SELECTION FOR EFFICENT LEAN GROWTH ON RESTRICTED FEEDING IN LARGE WHITE PIGS

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SUMMARY: Pigs from a strain selected for high post-weaning daily gain on restricted feeding had a fast growth rate, low backfat, efficient feed utilisation and high carcass lean percentage. These pigs wasted less food in maintenance heat production and thus had better adaptation to a high temperature climate. Sows of the high growth line produced piglets with heavier weights at birth, giving a potential for better viability of piglets in the pre and post-natal growth periods, and increased weight of piglets weaned per sow per year. It is concluded that selection for high growth rate on restricted feeding will produce pig strains with high lean growth and an adaptation to heat stress, which suits to the needs of the pig industries of Australia, Vietnam and neighbouring Asian countries.

Introduction

Australia and Vietnam have some common objectives in pig production. To increase production of lean pork per unit of input, both countries imported lean pig strains from Europe. These genotypes have a high capacity for lean production, low fatness and good food conversion efficiency. They perform less well in environments with higher temperatures and disease challenges than in Europe. Symptoms of this are a reduction in appetite depressing grower performance and failure of reproduction in sows. In addition, porcine stress syndrome (PSS) due to the presence of the halothane gene (Hal) can cause an increase in death rates during transport and incidence of PSE (pale, soft and exudative) meat. Thus there is a need to develop an adapted pig strain to suit challenging environments such as can be encountered by pig farmers in Australia and Vietnam.

Often the selection of pig breeding stock is carried out under conditions of nutrition and management which differ from those under which production is carried out. Thus the genetic changes brought about in the selection environment may not be exactly reproduced in the production systems. One component of the environment, which can vary between breeding and production sectors, is the level of feeding (*ad libitum* vs restricted feeding). Selection for growth rate on *ad libitum* feeding has been found to select for genes associated with increases in food intake (eg. McPhee, 1981). On the other hand, selection for the same trait on restricted feeding has been found to select for food efficiency genes (McPhee *et al.* 1988). Such a selection scheme is preferable for a long-term genetic improvement strategy where progeny are expected to be grown under a wide range of commercial feeding regimes (Cameron and Curran, 1995).

The current project has been undertaken to develop efficient selection procedures for identifying breeding stock with high genetic merit for efficient lean growth and a reduced energy requirement for maintenance.

Aim

To develop a fast growing lean pig strain adapted to high temperature climates.

Objectives

- To measure genetic changes in performance traits on either restricted or *ad libitum* feeding.
- To measure phenotypic changes in maintenance energy requirement.
- To measure genetic changes in body composition traits on *ad libitum* group feeding.

- To measure phenotypic changes in meat quality traits.
- To measure phenotypic changes in reproduction traits.
- To evaluate economic efficiency of the selection program.

Materials and Methods

Selection population

The present selection lines originated from continuous selection experiments in pigs for high efficiency of lean growth over the past 25 years (McPhee, 1981; McPhee *et al*, 1988). In the earlier study (McPhee *et al*, 1988), Large White pigs selected for high lean growth on restricted feeding had a reduced backfat and increased rate of lean growth. There was also a slight increase in appetite and apparent rate of glycogen depletion with fasting as measured by muscle acidity (McPhee and Trout, 1995). These responses are consistent with changes in the partitioning of metabolisable energy toward lean and away fat deposition and an increase in maintenance heat production. To test this hypothesis further, a new base population was reformed by outcrossing sows from the selected lines with superior Large White boars identified in boar performance testing station. DNA testing of the original base population stocks ensured that the herd was free of the halothane gene.

Two lines of Large White pigs were formed, a high line selected for high growth rate and a low line selected for low growth rate. Three batches were formed each with 12 sows of the high line and 12 sows of the low line. The matings of sows within each batch was synchronised within a period of 6.5 weeks between batches. The first litter for selection was produced in early 1997. Litters were weaned at five weeks of age, and after reaching 50 kg body weight, performance testing was carried out for 6 weeks and selection of breeding replacements was then made. This pattern of production, testing and selection was followed for the four-year duration of the experiment.

Performance testing procedures

From the two lines, pig produced in each batch, were subject to one of three performance testing methods:

- *Restricted feeding*: At 50 kg of body weight, pigs from the high and low growth were placed in groups but fed individually over a period of six weeks. During this testing period, pigs were all fed the same total amount of grower food, restricted to approximately 80% of average *ad libitum* intake.

- *Ad libitum individual feeding*: 12 pigs of each sex were sampled across litters from both lines and placed in individual pens and fed *ad libitum* over a 6-week period.

- *Ad libitum group feeding*: A sample of pigs from each line was also group housed and *ad libitum* fed and grown to a turnoff weight of 100 kg. End weight was measured before sending the pigs to the abattoir.

