SELECTION FOR LEAN GROWTH IN PIGS WITH A RESTRICTED FEEDING REGIME

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SUMMARY

Responses to four generations of divergent selection in pigs for lean growth rate with restricted feeding (LGS) were studied in populations of Large White (LW) and British Landrace (LR). Totals of 1250 LW and 875 LR pigs were performance tested in Edinburgh and Wye, respectively. After four generations of selection, cumulative selection differentials were 5.9 and 4.8 phenotypic s.d. for LW and LR pigs, respectively, with similar responses, 1.8 phenotypic s.d. Mean weight at the end of test, growth rate and backfat depths at the shoulder, mid-back and loin were 89 kg, 712 g/day, 26, 13 and 13 mm for LW and for LR pigs were 87 kg, 683 g/day, 28, 10 and 10 mm. High line pigs were heavier at the end of test (4.3 and 4.0 kg) for LW and LR pigs, with corresponding responses in growth rate (54 and 47 g/day). Responses in the shoulder, mid-back and loin backfat depths were -4.1, -2.6 and -2.9 mm for LW and -2.2, -2.2 and -2.4 mm for LR pigs. Responses in weight off test and backfat depths were symmetric about the control lines. Heritabilities for LGS were 0.34 and 0.28 for LW and LR, when estimated by residual maximum likelihood. Common environmental effects for LGS were 0.11 for LW and 0.17 for LR. Heritabilities for growth rate and average backfat depth were similar for LW and LR pigs (0.17 and 0.29, as were common environmental effects (0.10. Phenotypic and genetic correlations between growth rate and mid-back fat depth were small (0.16 and -0.06, respectively).
Responses to selection and genetic parameter estimates demonstrate that there is substantial genetic variation in growth and fat deposition when pigs are performance tested on restricted feeding.

INTRODUCTION

Divergent selection lines for lean growth on a restricted feeding regime, in Large White (LW) and British Landrace (LR) pigs, were established to complement the lean growth selection lines on *ad-libitum* feeding (Cameron and Curran, 1994). This study estimated the direct and correlated responses after four generations of selection and the corresponding genetic and phenotypic parameters.

MATERIAL AND METHODS

Animals. Within each population, there were high and low selection lines with a control line, each consisting of 10 boars and 20 gilts, with a generation interval of 13.5 and 12 months for LW and LR pigs. Animals were performance tested in individual pens from 30±3 kg for a period of 84 days and fed a high energy (13.8 MJ DE/kg DM) and high protein (210 g/kg DM crude protein) pelleted ration. Daily food intake was equal to 0.75 g/g of the daily food intake for *ad-libitum* fed pigs and the total food intake was 134 kg for LW pigs and 150 kg for LR pigs. On average, 3 boars and 3 gilts were tested per litter. The total numbers of pigs performance tested over four generations were 1250 LW and 875 LR.

Selection objective and criterion. The selection objective for lean growth on restricted feeding was to obtain equal correlated responses in growth rate and carcass lean content, measured in phenotypic s.d. The selection criterion included measurements of growth rate and ultrasonic backfat depth.

Statistical analysis. Additive genetic and common environmental (co)variances for performance test traits were estimated using the individual animal model in a multivariate derivative-free residual maximum likelihood analysis (Graser, Smith and Tier, 1987), for each population, using an adaptation of the algorithm of Meyer (1989), as proposed by Thompson and Hill (1990). Fixed effects for sex, testing house and month or period at the start of performance test were included in the model. Covariates for weight on test, separately for each sex, were included in the models for weight off test and backfat measurements, as in the experimental design the performance test started on a fixed weight basis. Responses in performance test traits to selection were estimated from the mean within-generation selection line breeding values for each trait, calculated using estimates of additive genetic, common environmental and residual variances.

RESULTS

Direct and correlated responses. After four generations of selection, cumulative selection differentials were 5.9 and 4.8 phenotypic s.d. of the selection criteria for LW and LR pigs, respectively, with similar responses (1.8 phenotypic s.d.). High line pigs were heavier at the end of test, with comparable responses in growth rate, and had lower backfat depths than the low line. (Table 1). In both populations, responses in growth were asymmetric about the control lines, while responses in backfat were reasonably symmetric about the control lines, except for shoulder fat depth in LW pigs.

