Proc. Assoc. Advmt. Anim. Breed. Genet. ***17****: 61-64*

GENETIC ANALYSIS OF FEED INTAKE IN LACTATING SOWS

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SUMMARY

Records for daily feed intake during lactation were available for 774 sows with 2,234 litters farrowing from May 2002 to November 2006. Genetic parameters were estimated for whole-of-lactation feed intake and feed intake averaged over 5-day periods during lactation. Estimates of heritabilities and the permanent environment of the sow were 0.16±0.05 and 0.18±0.04 for total lactation feed intake and 0.19±0.05 and 0.17±0.05 for average lactation feed intake. Both traits were adjusted for lactation length. Heritability estimates for lactation feed intake defined as separate traits for each of the first 3 parities ranged from 0.17 to 0.28. Genetic correlations between lactation feed intake recorded in different parities were 0.45±0.33 and lower suggesting that lactation feed intake of first parity gilts is genetically a different trait than lactation feed intake of sows recorded in later parities. Heritabilities for feed intake averaged over 5-day periods from day 6 to 20 of lactation were similar to total lactation feed intake. These 5-day period measures of average feed intake were genetically the same trait and had high genetic correlations with total lactation feed intake. The use of a 5-day measure of feed intake during the second or third week of lactation reduces costs of recording and should be explored further by evaluating genetic relationships with other performance traits.

INTRODUCTION

The demand of sows for nutrients is increased during lactation. Selection for higher litter size, reduced backfat and higher growth rate has resulted in higher milk production and maintenance costs of the lactating sow as well as reduced body fat reserves at farrowing (Eissen *et al*. 1999). The sow will mobilise body tissue if her feed intake during lactation is insufficient to meet nutrient demands. Excessive weight loss during lactation has been shown to lead to several reproductive problems in sows and Eissen *et al*. (1999) recommend selection for higher feed intake of sows during lactation.

Feeding charts have been suggested as a management tool to monitor and improve daily feed intake of sows during lactation (Welch, 2005). However, recording of daily feed intake over the whole lactation is labour intensive. In addition, a step-up feeding system is commonly used whereby the daily feed intake is gradually increased until day five or six of lactation. For genetic improvement purposes it may be sufficient to record daily feed intake during the peak of lactation as a measure of feed intake capacity of sows during lactation.

The aim of this project was to estimate genetic parameters for total and average daily feed intake of sows during lactation and average feed intake of sows over 5-day periods during lactation to identify the part of lactation that is most useful for pig breeding programs.

MATERIALS AND METHODS

Daily feed intake records of sows during lactation were available for 2,234 litters (774 sows), which were recorded from May 2002 until November 2006 including 1,691 Large White, 388 Landrace and 155 Crossbred litters from sows in their first to eighth parity. Daily feed intake was gradually (1 kg

* AGBU is a joint venture of NSW Department of Primary Industries and the University of New England

per day on average) increased during the first 5 days of lactation. Sows were then fed to appetite for the remainder of lactation with a maximum daily feed delivery of nine kg per day from May 2002 until August 2004 or eight kg per day since September 2004. Sows were fed twice daily from Monday to Saturday and received only one meal on Sundays. The average lactation length was 21 days ranging from 4 to 30 days. No restrictions were imposed to ensure that all sows had complete parity records from the first parity onwards. The pedigree included 1,217 animals covering a 9-year period from 1997 to 2006. Sows with performance records were from 178 sires and 426 dams.

Traits analysed include the total feed intake (TFI) and average daily feed intake (AFI) of sows during lactation. The different stages of lactation were described through average feed intake from day 1 to 5 (FI1), day 6 to 10 (FI2), day 11 to 15 (FI3) and day 16 to 20 (FI4). The two traits describing lactation feed intake (TFI, AFI) were also defined as separate traits for the first (P1TFI, P1AFI), second (P2TFI, P2AFI) and third (P3TFI, P3AFI) parity. Observations that were outside three standard deviations from the mean were deleted for each trait.