All performance tested pigs were fed the same diet, which mainly consisted of wheat, soya bean, fish meal, minerals and vitamins and contained 14.1 MJ DE and 0.65g/MJ available lysine.

Measurements

- *Performance traits:* Live weights were recorded at the start and end of test and used to calculate test average daily gain (TADG). For the individually housed *ad lib* fed pigs, daily food intake (DFI) was calculated by subtracting the total amount of food refused from the total amount of food 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 TADG. P2 backfat thickness (P2-fat) was measured ultrasonically at the end of the test.

- *Body composition traits:* Hot carcass weight (HCW) and carcass fat depth (CF) were measured at slaughter. Measurement of fat was made at the P2 position using Hennessy Grading Probe (Hennessy Grading Systems, Auckland, New Zealand). Hot carcass weight including fore and hind trotters, and leaf fat but without head. Predicted lean meat percentage (LEAN) was based on hot carcass weight and carcass fat following Ferguson *et al* (1994).
- *Meat quality trait (pH)*: Measurements of pH were taken on carcasses stored in a chiller at -5^{o}C at 24 h post-mortem. The pH24 was measured at the P2 site using the WP80 TPS meter (Brisbane Qld).
- *Reproduction traits*: Measurements of reproductive performance included number of piglets born alive (NBA), average piglet birth weight (ABW) and daily feed intake (DFI) of lactating sows. Food intakes were measured from 7 days to 35 days after farrowing. A small number of piglets were cross-fostered prior to 7 days of age among sows of the same line.

Statistical analysis

A standard animal model-restricted maximum likelihood method (AM-REML) was used to estimate environmental and genetic (co)-variance components. Genetic parameters obtained were incorporated into the estimation of breeding values for all the traits using best linear unbiased prediction (BLUP). Different genetic models of the analysis were used for different trait groups.

Results and Discussion

Production traits on restricted and ad libitum feeding

Genetic changes in performance traits were evaluated in terms of estimated breeding values. That is the amount of genetic merit, which can be transmitted from parent to offspring. On both restricted and *ad libitum* feeding, the high selected line had a significantly higher growth rate (GR) and lower P2-fat (BF) and food conversion ratio (FCR) than the contemporary low line. Genetic changes (the high minus the low) in GR (50.21 vs 52.58 g/d), BF (-0.68 vs -0.62 mm) and FCR (-0.22 vs -0.24 unit) were almost identical between restricted and *ad libitum* feeding, respectively. This suggested that selection on restricted feeding produced pigs, which could perform equally well on a range of commercial feed rations.

Residual feed intake

Residual feed intake (RFI), that is, the amount of feed consumed in excess of that required for tissue (lean and fat) deposition, has been proposed not only as an alternative measure of feed efficiency but also as an indicator of maintenance energy requirements (ME_m) in pigs. RFI is derived as the difference between the actual *ad libitum* food consumption of each animal and that predicted on the basis of its growth rate alone or combined growth rate and backfat. Phenotypic changes in RFI showed that after four years of divergent (high and low) selection for post-weaning daily gain on restricted feeding, the high line had a significant reduction in residual feed intake relative to the low line (-11.63 g/d vs 13.87 g/d). This indicated a lower energy requirement for maintenance in the high than the low line, possibly due to reduced physical activity of the animals (McPhee *et al*, 2000).

In summary, pigs selected for growth rate on restricted feeding displayed a reduced basal metabolism and maintenance requirement and thus had a better adaptation to heat stress in the tropical production systems.

Body composition traits on group housed *ad libitum* fed pigs

Selection for post-weaning daily gain on restricted feeding resulted in substantial improvement in breeding values for body composition traits in group housed *ad libitum* fed pigs. The high growth line had significant lower carcass backfat (-0.52 vs 0.72 mm) and higher lean percentages (0.78 vs -0.59 %) than the low line. It is concluded that restricted feeding is an effective performance testing approach for seedstock lines supplying commercial systems that use either *ad libitum* or restricted feeding.

Meat quality (pH)

Consumers and the pig industry have been increasingly focused on meat and eating quality. The most frequently measured meat traits are colour, pH, water-holding capacity and intramuscular fat content. Among those traits, measurement of pH taken 24h post-mortem (pH24) is widely used as an indicator trait of meat quality. The high and low selection line means for pH24 were 5.99 and 6.06 on restricted feeding and 6.03 and 6.04 on *ad libitum*, which are not significantly different between either the selection lines or feeding regimes (average standard error of difference 0.05). In the earlier study after four generations of selection for high growth rate and low backfat, McPhee and Trout (1995) found that the selected line had a higher pH value than the control. It was hypothesised that strong selection for efficient lean growth had raised metabolic rate associated with an increased rate of protein deposition. This increased the rate of exhaustion of glycogen reserves during the prolonged period of pre-slaughter fasting and transport, and reduced the amount available for conversion to lactic acid causing a movement toward the DFD and away from the PSE end of the meat quality spectrum.

