trait genetic correlations between these time points were less than one. Positive genetic (r_a) and phenotypic (r_p) correlations show that increased LFI is associated with higher sow weaning weight and fat depths (r_a: 0.52±0.13 and 0.21±0.16; r_p: 0.38±0.02 and 0.15±0.03) and higher litter gain (r_a: 0.10±0.24, r_p: 0.20±0.02). While correlations are not antagonistic between LFI and TB, ABW or litter gain, any correlated response in LFI to selection on these traits would be low.

INTRODUCTION

The group of desirable maternal traits includes large litter size, excellent mothering ability and adequate milk production to ensure high piglet survival and growth, followed by successful sow rebreeding after weaning. There are two major contradictory elements within this trait complex. Firstly, piglets from larger litters are generally lighter at birth, can suffer more hypoxia during farrowing, and have reduced access to colostrum and teats. Piglets from larger litters are therefore more vulnerable to environmental stressors that can result in piglet death (Knol 2001). Secondly, sows that successfully rear large, heavy litters have increased risk of longer weaning to conception intervals and reduced stayability in the herd (Tholen *et al.* 1996). These areas of antagonism are likely strongest for primiparous sows which must balance their own continuing growth and development against reproductive demands. This particular study focused on the genetic relationships between sow lactation intake and body composition, along with early litter growth, which is an area where information for modern sow genotypes is scarce.

MATERIALS AND METHODS

Approximately 2500 sows from two maternal lines (Large White and Landrace based, Primegro™ Genetics) were recorded for their first gestation and farrowing outcomes between January 2007 and June 2008 at QAF Meat Industries, Corowa, Australia. Records available for first parity sows in this study included aspects of sow body condition, described by sow weight and average fat depth at day 110 of gestation (W110, F110) and at weaning (SWW, SFD). Reproductive traits included total number of piglets born (TB), average piglet birth weight (ABW) of live born piglets, along with litter gain from day 1 (after cross fostering) until day 10 (LG10) and the average daily lactation feed intake of the sow (LFI). An estimate of the sow's own body weight (SW110) prior to farrowing was calculated as SW110=W110-(TB×ABW). During lactation feed was delivered 4 times per day to enable expression of appetite. Average lactation

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intake was based on daily records averaged over a maximum lactation length of 35 days. Data were subsequently edited based on trait distributions. The UNIVARIATE procedure (SAS 2003) was used to identify outliers, whereby trait records that deviated by more than 3 times the interquartile range from the mean value were deleted. After editing, there were 2264 animals representing 206 sires and 1268 dams in a pedigree extended back to include all animals born since 2003 (N=53124).

Models for analyses were developed using ASReml software, which estimates variance components under a linear mixed model by residual maximum likelihood (Gilmour *et al*. 2006). Univariate analyses were used to develop models for systematic effects and to obtain initial estimates of genetic parameters under an animal model. Approximate F-tests were used to assess the significance of systematic effects and/or their interactions, only those effects significant at $P<0.05$ were retained. Systematic effects for all traits included year/month of farrowing (20 levels) and sow line (2 levels). Gestational treatment (4 levels) was fitted for W110, SWW and ABW. A factor categorising fostering events prior to day 10 (4 levels) was included in the model for LG10, while lactations of shortened or normal duration (2 levels) were modelled for LFI. Linear covariates included age at mating for all traits except LFI and LG10. The number of piglets on day 1, after cross-fostering, was a linear covariate for LG10 and SWW, while lactation length was fitted as a linear and quadratic covariate for LFI. Common litter effects, if present, were not estimated due to the low number of sows farrowing per source litter. Correlations between specific traits were subsequently estimated using the univariate model for each trait, fitted in a series of bivariate analyses.

