BROADLY the objectives of all genetic improvement programmes in pigs can be defined in terms of those traits related to the quality of pig meat and those related to the cost of producing it.

QUALITY TRAITS

These can be divided into subjective and objective traits. Subjective traits, such as flavour, can only be evaluated by the human senses. This places severe limitations on efforts to improve them genetically. Amongst the objective traits Malmfors (1979) identified colour, water content, drip loss and fatness. With reasonably high heritabilities (0.3 to 0.6), they appear to offer fair potential for improvement through selection. However, most suffer through not being measurable on the live animal and, in Australia, through the absence of economic incentives for their improvement. The one exception is fatness.

LOW Fatness

An incentive is offered to pig breeders through factory grading systems which place a price premium on carcases with an optimum degree of fatness. This optimum tends to be set at a lower level than that expressed currently by pigs on high levels of feeding. Carcase fatness is accurately assessed on the live pig using a measurement of subcutaneous fat depth at the P2 position (MLC 1973) either by ultrasound or a needle probe. Heritability of the trait remains high even in breeds with a long history of selection (MLC 1978). Where selection emphasises low fatness and performance testing is carried out under full feeding conditions which allow appetite variation between animals to be expressed, a decline in appetite is expected with possible adverse effects on growth rate (Nikami et al., 1980) and a Pietrain type pig is expected to result. Under less liberal feeding where appetite variation is reduced to a minimum, selection for low fatness is expected to produce a pig with a higher rate of growth of lean tissue (Kielanowski, 1968).

Malmfors (1979) presents some evidence that long term selection for low subcutaneous fat might lead to brighter meat colour, lower water holding capacity and lower intramuscular fat content. Where increased muscular development is emphasised as it is in some continental European countries, the likelihood of increased paleness and decreased water holding capacity of muscle is increased (McGloshlin, 1980). In addition, where the recessive gene causing malignant hyperthermia syndrome (MHS) is present, selection for increased muscular development is likely to increase its frequency in the population with a resulting increase in the incidence of stress death and poor muscle quality. Generally the unfavourable association between the quantity and quality of carcase lean is not so strong as to prevent the simultaneous improvement of both traits. However, selection for meat quality at present has to be on the basis of measurements...
made on slaughtered relatives with the usual associated inefficiencies and high costs. The use of computer tomography may change this dramatically in the future (Skjervold pers. comm.). Present lack of financial incentives for improved meat quality means that selection for quality traits is not cost effective here in Australia. It is sensible however, to apply selection against the MHS gene mainly because of its association with stress death, a condition which dramatically affects the producer's income. When this condition is common in a breed, it can be rapidly reduced to an acceptable minimum by screening out homozygous carriers using the Halothane test. At present MHS is not a major problem in Australian pigs. It appears to be absent from Large White and to affect only about 4% of Landrace pigs (McPhee et al., 1979a). However, the recent increasing importation of overseas pigs into Australia could result in an increase in MHS here.

A linear reduction in fatness oversimplifies the market requirement for carcass quality in Australia. Payment incentives aim for an optimum degree of fatness with minimum variation between carcasses, an objective which is very difficult to attain by genetic manipulation. It may be best to pursue selection for low fat and adjust upwards to the desired level through the feeding system. This would only be feasible if appetite had not been reduced during the selection process.

Apart from possible adverse changes in growth rate on self feeding and in meat quality, which can be overcome, there appear to be no other serious antagonisms between low fatness and other economically important traits in pigs. In fact there appears to be a slightly beneficial association with reproductive traits (Morris 1975).

**COST OF PRODUCTION TRAITS**

Traits which have most bearing on the cost of producing pigs are growth rate, food conversion efficiency and pig output per breeding sow.

**Growth Rate**

Rapid growth rate leads to quick turnoff of pigs and thus reduced overhead costs. Genetic limits to growth rate appear not to have been reached yet, even in pig populations with long histories of selection for the trait, e.g. British Large White. Heritabilities appear lower under restricted rather than full levels of feeding where feed intake variation is permitted to contribute to growth rate variation. Selection for growth rate on ad libitum feeding increased appetite and carcass fatness. The consequences of selection for growth on restricted feeding levels have not yet been fully explored in pigs, but improved utilization of metabolizable energy in favour of lean rather than fat deposition is expected (Kielanowski, 1968). There is some evidence from mice selection studies that this expectation can be fulfilled (Netzel and Nicholas, 1978).

So far, observations on the genetic correlation between growth rate and reproductive traits have generally been favourable (Johansson, 1979). It has been shown that rapid growth is associated with larger body size at first mating of gilts and this leads to larger first litters (Young et al., 1977). Faster growth rate also leads to larger body size at maturity with a possible associated increase in the cost of maintenance of the breeding herd. Genetic manipulation of the growth curve to offset this could probably be achieved at the expense of
improvement in more important traits. Since nutritionists are actively engaged in evolving least cost feeding systems for breeding animals the solution of this problem is probably best left to them.

Food Conversion Efficiency

A recent economic survey of pig herds in Queensland revealed that 77% of the costs of pig production were accounted for by food costs. Therefore, a reduction in the amount of food eaten for each kilogram of weight gained is a most important economic trait. As for fat and growth rate, the heritability of food conversion ratio remains high in most selected pig populations (MLC 1978). With the possible exception of pigs grown on very high levels of feeding, pigs which convert food efficiently are also the fastest growers and produce the leanest carcases. On very high levels of feeding, selection for high food conversion efficiency may reduce appetite and growth rate (McPhee et al., 1979b).

Current thinking expressed by Fowler et al. (1976) is to combine the three performance traits; growth rate, fatness and food conversion efficiency into a single composite trait; efficiency of lean growth (lean growth/food eaten). Pigs are selected for this trait using liveweight and fat measurements taken on a time-based feeding scale set to minimise variation in food intake between animals undergoing performance testing.

Reproduction

The number of pigs produced per sow per year is one of the most economically important traits in pigs. This trait is complex; depending on the number of eggs ovulated, the proportion of eggs fertilised, the proportion of embryos and fetuses surviving up to and beyond parturition to slaughter. Negative correlations are known to exist between some of these traits (Vangen, 1981) (e.g. eggs shed vs. proportion of embryos surviving and pigs born vs. proportion weaned). It has also been shown by Robison (1981) that females born in large litters, tend themselves to produce litters which are smaller than average when they grow to adulthood. These factors contribute to the extreme difficulty experienced in increasing sow output by normal selection procedures. Successful attempts to increase ovulation rate have not resulted in improvements in litter size (Cunningham et al., 1979). Attempts to overcome the negative maternal effect on daughter's litter size by basing selection on half-sister and grand-dam records and standardising litter size at birth appear not to have been tried yet in pigs. However, standardising litter size at birth has been found effective in increasing litter size by selection in mice (Eisen, 1978).

Selection between breeds and their crosses still appears the best way of making genetic gains in reproductive performance. Where the available breeds are numerous, this sorting out process can be time consuming and costly. However, since the reproductive capacity of pure breeds is a major component of reproduction in their crosses, intensive testing of crossbreds can usually be confined to those breeds with highest reproductive performance. It would appear, from the testing that has been done throughout the world, that the cross between Large White and Landrace produces the most prolific sow.
An important piece of recent work (Skjervold, 1980) has shown that if the antigenic properties of the cell surface of a fetus are very different from the corresponding antigens of the mother, fecundity is improved. This may partly account for hybrid vigour expressed in crossing genetically diverse breeds. Future advances in the improvement of reproduction may lie in selection within antigenically different breeds for ovulation rate followed by crosses between them (Cunningham et al., 1979).

REFERENCES