Fixed effects were evaluated using Proc GLM and Proc MIXED (SAS, 2003). Month of farrowing and breed were fitted for all traits. Parity was an additional effect for traits based on repeated measures of feed intake of sows. Lactation length was fitted as a linear covariable for total and average lactation feed intake. Each feed intake trait averaged over 5-day periods was adjusted for day of farrowing to account for the Sunday feeding regime. Variance components were estimated using ASReml (Gilmour *et al*. 2002) applying an animal model with the permanent environment effect of the sow fitted as an additional random effect to take repeated records into account. Genetic parameters are presented from univariate and bivariate analyses unless stated otherwise.

RESULTS AND DISCUSSION

There was considerable variation in the amount of feed consumed by sows during lactation (Table 1). Total feed intake ranged from 5.5 to 209 kg and the coefficient of variation (CV%) was 30.1. On average, sows consumed 5.11 kg feed per day (CV%: 21.9) with gilts eating approximately one kg less per day than sows in later parities (Table 2). In comparison, the average daily feed intake of gilts between eight and 35 days inclusive was 4.32 kg/d in the study by Bunter *et al*. (2007). Feed intake was not limited at the start of lactation in the study by Bunter *et al*. (2007). Average feed intake increased continuously during lactation from 2.69 kg/d (FI1) to 6.11 kg/d (FI4) (Table 1).

Length of lactation was the independent variable contributing most to the high coefficients of determination for total and average feed intake followed by the effect of parity, which accounted for a larger proportion of the variation during the later stages of lactation (FI2 to FI4).

Heritability estimates for total and average feed intake (Table 1, Table 2) were within the range of estimates of 0.14±0.05 (restricted) and 0.30±0.08 (*ad libitum*) for total feed intake presented by Bergsma *et al*. (2007) and slightly higher than the estimate of 0.11±0.09 for average daily feed intake of gilts shown by Bunter *et al*. (2007). The proportions of variation explained by the permanent environment effect of the sow for lactation feed intake (0.18±0.04 and 0.17±0.05) were higher than the estimates presented by Bergsma *et al*. (2007) for restricted (0.09) and *ad libitum* (0.04) feeding. The restriction in feed intake during the first five days of lactation reduced the heritability estimate to 0.02±0.02. In contrast, heritability estimates for feed intake averaged over 5-day periods between days six to 20 of lactation were not significantly different to the heritabilities for lactation feed intake.

Genetic correlations between total and average feed intake recorded in the first, second and third parity, obtained in trivariate analyses, ranged from 0.32 to 0.45 but had also high standard errors

(0.27 to 0.40; Table 2). In contrast, genetic correlations between second and third parities were not significantly different from 1 (0.99±0.29 and 0.91±0.29). These genetic correlations suggest that lactation feed intake of sows recorded in the first parity is genetically a different trait than lactation feed intake measured in later parities. Comparable genetic correlations were not found in the literature. However, litter size and litter weight traits recorded in the first parity versus later parities were genetically different traits in the study by Tholen *et al*. (1997).

Table 1. Number of litters (N), means, ranges, coefficients of variation (CV%) and determination (R^2), heritabilities (h^2) and permanent environment of the sow (pe_{sow}) as a proportion of the phenotypic variance (σ^2_p) for lactation feed intake of sows.

Trait	N	Mean	Range	CV%	R^2	h^2 (se)	pe_{sow}(se)	σ^2_p
TFI (kg)	2215	109	5.5-209	30.1	0.74	0.16(0.05)	0.18(0.04)	300
AFI (kg/d)	2206	5.11	1.5-8.2	21.9	0.50	0.19(0.05)	0.17(0.05)	0.679
FI1 (kg/d)	2197	2.69	0.5-4.9	26.0	0.30	0.02(0.02)	0.13(0.03)	0.357
FI2 (kg/d)	2147	5.43	1.6-8.8	23.6	0.51	0.17(0.05)	0.10(0.04)	0.870
FI3 (kg/d)	2081	6.08	1.8-9.0	24.0	0.48	0.14(0.04)	0.15(0.04)	1.19
FI4 (kg/d)	1719	6.11	1.7-9.0	23.6	0.40	0.12(0.05)	0.18(0.05)	1.31

Table 2. Number of litters (N), means, coefficient of determination (R^2), heritabilities (h^2), phenotypic variation (σ^2_p) and genetic (bold) and phenotypic (italic) correlations for lactation feed intake of sows recorded in first to third parity.