RESULTS AND DISCUSSION

Characteristics of the data. The similarity of coefficients of variation (CV~9%) for weight or fat depths observed at mating (not presented), prior to farrowing and at weaning (Table 1) masks the much larger underlying variability between sows in how they transitioned between these time points. Gestational weight and fat gains calculated from this data had CV of 22% and more than 200%, respectively. Lactation feed intake averaged 4.99 kg/day (~2.4% of sow body weight), higher than was observed in a previous subset of this data predominantly recorded throughout summer (Bunter *et al*. 2007). The CV for TB (27%) was larger than the CV for ABW (17%), possibly indicating that piglet birth weight is under some form of physiological regulation to reduce variability generated by differences in litter size. In contrast, litter gain was highly variable (CV=61%), reflecting both variation in piglet losses and the weight gain of surviving piglets.

Table 1. Characteristics of the data after editing for outliers

Trait	Abbreviation	N	Mean (SD)	Min-Max	h^2	σ_p
Weight at D110 (kg)	W110	2244	224 (19.8)	150-289	0.28±0.05	16.9
Sow weight at D110 (kg)	SW110	2182	208 (18.8)	135-269	0.27±0.05	16.2
Fat depth at D110 (mm)	FAT110	2225	19.3 (3.98)	7.5-35.5	0.37±0.05	3.47
Sow weaning weight (kg)	SWW	1963	197 (18.0)	129-265	0.35±0.06	16.7
Fat depth at weaning (mm)	SFW	1867	17.4 (3.48)	6.5-32.0	0.34±0.05	3.35
Total born (N)	TB	2288	11.7 (3.18)	2-21	0.10±0.03	3.13
Average piglet birth weight (kg)	ABW	2223	1.41 (0.24)	0.63-2.42	0.27±0.03	0.23
Lactation feed intake (kg/day)	LFI	2034	4.99 (1.10)	0.50-9.00	0.16±0.04	0.78
Litter gain to 10 days (kg)	LG10	1970	10.0 (6.10)	-12.4 to 32.5	0.09±0.04	5.91

Genetic parameters. Heritability estimates from univariate analyses for sow weight and fat depths prior to farrowing and at weaning were moderate (range: 0.28 to 0.35, Table 1). The estimate of heritability for LFI (h^2: 0.16±0.04) was similar to that previously reported by Bunter *et al*. (2007). For comparison, heritabilities for total lactation feed intake reported by Bergmsa *et al*. (2008) for sows recorded using different lactation feeding regimes over parities were 0.14±0.05 and 0.30±0.08, whereas the heritability for litter gain until 28 days was 0.18±0.05, not significantly higher than in this study. Genetic parameters for TB and ABW were consistent with averages from numerous studies reported by Rothschild and Bidanel (1998). Estimates of heritabilities from bivariate analyses (not presented) were similar to those estimated from univariate analyses.

Genetic correlations between sow body weights or fat depths before farrowing (W110 or SW110 and FAT110) and at weaning (SWW and SFW) were high but significantly less than one (Table 2). Phenotypic correlations for the same traits were much lower (~0.65) suggesting considerable variation amongst sows for changes in body weight and fatness as lactation progresses. Differences in weights pre- and post-farrowing include loss of conceptus products at farrowing, changes to sow body weight and composition during lactation, along with variation in mammary tissue development between these time points. Genetic and phenotypic correlations between weight and fat depths were moderate (range: 0.30 to 0.52) regardless of physiological state (pregnant or farrowed), and were similar to comparable estimates for weight and fat mass reported by Bergsma *et al*. (2008).

