THE BREEDING PROGRAM

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1. BREEDING FOR THE FUTURE

There is a trend, both in Australia and internationally, for there to be fewer and larger pig production units. Being larger is not necessarily more efficient, but if this trend continues there will be fewer pig producers operating in the increasingly competitive market place. The higher level of competition in an already competitive industry suggests that in designing breeding programs breeders must keep in mind both their present situation and the direction of industry movement if they wish to remain competitive in the future market environment.

The breeding stock business is a long term endeavour. Many breeders will reply, "Yes, but I still have to pay my banker today!" There is the practical reality that breeders must stay in business in the short term (cash flow), but they must always remember how long it will take the effects of decisions today to reach the final market place. Figure 1 gives an example of this lag. The breeding has already been done for today!

FIGURE 1: Lag in Time from Point of Selection Decisions in Nucleus Herds to When Market Pigs are Sold in Commercial Herds

ACTION	TIME FRAME
Select parents in the nucleus level	0
Sell or move 1st boars from that selection to the multiplier level	1 year
Sell 1st boars to the commercial level	2 years
Producer sells 1st progeny from purchased boars	3 years
Producer replaces purchased boars	4-5 years

If the multiplier level could be circumvented (i.e., the commercial producer is getting boars from the nucleus level), a year could be saved, but there is still quite a lag between when selection decisions are made in the nucleus and when the commercial producer reaps the benefits from that genetic improvement. Since the success of breeders is very dependent on the performance of the offspring of their breeding stock in commercial herds, breeders should be planning 5-7 years into the future when designing their breeding operations.

2. KEY ASPECTS OF BREEDING PROGRAM DESIGN

Many producers of breeding stock are: weighing pigs, probing pigs, counting numbers of piglets born/litter and making selection/culling decisions using this production information but have never taken a step back and considered the design of their breeding program. They have developed their testing and selection procedures for a variety of reasons (sometimes based simply on convenience) and have never critically evaluated the overall design such that improvements could be made.

PIGBLUP provides signals on the effectiveness of your breeding program. Our purpose here is to present some of the key aspects of breeding program design and how they can impact on the genetic gain being made in the herd.

2.1 Defining Breeding Objectives

In designing breeding programs one of the critical areas is defining breeding objectives. In a nutshell, this is making the decision of where you want to go (e.g., breeding a lean, fast growing line of pigs to be used to produce terminal sires), in economic terms! Several of the issues concerned have been discussed earlier, regarding the $INDEX module, which helps breeders determine their breeding direction. However, the importance of establishing a breeding objective cannot be over-emphasised.

Consider the resources available for the breeding program. A very small breeder should probably not try to breed a maternal line, as inbreeding and genetic drift, coupled with the low heritability for litter size could frustrate their endeavours to make genetic progress. However, this type of breeder could have some success in developing a terminal sire line. Inbreeding would still be a problem but heritabilities would be more favourable to making progress.

Breeders must take into account their competitive position in the market place when defining breeding objectives. If, for example, a breeder had been selecting for backfat only and had developed a very lean line of pigs (averaged 10mm of backfat on ad libitum feeding), they might want to change breeding objectives such that more emphasis was placed on growth. Their pigs might be 'known* in the industry as being very lean and they would want to maintain that level of leanness in the line, but could redirect selection pressure to other traits of economic importance.

Breeders must also consider how to balance present versus future gains when defining breeding objectives. For example, rapid genetic progress could be made if only gilts were farrowed; thereby improving future gains, but present gains could be diminished due to the lower levels of production of gilts. It is very difficult to make general recommendations about breeding objectives to breeders as this will depend on their individual situations. However, it is an area that must be considered when designing breeding programs (often it isn't, or is done trivially).

2.2 Testing

Performance testing is another of the critical areas in any genetic improvement program for pigs. One of the important design aspects is the size and structure of the test or management group. A management group is defined as a group of animals performing under similar environmental conditions. By accounting for these management groups in a genetic evaluation procedure, the breeder is able to get more accurate estimates of breeding values. However, the size and structure of those management groups can affect the accuracies of those EBVs. Table 1 shows some results from the US (Rothschild et al., 1987) on how size of management group and number of sires with offspring in the management group can affect the accuracies of EBVs. (The lower the number the more accurate the EBVs, and the units are in inches).

