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GENETIC CORRELATIONS BETWEEN JUVENILE INSULIN-LIKE GROWTH FACTOR-I (IGF-I) AND MEASURES OF SOW REPRODUCTIVE PERFORMANCE ARE LOW

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SUMMARY
Sow reproductive data (N=9 652 sows) and records on juvenile insulin-like growth factor I (IGF-I: N=23 730 records) were used to estimate genetic correlations between IGF-I and age at first farrowing (AFF), the total number of litters produced prior to culling (TNL), weaning to conception interval between the first and second parity (WCI_{12}), and number born alive (NBA_{1-3}) or average piglet birth weights ($ABWT_{1-3}$) recorded in parities one to three. Heritability estimates (h^2±S.E.) were moderate (0.26±0.02) for IGF-I, but considerably lower (range:0.03±0.01 to 0.15±0.04) for sow reproductive traits. Estimates of genetic correlations between IGF-I and most sow reproductive traits were generally low (range: -0.08 to +0.08), did not differ significantly from zero, and were accompanied by negligible phenotypic correlations. The exceptions were either unfavourable genetic (r_g) and/or phenotypic (r_p) correlations between IGF-I and AFF (r_g: -0.15±0.10, r_p: -0.06±0.02) or WCI_{12} (r_g: -0.45±0.15, r_p: 0.01±0.03). Genetic correlations between IGF-I and NBA or ABWT were low and favourable in parities one and two, unfavourable in parity three, but not significantly different from zero in all cases. In a multiple trait context, selection for improved efficiency of lean meat production using information provided by juvenile IGF-I is unlikely to result in significant unfavourable correlated responses in sow reproductive performance.
Keywords: heritability, litter size, birth weight, longevity, age at first farrowing, remating

INTRODUCTION
Pig and cattle breeding programs that place selection emphasis on efficient lean meat production can use the physiological indicator juvenile insulin-like growth factor-I (IGF-I) to improve accuracy of and response to selection (Bunter *et al.* 2002). However, since breeding goals are typically complex and involve many traits, it is necessary to establish whether IGF-I is also correlated with female reproductive traits expressed later in life. IGF-I, measured before puberty, has been implicated as a possible modulator of the attainment of puberty through its association with body weight and fat (Barb *et al.* 2000). In addition, Karsten *et al.* (2000) reported unfavourable genetic correlations (r_g) between litter size and feed conversion ratio (r_g: 0.13 to 0.44) or backfat thickness (r_g: 0.07 to 0.25), while Hermesch *et al.* (2000) reported unfavourable correlations between litter size and growth rate or feed intake. Since genetic correlations between IGF-I and feed intake, feed conversion ratio or back fat levels are positive (Bunter *et al*. 2005), these results suggest that genetic correlations between juvenile IGF-I and measures of sow reproductive performance may be unfavourable.

Swanchara *et al.* (1999) reported no significant changes in age at puberty in gilts immunized at 35 days of age against growth hormone releasing factor (resulting in lower body weight, lower growth

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hormone and lower IGF-I levels in gilts), but observed lower ovulation rates after the third estrus. However, their study was very small (N=70) and illustrated results of artificial lowering of IGF-I through exogenous manipulation. Previous estimates of genetic correlations between juvenile IGF-I and litter size (Bunter, unpublished) were variable in magnitude and direction, and accompanied by large standard errors. The purpose of this study was to estimate genetic correlations between juvenile IGF-I and measures of sow reproductive performance using a commercial nucleus population (maternal line) with extensive multi-generational recording for both juvenile IGF-I and measures of female reproductive performance.

MATERIALS AND METHODS

Data for juvenile IGF-I, measured in piglets at 20 to 42 days of age, and sow reproductive performance (parities 1-9) recorded in a maternal nucleus line at QAF Meat Industries between January 1992 and December 2003 were available. Reproductive records analysed consisted of age at first farrowing (AFF), number born alive (NBA_{1-3}: parities 1-3 only), weaning to conception interval between the first and second farrowing (WCI_{12}), average piglet birth weight ($ABWT_{1-3}$), along with the total number of litters (TNL) produced prior to culling. Sows had to have a first parity record to be retained in the data for further analyses. Further, TNL records were restricted only to sows that had sufficient opportunity to complete their reproductive life before December 2003 (ie their uncensored stayability). That is, data for TNL were truncated to include only sows born before November 1999. Records for NBA and ABWT from different parities were treated as separate traits.

Data were subsequently edited based on trait distributions. Proc UNIVARIATE (SAS Institute Inc. 1990) was used to identify outliers, whereby trait records that deviated by >3 interquartile ranges (obtained from the 25^{th} and 75^{th} percentile values) from the mean value were deleted. After editing for outliers there were 23 730 records for IGF-I (both males and females recorded) and 9 652 sows with reproductive performance recorded; 19% with records for juvenile IGF-I and 70% of which had records from more than one parity.

Systematic effects were investigated and genetic parameters obtained under an animal model using ASREML (Gilmour *et al.* 1999). F-tests were used to assess the significance of systematic effects and/or their interactions. The final model for IGF-I accounted for week of birth, assay batch, sex and age of the animal at testing (treated as a linear covariate). Models for AFF and TNL included year-month of birth, along with service sire breed for AFF and location for TNL. Models for WCI_{12}, litter size and average piglet birth weight traits incorporated farrowing year-month along with location. Estimates of heritabilities and common litter effects (where significant) were obtained for each trait using univariate analyses, whereby the significance of litter as an additional random effect was assessed using the Likelihood Ratio test. Estimates of genetic correlations between IGF-I and reproductive traits were obtained from bivariate analyses (not reported for NBA or ABWT traits). Reported estimates of correlations between IGF-I and litter size or birth weight traits were obtained from analyses containing four traits: IGF-I and either NBA_{1-3} or $ABWT_{1-3}$.

