# PIG GENETICS- AN OVERVIEW

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**SUMMARY: Over the past 20 years genetic gains of the order of 1% of the mean annually have compounded in growth and body composition traits of pigs. These have been accompanied by mildly unfavourable trends in meat quality traits. Only in the last 10 years has there been a significant improvement in litter size. This has been due to developments in computing power (e.g. BLUP). The use of molecular markers gives hope of accelerated gains but many uncertainties remain as to its real value in future pig improvement programs. These programs will continue to rely heavily on the management of genetic variability (eg. crossbreeding) and the efficient use of breeding values (eg. BLUP).**

In deciding the best way of putting the science of genetics to work in improving the profitability of pig production,a number of questions arise:

- Which traits are important?
- Can we alter these traits genetically?
- What effect does a genetic change in one trait have on others?
- What breeding systems can we use which will bring about these changes?

There are two groups of important traits:

- Traits connected with the cost of producing pig meat and
- Traits connected with the quality of pig meat.

Traits which mostly affect the cost of producing pig meat are growth rate, food conversion efficiency and reproduction measured by pig output per breeding sow. Traits which are connected with quality are almost exclusively concerned with the content and quality of lean in the carcase.

Other traits which are becoming of interest are; fat distribution, structural soundness, disease resistance, adaptation to intensive housing.

## Growth rate

Fast growth leads to heavier carcasses at turnoff age. Growth rate is a good trait for selecting breeding animals because it can be easily and accurately measured on the growing animal before it reaches breeding age. Growth rate has a heritability of about 30%. This means that 30% of the superiority of parent animals is passed to their progeny.
Breeds that have been selected for increased growth rate for many years eg. Landrace are still responding.

Selection for increased growth on *ad libitum* feeding increases growth rate, food intake and carcass fatness. Less food is used to reach a fixed slaughter weight because there are fewer days to maintain the animal to reach that weight but more food is wasted in increased feeding activity and fat deposition. Overall, selection for growth rate on *ad lib* feeding will improve food conversion efficiency (ie. reduce feed/gain).

Selection for increased growth on restricted feeding emphasises lean over fat growth because of the lower energy density of lean than fat tissue. It also leads to a reduction in food used for maintenance. Breeding stock selected for growth on restricted feeding have descendants with efficient lean growth on both restricted and *ad libitum* feeding.

Some hybrid vigour is expressed in growth rate. Progeny of a crossbred sow can have a growth rate which is 5% to 10% faster than purebred progeny depending on whether or not their sire is the same breed as one of their mother's parents.

**Food Conversion Efficiency**

Worldwide it has been found that 70 to 80% of the cost of raising pigs is food cost. Therefore reducing the amount of food eaten for each kilogram gain is economically important. Although the heritability of food conversion ratio is about the same as that of growth rate, FCR is expensive to evaluate since it requires the measurement of individual food intake and attempts to change feed efficiency by direct selection have largely failed. New ways of measuring FCR are being devised, including the use of electronic feeders which can measure the intakes of individual animals and record their identities. The level of IGF1 (insulin-like-growth-factor) in the young pig is also being explored as a possible predictor of its future food conversion efficiency. Because of the difficulty and expense of obtaining FCR values, its measurement is usually confined to those animals which have the greatest genetic influence on the population e.g. boars in seedstock producing herds. Useful changes in FCR usually accompany selection for growth rate alone.

There are few studies on the effect that crossbreeding has on FCR. Those that have been done suggest a lower level of heterosis (<5%) for the trait than for growth rate.