The high average pH24 of the present study indicated that the same stressful pre-slaughter conditions prevailed as in the previous study by McPhee and Trout (1995). However, this time, no genetic relationship between lean growth and pH24 was apparent as there was no difference between the high and low growth lines. It is suggested that an increase in metabolic rate due to increased protein deposition rate in the high relative to the low line may have been compensated by a reduction in metabolic energy production from a source other than protein deposition eg. physical activity. Such a reduction was evidenced by the reduced residual food intake in the high line (Nguyen *et al*, 2001).

Reproduction traits

Phenotypic changes in reproductive performance included number born alive, average piglet birth weight and daily lactation feed intake of sows. There were no significant differences in number of piglets born alive between the high (10.9) and low (10.5) lines selected for post-weaning growth rate. However, the high line piglets were considerably heavier at birth than the low line piglets (1.45 kg vs 1.39 kg). This increase in piglet birth weight is expected to increase viability and post-natal growth of piglets.

A reduced appetite can be a severe problem in sow populations, especially in first litter sows under tropical climates. This is because a reduced feed intake of sows during lactation is accompanied by high body weight and fatness loss during lactation, resulting in prolonged intervals from weaning to oestrus and to conception and possibly reduced ovulation rate in subsequent litters. A reduction in lactation feed intake may also be associated with a decreased piglet birth weight, leading to increased pre-weaning mortality and reduced post-natal growth of piglets. After four years of divergent selection for growth rate, lower feed intake in the high than in the low growth lines was apparent in growing stock, but there was no significant difference between the high (6.11 g/d) and low (6.24 g/d) lines in the daily feed intake of lactating sows. This indicated that the reduction of feed intake in growers was not carried over to lactating sows, suggesting that selection for rate of lean growth on restricted feeding would have no effect on lactation feed intakes of sows.

In summary, selection for high growth rate on restricted feeding increased piglet weight at birth and thus enhanced reproductive performance of sows.

Economic evaluation

Economic values are derived from a bio-economic model of a typical Australian pig herd (McPhee and Macbeth, 2000). An increase in average daily gain of 0.1 kg was expected to increase profit by $AU 441 per sow per year. A reduction in P2- fat by 1 mm was expected to gain $AU 31 per sow per year. Applying these values, economic gains obtained from the selected lines were estimated at $121 per sow per year with restricted feeding and $126 per sow per year with *ad libitum* feeding. In an Australian commercial nucleus pig herd, economic gain per generation of selection was also predicted at $91 per sow per year in restrictively fed males in comparison to only $70 per sow per year in *ad libitum* fed females (Nguyen *et al*, 2000). This shows the advantages of restricted feeding performance testing for identifying breeding stock, which will transmit superiority in efficiency of lean growth to their progeny, regardless of feeding level.

Conclusions

Breeding pigs selected for increased growth rate on restricted feeding had high growth and low backfat and high lean percentages in the carcasses of their descendants when raised on either restricted or *ad libitum* feeding.

The high growth line had a significant reduction in residual feed intake, indicating a lower energy requirement for maintenance than in a low growth line.

As pH24 was not significantly different between the high and low lines, it was concluded that selection for growth rate on restricted feeding had no effect on meat quality.

High line sows produced heavier piglets at birth than low line sows, suggesting that selection for rate of growth on restricted feeding would improve piglet viability.

Economic gains from the high growth selection were estimated at $121/ sow/ year on restricted feeding and at $126/ sow/ year on *ad libitum* feeding.

Industry Implications

Genetically superior stocks from the selection program have been used for disseminating improved genes to a large number of commercial pig producers.

On-farm genetic improvement programs can take the advantage of selection procedures on restricted feeding for identifying genotypes with high lean growth and adaptation to environments which impose high temperature and pre-slaughter fasting stress.

The pig industry would benefit from the inclusion of current results into PIGBLUP software package to customise selection decisions for breeders using a variety of feeding regimes.

Suggestions for Further Research

Australian breeding stocks in Vietnam need to be continuously selected to provide the best genotypes for AI centres throughout the country. In this way genetic improvement can flow directly to small householder producers.

Crosses between Australian Large White and Vietnamese local breeds should be developed for future genome research. Genetic markers responsible for high rate of lean growth rate and low backfat could be utilised to develop new breeds with the best features of their parental breeds.

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