REPRODUCTIVE PERFORMANCE OF PIGS SELECTED FOR COMPONENTS OF EFFICIENT LEAN GROWTH

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SUMMARY

Correlated responses in reproductive performance to five generations of divergent selection for daily food intake (DFI), lean food conversion (LFC), lean growth rate on *ad-libitum* feeding (LGA), and lean growth rate on scale feeding (LGS) were studied. Litter traits were measured on 1220 selected Large White gilts. Litter birth weights were reduced (-2.8kg) in the low DFI and high LFC lines. The response for litter birth weight in LGS was greater than in LGA (3.0 vs -0.1). Relationships between litter size, litter weights and piglet weights at birth and weaning were essentially linear. An extra piglet at birth and weaning corresponded to an increase of 1.0 kg and 6.9 kg in litter weights and a decrease of 0.03 kg and 0.19 kg in piglet weights. Heritabilities for litter size, weight and piglet weight at birth (0.06, 0.11 and 0.16) were similar to those at weaning. Common environmental effects on piglet weights (0.38 and 0.45) were higher than heritabilities.

INTRODUCTION

Selection for growth and efficiency in pig breeding schemes has been based on performance test traits and predicted carcass traits. Responses in reproductive performance to selection on performance test traits have not been extensively evaluated. The purpose of the current study was to determine correlated responses in reproductive performance to five generations of divergent selection for components of efficient lean growth rate in Large White pigs and to estimate the genetic and phenotypic parameters for reproductive traits.

MATERIAL AND METHODS

Animals. Data were collected from five generations of pigs divergently selected for daily food intake (DFI), lean food conversion (LFC), lean growth rate on *ad-libitum* feeding (LGA) and lean growth rate on scale feeding (LGS). Details on establishment of the selection lines and performance test are given by Cameron (1994) and Cameron and Curran (1994). In each of the four selection groups, there were high, low and control lines and each line was designed to consist of 10 sires and 20 dams. All animals were mated at around 9.5 months of age and were batch farrowed at an average of 414 (s.d. 19) days of age. No cross fostering was practised. Piglets were offered creep feed from 14 days of age and were weaned at an average of 35 (s.d. 3) days. Litter traits were measured on a total of 1220 selected Large White gilts, with 13030 and 9951 records of piglet birth and weaning weights respectively. For each selected gilt, measurements of litter size and weight at birth and weaning were taken. Piglet weights at birth and weaning were also recorded.

Statistical analysis. Additive genetic (co)variances for gilt traits were estimated using an individual animal model. Full pedigree information was included in a multivariate residual maximum likelihood (REML) analysis, using the REML algorithm of Meyer (1986). Additive genetic and common environmental (co)variances for piglet traits were estimated using an individual animal model in a multivariate derivative-free residual maximum liklihood (DFREML) analysis (Meyer, 1989). Mortality of pigs from birth to weaning was analysed using a marginal model fitted by a generalised linear mixed model procedure as it was not normally distributed. For variance component estimation no fixed effects were included in the analysis of gilt traits, but sex was included in the analysis of piglet traits. To estimate the correlated responses at generation five, a model including genetic group as a fixed effect was used, where genetic group corresponded to the selection group, line and generation subclass of each individual. Linear relationships between litter and piglet weights with litter size, at birth and weaning, were examined using univariate DFREML analyses.

RESULTS

Correlated responses to selection. Responses in litter size at birth and weaning were not statistically significant in the four selection groups (Table 1). Mortality rate between birth and weaning was significantly higher in the high LGS line than in the corresponding low line. The low DFI, high LFC and low LGS lines had significantly lower litter weights at birth, than the complementary selection lines, but there were no responses in piglet birth weights. The high DFI line had heavier piglets at weaning than the low line with no difference in weaning age (1.5 days, s.e.d. 2.5).

Table 1 Correlated responses in reproductive traits after five generations of divergent selection for each selection group expressed as deviations from the mean

Selection group		DFI		LFC		LGA		LGS		s.e.d.
Trait	Mean	High	Low	High	Low	High	Low	High	Low	H-L†
Litter size at birth	10.3	1.2	-0.7	-1.2	0.1	0.6	-0.4	-0.1	-0.7	1.1
Litter size at weaning	7.9	-0.4	-1.3	-0.8	1.0	0.7	0.5	-0.6	0.2	1.2
Mortality x 100 (%)	23.1	9.8	6.4	-2.5	-8.7	-2.9	-8.5	6.1	-8.4	-
Litter birth wt (kg)	12.9	0.3	-2.7	-2.2	0.6	-0.3	-0.2	1.1	-1.9	1.4
Litter weaning wt (kg)	63.5	0.0	-17.5	-6.5	10.8	4.1	4.6	-6.9	-2.5	10.1
Piglet birth wt (kg)	1.3	-0.2	-0.2	-0.1	-0.0	-0.2	0.0	0.1	-0.1	0.1
Piglet weaning wt (kg)	8.1	0.4	-0.9	0.3	0.3	0.1	0.3	-0.2	0.0	0.5