**Lean Content**

Most meat processors offer pig producers a financial incentive to produce carcasses with an optimum lean/fat ratio. This optimum tends to be set at a higher level than that currently expressed by pigs on high levels of feeding. There are many examples of successful selection for increased leanness in pigs and the trait is still heritable in breeds which have been selected for many years for this trait. The best single predictor of carcase lean in pigs is still subcutaneous fat depth at the P2 position. It is easily and cheaply measured on the live pig using ultra-sonics. A concern that concentration on selection at P2 will move fat elsewhere in the carcase appears to be ill founded. However an emerging concern are low levels of intramuscular fat in breeds that have been made very lean. Meat from such breeds tends to taste drier than meat from fatter breeds. This problem is most severe in breeds such as Yorkshire/Large White and Pietrain and least in coloured breeds such as Duroc. Magnetic resonance scanning can give an indication of intramuscular fat levels in the live pig at considerable expense. Practical methods are being developed to use the same technique on carcasses and this opens the possibility of selecting breeding stock on the measurements taken on their slaughtered relatives.

The general outcome of crossbreeding studies is that heterosis does not occur in lean content.

**Efficiency of lean growth**

Most selection programs in pigs have as their objective an efficiently grown lean carcase (high lean growth/food eaten). Measurements taken to improve this trait are usually growth rate (from birth to turnoff) and fat (at turnoff). Sometimes food intake is measured on important animals as well (eg. on boars during a post-weaning period).

Whatever traits are used to select for efficient lean growth, the level of feeding during the performance testing period has a bearing on the outcome. Recent research indicates that testing animals on a fixed intake scale over a fixed time period is better than testing them on *ad libitum* feeding. Fast growers on the fixed scale produce offspring which are efficient growers of lean on all levels of feeding whereas fast growers selected on *ad libitum* feeding may not produce offspring which are more efficient growers of lean meat on restricted rations.

**Lean quality and other traits**

Most work on the inheritance of lean quality traits appears to have been done in countries where pre-slaughter transport and handling conditions for pigs are good. In those countries, colour, water content and drip-loss are identified as characteristics of lean quality which have reasonably high heritabilities (0.3 to 0.6) and which could be measured in the abattoir. In countries where pre-slaughter conditions are much less controlled heritabilities of these traits would be much lower, most of the variation between carcasses being due to environmental factors. The quality traits, with the exception of PSE, part of malignant hyperthermia syndrome (MHS), suffer through not being measurable on the live animal and the absence of economic incentives for their improvement, although concern for their apparent deterioration is growing. There is almost universal condemnation now of the halothane gene, a recessive gene responsible for MHS but this is easily removed from the population with a DNA test.

Research studies indicate that long selection for lean content will not necessarily have an adverse effect on pork quality but where increased muscular development is emphasised there may be increased paleness and decreased water-holding capacity.

**Reproduction**

The number of pigs produced per sow per year is becoming an increasingly important trait, particularly as carcase fatness reaches an optimum level in many breeds. The trait is complex; depending on the number of eggs ovulated, the proportion of eggs fertilised and the proportion of embryos and foetuses surviving up to and beyond parturition to slaughter. A review of studies on the heritability of litter size gave an average value of 0.11 and this explains the poor response to selection for the trait in the past. The use of BLUP technology across herds has now transformed the situation. Consequently, increasing litter size has become a major selection goal in maternal lines of pigs and increases of up to 0.3 piglets/litter have been obtained in some populations over the last few years.

Selection between breeds and their crosses still appears to be the best way of making genetic gains in reproductive performance. Where the breeds are numerous, this sorting out process can be time consuming and costly. However, since the reproductive capacity of purebreds is a major part of reproduction in their crosses, intensive testing of crossbreds can usually be confined to those breeds with the highest reproductive performance. It would appear from the testing done throughout the world, that the cross between Large White and Landrace (or local derivatives of these breeds) produces the most prolific sow. Another avenue for gains in prolificacy, pubertal age and mothering ability can be expected from the increasing use of Chinese breeds or synthetic lines developed using these prolific breeds in crossbreeding plans. For example, Meishan sows typically have a pubertal age of three months, and can wean up to 13 pigs per litter.

Most improvement in the reproductive traits derives from hybrid vigour and crossbreeding systems have been devised for pigs to take advantage of this. The outcomes from some of these systems are given in the table.