Table 1. Correlated responses in performance test traits after four generations of divergent selection

Population	Large White - Edinburgh					Landrace - Wye				
	Mean	High	Con.†	Low	s.e.d.‡	Mean	High	Con.	Low	s.e.d.
Weight off test (kg)	89.0	1.8	0.5	-2.5	1.4	87.2	2.7	-0.3	-1.3	1.6
Average daily gain (g/day)	712	23	7	-31	16	683	32	-2	-15	18
Backfat : shoulder (mm)	25.6	-1.4	0.2	2.7	1.2	28.3	-1.1	0.2	1.1	0.5
mid-back (mm)	12.7	-0.9	0.3	1.7	0.7	9.5	-1.1	0.2	1.1	0.4
loin (mm)	12.7	-1.1	0.3	1.7	0.7	10.8	-1.1	0.2	1.2	0.5

† : Control line and ‡ : standard error of the difference between the high and low selection lines

Genetic and phenotypic parameters. Heritability estimates of 0.34 and 0.28 (s.e. 0.05), estimated by residual maximum likelihood were similar to the realised heritabilities, when estimated by weighted regression of cumulative response in cumulative selection differential (0.32 and 0.29, s.e. 0.06) for LW and LR populations (Table 2). Heritabilities for growth rate and backfat depths were similar for LW and LR pigs, but common environmental effects for backfat were lower in LW than in LR pigs. Genetic correlations between growth rate and backfat were not significantly different from zero. Correlations between the three backfat measurements were equal to unity in LR pigs, but were substantially lower in LW pigs. Standard errors of common environmental effects, genetic correlations of growth with backfat and between backfat measurements were 0.03, 0.15 and 0.04, respectively.

Table 2. Estimates of genetic and phenotypic parameters (x100) for performance test traits

Population		Large White - Edinburgh				Landrace - Wye			
		ADG	BFS	BFM	BFL	ADG	BFS	BFM	BFL
Average daily gain	(ADG)	18 †	14	18	21	17	11	14	13
Backfat : shoulder	(BFS)	-32	20	74	70	-9	21	80	80
mid-back	(BFM)	-4	70	37	84	-7	99	30	90
loin	(BFL)	13	76	88	35	2	99	99	26
Common environmental effects		12	8	7	8	11	15	16	19

† : Heritabilities on diagonal, genetic correlations below and phenotypic correlations above diagonal

DISCUSSION

Responses to selection and genetic parameter estimates demonstrate that there is substantial genetic variation in growth and fat deposition, when pigs are performance tested on restricted feeding. Less variation in growth rate and backfat depth with restricted feeding compared to *ad-libitum* feeding has been reported (Cameron *et al*, 1988; Gu *et al*, 1989). In the present study, phenotypic variances for growth rate and average backfat depth with restricted feeding were proportionately equal to 0.34 and 0.67 of the variances with *ad-libitum* feeding, although the mean values were proportionately reduced by only 0.83 and 0.93 respectively. On restricted feeding, fat deposition, with marginally less variation, was sustained but variation in growth rate was substantially reduced to a greater extent than expected from reduction in the mean value. Around 85 to 90 kg, the preference for fat deposition rather than muscle growth suggested that selection line differences in fat deposition may be expected to be relatively greater than differences in weight off test. In the LW and LR populations, the selection line differences in mid-back fat depths and weight off test, relative to the mean, were 0.21 and 0.05, respectively.

Selection for lean growth on restricted feeding may identify animals which preferentially partition energy towards protein deposition rather than towards fat deposition, due to the higher energy cost of fat deposition. In the LW pigs, proportionally more energy was credited to protein deposition in the high selection line than in the low line (0.25 v 0.21) and conversely less to lipid deposition (0.37 v 0.41), with the control line intermediate (0.23 and 0.39), using formulae of Whittemore, Kerr and Cameron (1994) for energy requirements, assuming energy for maintenance is solely a function of liveweight. Vangen (1980) compared lines divergently selected for lean growth and suggested that the lower maintenance requirement of the high lean growth line was due to less energy being required to retain protein than to retain fat depots. However, Kanis (1990) suggested that energy partition towards protein deposition was negatively associated with food intake capacity, such that on restricted feeding with no variation in food intake, genetically lean animals with low food intake capacity would have similar growth rates, but higher maintenance requirements than fat animals. An interpretation of Kanis's (1990) hypothesis, which is consistent with the results of Vangen (1980) and the formulae of Whittemore *et al* (1994), is that genetically lean animals have higher rates of protein turnover, such that energy requirements per g of protein retained (deposited - degraded) were greater than in genetically fat animals, assuming that energy requirements per g of protein and fat deposited and for maintenance were similar.

The divergent selection lines with *ad-libitum* and restricted feeding provide the facility to efficiently test for genotype with environment interaction (GxE), by testing litter mates of *ad-libitum* and restricted fed animals on the alternative feeding regime, and then estimating the genetic correlation between performance test traits on *ad-libitum* and restricted feeding. Similarly, the existence of a GxE for carcass traits needs to be determined.

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