Table 2. Genetic (upper) and phenotypic (lower triangle) correlations (±se) (all values ×100)

	W110	SW110	FAT110	SWW	SFW	TB	ABW	LFI	LG10
W110	-	**98±0.6**	**29±11**	**79±5**	**30±12**	21±17	**32±12**	**34±16**	-1±18
SW110	**97±0.1**	-	**30±11**	**75±6**	**52±12**	3±18	16±13	29±17	-4±17
FAT110	**36±2**	**37±2**	-	**27±11**	**90±4**	-5±16	6±12	-12±15	-9±16
SWW	**65±1**	**64±1**	**24±2**	-	**43±10**	26±17	**-31±13**	**52±13**	**-39±15**
SFW	**30±2**	**41±2**	**66±1**	**46±2**	-	17±17	-12±13	21±16	-21±18
TB	**20±2**	-5±4	**-8±2**	3±2	0±2	-	-7±18	18±23	-24±24
ABW	**12±2**	**11±2**	2±2	**-8±2**	**-10±2**	**-46±2**	-	21±17	33±19
LFI	**-7±2**	**-10±2**	**-12±2**	**38±2**	**15±3**	**8±2**	**-4±2**	-	10±24
LG10	3±2	3±2	-1±2	**-18±2**	**-19±2**	-4±3	**14±2**	**20±2**	-

See Table 1 for trait abbreviations. Correlations significantly (P<0.05) different to zero are in bold.

Genetic correlations between TB and sow weight or fat traits were not significantly different from zero. Genes controlling ovulation rate and embryo survival, which determine TB, are largely independent of genes associated with body composition of the sow, as expected. The positive phenotypic correlation between W110 and TB (r_p: 0.20±0.02) arose from a part-whole relationship, since the phenotypic correlation was not different to zero between SW110 and TB (r_p: -0.05±0.04). Primiparous sows gestating larger litters were leaner (r_p: -0.08±0.02) prior to farrowing which suggests that sows have partially supported piglet development at the expense of accumulating their own body reserves during gestation. As has been observed from many studies, the phenotypic correlation between TB and ABW was strongly negative (r_p: -0.55±0.03).

Moderate negative genetic correlations between ABW or LG10 and SWW (r_a: -0.39±0.15 and -0.31±0.13) show that sows with heavier piglets at birth or with higher litter gains to day 10 were lighter and leaner at weaning, likely due to increased litter demands on sow resources. Additional estimates of correlations between ABW and sow weight or fat loss were strongly positive (r_a: 0.69±0.12 and 0.33±0.16; r_p: 0.20±0.02 and 0.15±0.02). Grandinson *et al.* (2005) and Bergsma *et al*. (2008) generally had similar results. Litter weight gains to day 10 of lactation were uncorrelated with sow weight or fatness prior to farrowing. Additional estimates of genetic and phenotypic correlations between ABW and piglet weight at 10 days were 0.67±0.10 and 0.41±0.02. Piglet birth weight explains a large part of the genetic variability in piglet weight at day 10.

Genetic and phenotypic correlations between LFI and SWW, SFW or LG10 indicate that sows with higher lactation feed intake achieve higher body weight and condition at weaning (r_a: 0.52±0.13 and 0.21±0.16; r_p: 0.38±0.02 and 0.15±0.03) and higher litter gain, although only at the phenotypic level for the latter (r_a: 0.10±0.24, r_p: 0.20±0.02). While genetic correlations between LFI and ABW or TB were favourable, they were not significantly different from zero. Selection for larger surviving litters would therefore not be expected to generate a significant correlated response in LFI, with possibly detrimental effects for sow condition at weaning.

CONCLUSIONS

Genes controlling sow body weight and fatness at the end of lactation are either not identical or act differently to those controlling the same traits prior to farrowing. Sows with high genetic potential for farrowing and rearing heavier piglets are at risk of lower weight and fat depth at weaning. Gestating litter size had a negative phenotypic association with weight or fat gain of primiparous sows prior to farrowing. These effects can have negative consequences for sow longevity. Phenotypic correlations suggest that sows partially adjusted LFI according to their own body condition at farrowing and to the demands of the suckled litter. However, the absence of a substantial genetic correlation between TB and LFI indicates that a correlated response in LFI to selection on TB will not occur, potentially exacerbating the deficit between feed intake potential and requirements during lactation. Further research into achieving the best farrowing outcomes and treatment in the first parity is implicated for improving sow longevity.

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