**Breeding values**

Because so much is now known about the heritabilites and genetic correlations between the important traits of the pig, it is possible to calculate a breeding value for each trait (eg. efficiency of lean growth) for each animal under consideration as a future breeder using performance measurements made on itself and its relatives. An animal's breeding value for a particular trait is the merit which that animal passes to its progeny. It follows that high breeding values are very important for the selection of breeding stock since it is their progeny which earn the income for the farmer, eg. when they are sold for meat. Calculating the breeding value of a certain trait for an animal is a complex process requiring the combination of information on the animal itself, its relatives and the environmental conditions under which the information is collected. The calculation is best carried out using a computing procedure called BLUP (best linear unbiased prediction). Pigblup is a computer package specifically designed for pig breeders.

**Breeding Systems**

With 3 breeds, there is a wide range of possible systems for putting them to work, viz., 2 or 3 breed cross, 2 or 3 breed rotation, back-cross, 2 or 3 breed synthetic or even pure-breed. In comparing these systems we have to consider, not only the amount of hybrid vigour each produces, but also the delay in passing the benefits to the slaughter stock and the cost of maintaining the pure-breeds to keep the systems going.

In the US, a comparison was made between three crossbreeding systems involving Duroc, Yorkshire and Landrace; first cross and 2 and 3 breed rotations. The total number of animals produced by each system is given in the Table as a percentage above the average number produced by the purebreds in each system. Also given are the monetary values per sow relative to those expected from a pure Yorkshire herd. These take account of improved litter size, backfat and growth rate.

**Table 1. Percentage increase in number of animals produced above purebreds and economic advantage of different crossbreeding systems**

| Boar | Sow | % increase in pigs produced | Change in value ($/sow) |
|---|---|---|---|
| Yorkshire | Duroc | 7 | 4 |
| Landrace | Duroc | 7 | -8 |
| Duroc | Yorkshire | 9 | 8 |
| Landrace | Yorkshire | 16 | 15 |
| Duroc | Landrace | 16 | -3 |
| Yorkshire | Landrace | 9 | 14 |
| Yorkshire | Landrace rotation | 32 | 19 |
| Duroc | Yorkshire rotation | 27 | 12 |
| Duroc | Landrace rotation | 18 | 1 |
| Duroc | Yorkshire Landrace rotation | 29 | 12 |

Clearly the systems which include Yorkshire and Landrace are better than those with the Duroc, even the three- breed rotation, which should theoretically have the greatest degree of hybrid vigour. The best of the systems is the Yorkshire-Landrace rotational cross. The reason for the poor showing of the systems which include the Duroc is due to the depressing effect that breed has on litter size. In purebred comparisons the Duroc has been found to wean 10% fewer pigs than the white breeds. Thus, notwithstanding hybrid vigour, the presence of Duroc blood in the females of rotational crossing systems depresses their profitability.

Although the data in the table does not include 3 breed static or backcrossing systems, results on the rotational crosses suggests that a Yorkshire sire backcrossed to a Yorkshire x Landrace sow would have about the same profitability as a Duroc sire over the Yorkshire x Landrace sow if the cost of maintaining the pure breeds is not considered. If it is, the backcross would be better than the 3 breed cross because of the extra cost of maintaining the Duroc with its smaller litters.

**Transgenics and molecular markers**

Transgenesis is the transfer of genes between species. Techniques have been developed for using viruses and bacteria for transferring genes from one species into the germ line of another. In this way the human growth gene has been transferred to the pig. However, lack of control over the expression of this gene have prevented transgenesis from becoming a useful technology for pig improvement. Molecular marker genes have been found which are linked to genes which have an effect on economically important traits in the pig. Selection for these markers can sometimes assist normal selection methods (eg. BLUP) to improve the trait. Marker assisted selection has greatest potential for improving new breeds formed by combining widely different existing breeds. For example, forming a new breed by combining the efficient lean production of the Yorkshire with the superior littering and mothering characteristics of the Chinese breeds eg. Meishan.