The first thing to note from Table 1 is the importance of having more than one sire's offspring represented in a management group and this assumes it will be connected with the other management groups in the herd analysis. For a group size of 40, accuracy improved from .026 to .023 in going from 1 to 3 sires represented in the management group. There

TABLE 1: Accuracy Values for Backfat EBVs When Numbers of Sires and Offspring Vary for a Single Management Group

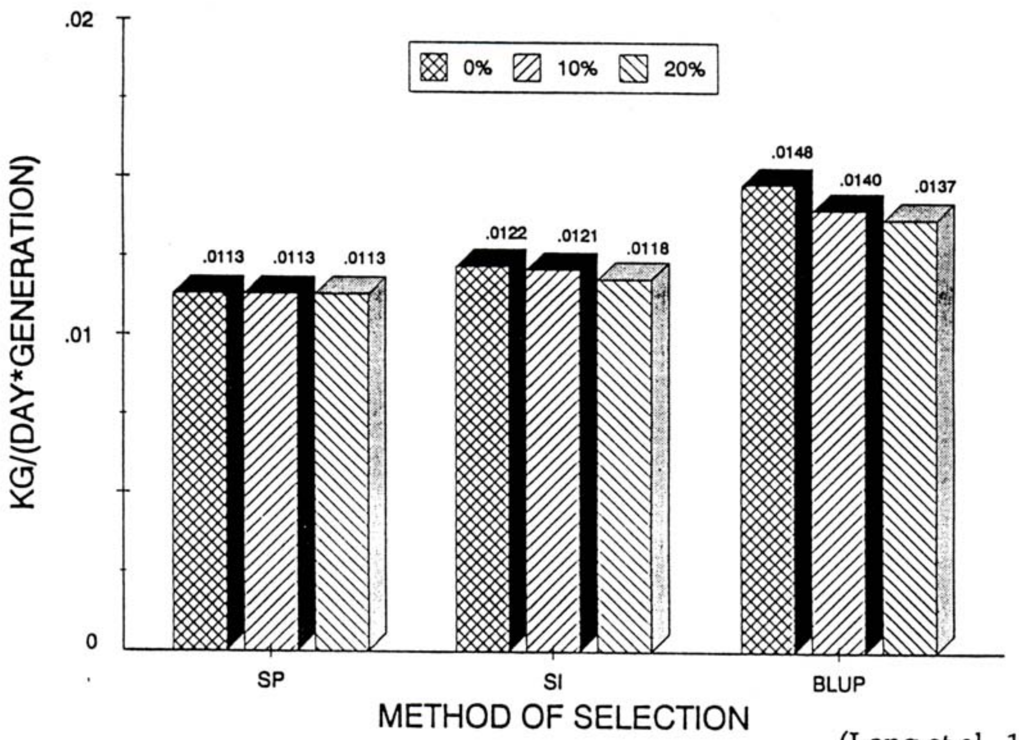
Pigs in Group	Number of Sires		
	1	3	5
20	.026	.023	.023
40	.026	.023	.022
100	.025	.021	.020
150	.024	.020	.020

was an additional improvement in going from 3 to 5 sires, but this improvement in accuracy was not as great as the improvement in going from 1 to 3 sires. When only one sire is represented in a management group, there is the potential for confounding between the sire effect and the management group effect which can reduce the accuracies of EBVs obtained. The second point to note from Table 1 is that as group size increases (for a fixed number of sires in the group) the accuracies of the EBVs will also increase. The effect on accuracy of increasing group size is not as great as increasing the number of sires represented in the management group from 1, but it will help the analysis. Group size should be as large as possible, but it must be emphasised that pigs raised under different environmental conditions should never be combined to make one large contemporary group. Large test groups occur normally in large breeding units, and smaller breeders should try to assure large test group size by farrowing sows in groups.

Another important design aspect in developing a breeding program is deciding which and how many animals to performance test. It is optimal to performance test all animals. Because performance testing costs money or testing space is limited, however, some breeders will only test some of the animals available or remove slowly growing pigs before the end of the test period. This can have a negative effect on possible genetic gain, especially when a genetic evaluation system is used, such as PIGBLUP, which uses information from all known relatives. Figure 2 shows what can happen to expected genetic gain for ADG (in kg/day/generation) when 0, 10 or 20% of the poorest performing animals are deleted prior to genetic evaluation.

Of the three methods of genetic evaluation compared, deleting poor performing animals prior to genetic analysis had the greatest effect on BLUP. When selection was based on the animal's own record only (SP), deleting or not including the records of poor performing animals had no effect on which animals were selected. Animals were ranked only on their own performance and the best were picked. Thus, when SP is used, this practice of not testing poor performing animals will not affect genetic gain. But when relatives' records of used in the estimation of breeding values, some animals whose own phenotype is good, could have relatives whose records were deleted. With the poor performance of relatives no longer influencing the EBV of the animal of interest, its EBV could be biased upward. This can lead to errors in selection that will decrease the rate of genetic gain compared to when all performance data is used in the analysis. It is important to note in the above study that even though expected genetic gain was reduced for BLUP when 20% of the poorest records were deleted from analysis, it was still superior to the other methods of genetic evaluation.

FIGURE 2: Expected Genetic Gain from Selection on Phenotype (SP), Selection Index (SI), and Best Linear Unbiased Prediction (BLUP) for Average Daily Gain (ADG) After Deleting the Poorest 0,10, or 20% of the ADG Records



(Long et al., 1991)

These results emphasise the importance of including as much information as possible to reap the maximum benefit from a genetic evaluation system such as PIGBLUP. Breeding program designs should be developed that allow for performance testing (both production and reproductive traits) on as many animals as possible.

