SELECTION FOR GROWTH RATE IN PIGS ON RESTRICTED FEEDING. GENETIC PARAMETERS AND CORRELATED RESPONSES IN RESIDUAL FEED INTAKE.

N.H. Nguyen[1], C.P. McPhee[2], L.J. Daniels[3] and C.M. Wade[1]

[1]School of Veterinary Science, The University of Queensland QLD 4072
[2]Queensland Department of Primary Industries, Animal Research Institute, Yeerongpilly, QLD 4105
[3]Queensland Department of Primary Industries, Research Station, Biloela, QLD 4715

SUMMARY

Residual Feed Intake (RFI) represents the deviation of the actual *ad libitum* food consumption from that predicted on the basis of growth rate alone, or combined with backfat. After four years of selection of lines for high and low post weaning growth rate on restricted feeding, the high line exhibited a significant reduction in RFI relative to the low line. This indicated a lower energy requirement for maintenance in the high than the low line, possibly due to reduced physical activity. Estimates of genetic parameters showed that RFI was moderately heritable. Genetic correlations of RFI with backfat and food conversion ratio were moderately to highly positive, suggesting that selection for low RFI would improve carcass lean content and efficiency of food utilisation.
Key words: Heritability, selection, *ad libitum*, restricted feeding.

INTRODUCTION

Selection for production traits, especially for efficiency of lean production, may lead to correlated changes in maintenance energy requirement (ME_m) because lean body mass directly influences the thermal capacity and the rate of heat loss; and indirectly affects the basal metabolic heat production and maintenance requirement (Kolstad and Vangen 1996). Knowledge in this area is incomplete. Generally, the literature suggests that selection for lean production is associated with high metabolic heat production and maintenance requirements in pigs (Stundstol *et al.* 1979). Selection for high lean growth rate on restricted feeding may however result in reduced maintenance requirement. Vangen (1980) reported that pigs selected for lean growth on semi-restricted feeding maintained heavier body weights than fat pigs feed the same amount, even though lean pigs had 6% less fat, and maintenance costs for fat are lower than protein. The results of McPhee *et al.* (2000) showed that sows selected for high lean growth on restricted feeding exhibited more placid behaviour around farrowing, possibly resulting in a reduced energy requirement for activity driven maintenance. This has been found to account for as much as 8 –10% of total metabolisable energy intake in pigs (Henken *et al.* 1991).

There has been little development of direct measures of ME_m due to the high cost of testing. Genetic differences in ME_m have been estimated using restricted feeding to maintain constant live weight for a fixed period (Taylor and Young 1967). Recently, residual feed intake (RFI), that is the amount of feed consumed in excess of requirements for tissue deposition, has been proposed as an alternative measure of feed efficiency, and an indicator of ME_m in cattle and poultry (Krover 1988; Luiting *et al.* 1990). The current study reports correlated responses in RFI, its heritability, and genetic correlations with production traits in Large White pigs divergently selected for high or low body weight gain on restricted feeding, when performance tested on *ad libitum* individual feeding.

MATERIALS AND STATISTICAL METHODS

Animals and performance testing procedures. Pedigree and data structures for the pigs are given in Table 1. On 33 occasions, 12 pigs of each sex were sampled across litters from the high and the low lines, placed in individual pens at 50 kg and fed *ad libitum* over a 6 week period. Animals were fed a diet containing 14 MJDE, 0.65g/MJ available lysine. Live weights were recorded at the start and end of the test, and used to calculate average daily gain (ADG). Daily food intake (DFI) was calculated by subtraction of the total amount of food refused from the total amount offered during the test period and dividing by the number of days on test. The food conversion ratio (FCR) was the ratio of DFI over ADG. Measurement was made of ultrasonic P2 backfat thickness (BF) at the end of the test.

Table 1: data structure and characteristics

Years	Animals	Sires	Dam
Base	118	16	61
1997	168	27	82
1998	141	30	77
1999	206	35	106
2000	119	19	69
Total	**752**	**88**	**266**

Estimation of residual feed intake. RFI was computed as the difference between the observed daily feed intake (DFI) and the predicted feed intake (pDFI). The observed daily feed intake was corrected for effects of batch and sex and their interactions using the following model:

$$DFI_{ijk} = \mu + B_i + S_j + B \times S_{ij} + e_{ijk}$$

Where: DFI is the observed daily feed intake of the individual k; μ is adjusted mean; B_i the effect of batch (i = 1, 2, 3, …33); S_j the effect of sex (j = 1, 2); B_{ij} X S the interaction of batch and sex; and e_{ijk} the random error term.