Trait	N	Mean	R^2	h^2 (se)	σ^2_p	Par 1	Par 2	Par 3
P1TFI (kg)	606	91	0.69	0.23(0.09)	248		**0.32**(0.27)	**0.45**(0.33)
P2TFI (kg)	470	113	0.69	0.27(0.11)	287	*0.33*(0.05)		**0.99**(0.29)
P3TFI (kg)	366	118	0.80	0.19(0.11)	268	*0.32*(0.06)	*0.43*(0.05)	
P1AFI (kg/d)	603	4.21	0.36	0.17(0.09)	0.541		**0.40**(0.29)	**0.39**(0.40)
P2AFI (kg/d)	469	5.26	0.34	0.28(0.11)	0.607	*0.31*(0.05)		**0.91**(0.29)
P3AFI (kg/d)	366	5.48	0.52	0.17(0.11)	0.581	*0.33*(0.06)	*0.46*(0.05)	

Genetic parameters did not differ significantly from estimates based on data limited to sows with complete parity records. Variance components were not restricted to the parameter space and some correlations due to the permanent environment of the sow were outside the parameter space (Table 3). Restricting these correlations to the parameter space (< 1) had only minor effects on other variance components. Feed intake averaged over 5-day periods from day six to ten and day 16 to 20 had high genetic correlations (0.93±.04 and 0.98±0.03) with total feed intake of lactation (Table 3). In addition, the three 5-day feed intake measures recorded from day 6 to day 20 of lactation were genetically the same trait. These results provide opportunities to reduce costs of recording lactation feed intake in sows for breeding programs. A 5-day period between day six to 20 may be used for selection purposes instead of lactation feed intake. This 5-day period may be recorded from Monday to Friday in the first or second week after farrowing, which implies that sows farrowing on either a Wednesday or Thursday (51% in this data set) would be recorded between days five to 10 or between days 12 to 17 of lactation.

Table 3. Genetic (r_g)and phenotypic (r_p) correlations (above diagonal) along with correlations due to permanent environment of the sow (r_{pe}) and residual (r_e) correlations (below diagonal) for characteristics of feed intake of sows during lactation. (standard errors in brackets)

		TFI	FI1	FI2	FI3	FI4	
TFI			**.72 (.21)**	**.93 (.04)**	**ne**	**.98 (.03)**	$\mathbf{r_g}$
			.48 (.02)	.72 (.02)	ne	.77 (.01)	r_p
FI1	r_{pe}	.75 (.11)		**.89 (.16)**	**.46 (.33)**	**.43 (.41)**	$\mathbf{r_g}$
	r_e	.42 (.02)		.44 (.02)	.27 (.02)	.19 (.02)	r_p
FI2	r_{pe}	1.13 (.14)	1.13 (.18)		**.86 (.08)**	**.88 (.10)**	$\mathbf{r_g}$
	r_e	.61 (.02)	.32 (.02)		.51 (.02)	.38 (.02)	r_p
FI3	r_{pe}	ne	.62 (.14)	1.10 (.18)		**.97 (.05)**	$\mathbf{r_g}$
	r_e	ne	.20 (.03)	.35 (.02)		.62 (.02)	r_p
FI4	r_{pe}	.99 (.04)	.53 (.16)	.96 (.18)	1.02 (.07)		
	r_e	.68 (.02)	.11 (.03)	.19 (.03)	.47 (.02)		

ne: estimate could not be obtained

CONCLUSIONS

Feed intake of sows recorded during lactation was heritable. Lactation feed intake was substantially lower in the first parity in contrast to later parities and genetic parameters suggest that lactation feed intake in the first parity is genetically a different trait than lactation feed intake in later parities. Heritabilites for feed intake averaged over 5-day periods from day six to 20 of lactation were similar to heritabilities for lactation feed intake. These 5-day feed intake records had high genetic correlations with total lactation feed intake and with each other. Therefore, it may be sufficient for selection purposes to record lactation feed intake in sows from Monday to Friday in the second or third week of lactation, which should be explored further by evaluating genetic relationships with other performance traits

ACKNOWLEDGMENTS

The author thanks Tracey and Stuart Neuendorf for making the data available and Robert Jones for diligent data checking. Analyses of data were funded by Australian Pork Limited under Project 2133.

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