† Standard error of the difference between the high and low selection lines at generation 5

Genetic parameters. Heritability estimates for litter size, weight and piglet weight at birth were 0.06, 0.11 (s.e. 0.04), and 0.16 (s.e. 0.02) and were similar to those at weaning (0.08, 0.14, s.e. 0.04 and 0.08, s.e. 0.02). The heritability of mortality was less than 0.01. Common environmental effects on piglet weights were substantially higher than estimates of the heritability (0.38 and 0.45, s.e. 0.01). Phenotypic correlations between litter traits were positive (0.7, on average). Genetic correlations were marginally lower than the phenotypic correlations, except for genetic correlations of 0.2 (s.e. 0.3) between litter size at birth with litter weights. Phenotypic and genetic correlations between piglet birth and weaning weights were 0.46 and 0.67 (s.e. 0.01 and 0.09) respectively.

Linear relationships between litter and piglet weights with litter size at birth and weaning. Linear regression coefficients indicated a 1.0 kg (s.e. 0.02) increase in litter birth weight and a 6.9 kg (s.e. 0.1) increase in litter weaning weight for every piglet increase in litter size at birth and weaning, respectively. Conversely, with increased litter size piglet birth and weaning weights decreased by 0.03 kg (s.e. 0.003) and 0.19 kg (s.e. 0.02) respectively. Within-selection group regression coefficients were not statistically different from each other or from the overall coefficients.

Variation in litter size proportionally attributed over 0.80 of the variation in litter weights at birth and weaning. Adjustment of litter birth and weaning weights to constant litter sizes diminished the selection line differences in litter weight traits, except in the LGA selection group. Responses in the LGS and DFI groups for litter birth and weaning weights, respectively, remained and adjustment of piglet birth weight to constant litter size, increased the magnitude of responses in the DFI, LFC and LGS selection groups (Table 2). Selection line differences in piglet weaning weights were unchanged when adjusted to constant litter size.

Table 2 Comparison of responses in litter and piglet weights at birth and weaning when litter size was included and not included as a covariate in the model

Selection group	Litter weight (kg)				Piglet weight (kg)			
	Birth		Weaning		Birth		Weaning	
Litter size‡	Included	-	Included	-	Included	-	Included	-
Daily food intake	0.8	3.0	11.3	17.5	0.14	-0.05	1.4	1.3
Lean food conversion	-1.3	-2.8	-3.9	-17.3	-0.13	-0.08	-0.3	0.0
Lean growth (*ad-lib*)	-1.1	-0.1	-1.8	-0.5	-0.08	-0.20	-0.2	-0.2
Lean growth (scale)	2.1	3.0	0.8	-4.4	0.27	0.22	-0.2	-0.2
s.e.d (H-L)†	0.9	1.4	4.6	10.1	0.06	0.13	0.3	0.5

† Standard error of the difference between the high and low selection lines at generation 5

‡ Litter size included or not included in the model

DISCUSSION

Responses in reproductive performance have shown that selection for aspects of efficient lean growth adversely affects reproductive performance in Large White pigs. Selection for low DFI and high LFC reduced performance in all reproductive traits. Selection for LGA and LGS did not affect reproductive performance, except for increased litter birth weight with selection on high LGS. Several studies have proposed that body composition is closely related to reproductive development and performance in pigs. Eliasson *et al* (1991), reported that at 90 kg live weight, gilts with low backfat depth attained puberty significantly latter than gilts with high backfat depth. McPherson *et al* (1977) reported that ovulation rate increased with the successive oestrus cycles, implying that delaying the onset of puberty may be associated with low backfat depth, reduced ovulation rate and subsequent litter size, when gilts are mated at the same age. The results of McPherson *et al* (1977) were consistent with the proposal of Kirkwood *et al* (1985) that selection for carcass lean content is indicative of selection for increased mature size, which, at a given age, produces a physiologically younger animal with a later onset of puberty.

Increased litter size was associated with a reduction in piglet birth weight, which suggested a uterine constraint on pre-natal growth, due to increased competition among litter mates for uterine resources (Christenson *et al,* 1987). The positive, linear relationship between litter weight and litter size at birth, with litter size ranging from one to 20 piglets, did not support the suggest of an upper limit to uterine capacity. However, the existence of a uterine constraint on pre-natal growth may be implied by the regression coefficient , which was less than the average piglet birth weight.

To understand the biological basis for responses in litter size, measurements of additional traits are necessary. Weight and ultrasonic backfat at mating need to be measured to establish the relationship between body composition of the sow with conception rate, litter size and piglet growth. Laproscopic measurement of ovulation rate is required to assess potential litter size and embryo survival. Genetic and phenotypic relationships between performance test and reproductive traits should be estimated, as prediction of responses in reproductive traits is required for the design of breeding programmes based on selection for growth and carcass traits.

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