The predicted feed intake was estimated from different regression models that included 1) growth rate (RFI_1) and 2) growth rate and backfat (RFI_2) after adjustment for the fixed effects of batch (33 classes) and sex (male and female). The general model is as the following:

$$pDFI = = \mu + B_i + S_j + B \times S_{ij} + b_1GR_{ijk} + b_2FT_{ijk}$$

Where: pDFI is the predicted daily feed intake; b_1 and b_2 are partial regression coefficients; GR is the growth rate (g/d); and FT is P2 backfat thickness (mm).

The RFIs were calculated per pig using the following models:

$$RFI_1 = DFI - (\mu + B_i + S_j + B \times S_{ij} + 0.598 \times GR_{ijk})$$

$$RFI_2 = DFI - (\mu + B_i + S_j + B \times S_{ij} + 0.545 \times GR_{ijk} + 0.780 \times FT_{ijk})$$

Genetic (co) variance components. Genetic and environmental variance components for all traits were estimated with the animal model - restricted maximum likelihood method using the average information algorithm of Gilmour *et al.* (1999). The model included fixed effects of batch and sex and animal as a random effect. Final body weight was fitted as a linear covariate for P2 fat depth.

RESULTS AND DISCUSSION

Correlated response. The correlated responses of RFI to selection for high growth rate on restricted feeding are given in Table 2. The high line exhibited lower RFI, indicating a lower energy requirement for maintenance than the low line. This reduced maintenance energy may have been due to reduced physical activity even though this has not been measured in these lines. In a different study, McPhee *et al.* (2000) found that sows in a line selected for high lean growth on restricted feeding displayed reduced physical activity.

Table 2: Correlated response in residual feed intake (RFI) of pigs on *ad libitum* individual feeding throughout four years of selection for high and low growth rate

Criteria /Years	RFI_1 (g/d)		RFI_2 (g/d)	
	High	Low	High	Low
1997	-0.15	3.58	2.61	0.81
1998	-10.66	26.45	-1.69	28.87
1999	-15.60	17.33	-20.61	2.21
2000	-10.40	52.96	-15.63	40.00
Standard Error of Difference	24.63		24.58	

Genetic parameters. The current estimates of heritabilities for RFI_1 and RFI_2 (Table 3) fall within the range of literature results recently reported in pigs, from 0.2 to 0.47 (Table 4). De Haer and de Vries (1993) and Labroue (1995) reported somewhat higher estimates than the published mean (0.45 in Dutch pigs, 0.46 in French Large White and 0.47 in Landrace breeds, respectively). Heritability for RFI_2 estimated from the model including backfat and growth rate is similar to that for RFI_1 estimated from growth rate alone. Genetic correlations of RFI with BF and FCR were all positive, suggesting that selection for reduced RFI would decrease BF and improve efficiency of food utilisation.

Table 3: Heritabilities (x 100), and genetic correlations (x 100) of RFI with performance traits

Traits	h^2	ADG	P2- fat	FCR
RFI_1 (g/d)	24 ± 8	*	13 ± 22	50 ± 15
RFI_2 (g/d)	20 ± 8	*	20 ± 22	29 ± 18

*Failed to converge

Variation between studies in the estimates of RFI using phenotypic regression as in this study is difficult to interpret at genetic level. This variation may be explained by differences in models fitted to estimate RFI. RFIs were mostly derived from DFI regressed on ADG and BF (Foster *et al.* 1983; and Von Felde *et al.* 1996) or ADG and lean growth or lean content (De Haer *et al.* 1993; Mrode and Kennedy, 1993; Labroue 1995) by multiple regression analysis. Johnson *et al.* (1999) also incorporated initial test age and weight, and loin eye area to estimate four different measures of residual food intake. They found that measures of RFI that included backfat had lower estimates of heritability than those without backfat. Furthermore, variation in RFI comprises numerous intrinsic factors such as variation in food digestibility, in energy efficiency partitioning for maintenance and production or variation in maintenance energy requirements for physical activity, body thermo-regulation, maintenance of body tissues and basal metabolic rate (De Haer *et al.* 1993).

It is concluded that pigs selected for high growth rate on restricted feeding have a reduced energy requirement for maintenance.

Table 4: Estimates of heritability and genetic correlations of RFI with performance test traits

References	h^2	ADG	BF	Loin Eye Area
Foster *et al.* (1983)	0.30			
De Haer and de Vries (1993)	0.45			
Mrode and Kennedy (1993)	0.34	0.24	0.37	
Labroue (1995)	0.47			
Von Felde *et al.* (1996)	0.18	0.03	0.00	
Johnson *et al.* (1999)	0.13	0.15	0.44	-0.29

Estimates were pooled across models or breeds

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