RESULTS AND DISCUSSION

Data characteristics after editing, and parameter estimates from univariate analyses, are presented in Table 1. Coefficients of variation (CV) for most traits ranged between 20-25%. The exceptions were the less variable AFF (CV 6%) and highly variable WCI_{12}, TNL and IGF-I (CVs: 93%, 59% and 46%, respectively), which also had positive skewed distributions. Low variability of AFF relative to the mean reflected rapid culling of females that failed to achieve their first pregnancy, while the high variability in IGF-I reflected, amongst other things, a trend in values for this trait over time.

Table 1. Data characteristics and estimates of genetic parameters (h^2:heritability; c^2:common litter effects; σ^2_p:phenotypic variance) from univariate analyses

Trait[1]	N	Mean (SD)	Range	h^2	c^2	σ^2_p
IGF-I (ng/ml)	23730	70.0 (32.4)	1-250	0.26±0.02	0.10±0.01	829
AFF (days)	9580	339 (20.0)	258-409	0.11±0.02	0.08±0.01	367
TNL	7621	3.26 (1.92)	1-9	0.08±0.02	-	3.67
NBA_1	9652	9.64 (2.65)	0-19*	0.09±0.02	0.03±0.01	7.00
NBA_2	6791	10.1 (2.71)	0-18*	0.10±0.02	-	7.22
NBA_3	4895	10.6 (2.72)	0-19*	0.09±0.02	-	7.29
WCI_{12} (days)	5996	12.3 (11.5)	1-55	0.03±0.01	-	117
$ABWT_1$ (kg)	3631	1.46 (0.30)	0.40-2.67	0.12±0.03	-	0.084
$ABWT_2$ (kg)	2515	1.66 (0.32)	0.42-3.00	0.15±0.04	-	0.100
$ABWT_3$ (kg)	1857	1.68 (0.34)	0.40-3.00	0.15±0.04	-	0.111

[1]IGF-I: juvenile IGF-I; AFF: age at first farrowing; TNL: total number of litters before culling; $NBA_{1,2 \text{ or } 3}$: number born alive (parities 1, 2 or 3); WCI_{12}: weaning to conception interval between parities 1 and 2; $ABWT_{1,2 \text{ or } 3}$: average litter birth weight (parities 1, 2 or 3); *total number born is >0.

Heritability estimates were moderate for IGF-I and low for the reproductive traits, being generally consistent with other literature estimates for comparable traits (see Tholen *et al.* 1996a,b and Bunter *et al.* 2002). Heritability estimates for WCI_{12} and ABWT traits were lower than reported in some other studies (eg. Tholen *et al.* 1996a,b, Hermesch *et al.* 2001, Saurez *et al.* 2005).

Table 2. Estimates of additive genetic (r_g), common litter (r_c), residual (r_e) and phenotypic (r_p) correlations between IGF-I and sow reproductive traits

	Correlations with juvenile IGF-I			
Trait[1]	r_g	r_c	r_e	r_p
AFF[a]	-0.15±0.10	-0.18±0.12	-0.02±0.04	-0.06±0.02
TNL[a]	0.07±0.13	-	-0.02±0.04	-0.00±0.03
NBA_1[b]	-0.08±0.09	-	0.05±0.03	0.03±0.02
NBA_2[b]	-0.02±0.10	-	0.01±0.04	0.00±0.03
NBA_3[b]	0.08±0.11	-	0.02±0.04	0.03±0.03
WCI_{12}[a]	-0.45±0.15	-	0.06±0.04	0.01±0.03
$ABWT_1$[b]	-0.02±0.11	-	0.03±0.04	0.02±0.03
$ABWT_2$[b]	-0.04±0.11	-	0.05±0.04	0.03±0.04
$ABWT_3$[b]	0.06±0.12	-	0.08±0.05	0.07±0.04

[1]see Table 1 for trait definitions; [a]bivariate analyses; [b]four-trait analyses using reproductive records from three parities, along with IGF-I

Genetic correlations between IGF-I and AFF, TNL and WCI_{12} were small, unfavourable, but generally insignificant, with the exception of WCI_{12} (Table 2). Nevertheless, any correlated response in WCI_{12} would likely be negligible under multiple trait selection where changes in IGF-I through selection are generally small. Genetic correlations between IGF-I and litter size or average piglet birth weight traits were small but favourable in parities 1-2, unfavourable in parity 3, but did not significantly differ from zero in all cases. Residual correlations between IGF-I and sow reproductive traits were close to zero, consistent with traits that are measured at very different points in an animal's lifetime. Low genetic and environmental correlations in combination resulted in low phenotypic correlations between IGF-I and sow reproductive traits. Phenotypic correlations between IGF-I and reproductive traits were slightly unfavourable for AFF, but differed negligibly from zero for all remaining sow reproductive traits.

CONCLUSION

The tendency for IGF-I to have slightly unfavourable genetic correlations with some reproductive traits is consistent with the few reports of unfavourable correlations between efficiency and reproduction in pigs. Nevertheless, estimated genetic correlations were extremely low and should be managed with appropriate selection strategies.

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