2.3 Generation Interval

As seen in Figure 1, it takes a fairly long time for genetic improvement in nucleus herds to reach the commercial level. This disparity between the genetic level in the nucleus and the genetic level in commercial herds (at a fixed point in time) is called the genetic lag. One important corollary to this concept is that the nucleus breeders need to be moving forward as rapidly as possible in genetic improvement in order to stay ahead of the commercial producers who purchase breeding stock from them.

One facet of maintaining genetic gain is to turn over generations quickly. The following equation gives the components involved in making genetic gain.

$$\text{Genetic gain per year} = \frac{\text{Selection Intensity} \times \text{Selection Accuracy}}{\text{Generation Interval}} - \text{Inbreeding Depression}$$

Although PIGBLUP will give breeders the most accurate assessment of breeding value currently available, this advantage could be lost if generations are not turned over relatively frequently. Age structure of the herd is a key aspect in breeding program design.

2.4 Population Size and Inbreeding

It is clear that if herd size is smaller there is a greater chance that animals being mated are related. Since inbreeding can be defined as the mating of relatives, accumulation of inbreeding and possible reduced performance due to inbreeding depression can become problems when the herd size is fairly small. It is not just herd size, but relative numbers of males to females that will affect inbreeding. The rate of accumulation of inbreeding in a herd maintaining 3 boars and 67 females would be much greater than in a herd with 10 boars and 60 females although both had a herd size of 70 animals. Keeping a number of boars standing at stud will help to minimise rate of accumulation of inbreeding. This must be balanced with a high selection intensity (selecting only the absolute top boars from a large number of available candidates) to maintain rapid genetic progress.

The age structure of the herd can also affect inbreeding. Table 2 shows how the number of boars used per year and the age structure of a herd can affect inbreeding over a 10 year period. The relative numbers of boars to sows and the age structure of the herd must be addressed to manage inbreeding when designing breeding programs.

TABLE 2: The Effect of Numbers of Boars in Use Per Year, and Average Age of Boars and Sows in the Breeding Herd, on the Rise in Inbreeding Over a 10-Year Period

		Rise in inbreeding (%) over 10 years				
Av. age (years)		No. of different boars used each year				
Boars	Sows	3	5	10	15	20
1	2	18.5	11.1	5.5	3.7	2.7
1	3	10.4	6.2	3.1	2.1	1.5
1.5	3	8.2	4.9	2.5	1.6	1.2

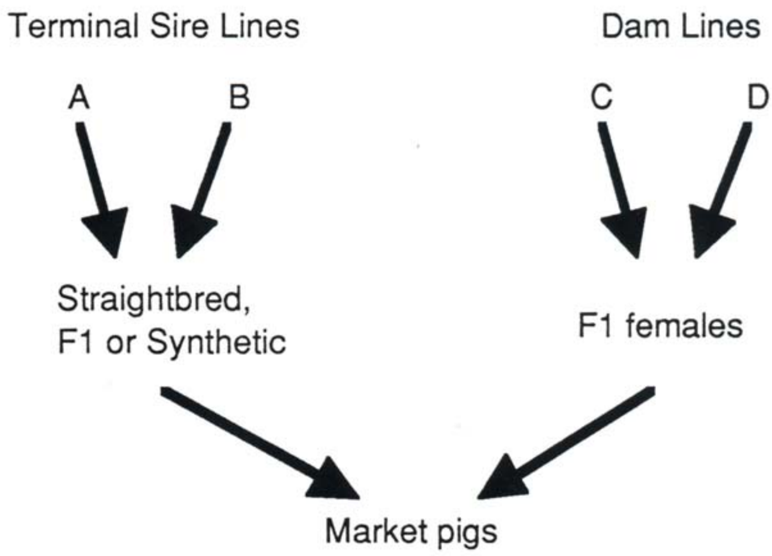
(Treacy, 1983)

Since BLUP uses information on all known relatives, the potential exists for an increase in the rate of inbreeding over other methods of genetic evaluation, especially when selection is on a trait of low heritability, such as litter size, and unless care was taken with the mating plan. Possible ways of addressing this would be to maintain large numbers of families within a dam line (increasing numbers of boars used). Of course, inbreeding in any closed small population (especially a dam line) can be a problem, regardless of the method of genetic evaluation. In larger closed populations, inbreeding can be kept at acceptable levels.

2.5 Straightbreds *versus* Synthetics

Breeders, when defining breeding objectives, need to consider how the commercial producer is going to use their seedstock in a genetic program. Some breeders are selling a 'complete package' (i.e., males and females provided to the commercial producer to raise market pigs), while other breeders sell boars to be incorporated into the commercial producers breeding program. With either system breeders need to consider how the breeds/lines they are selecting will be utilised, as the final product (the market pig sold by the commercial producer) will ultimately determine their success as a breeder.

A system which makes maximum use of potential heterosis and breed/line complementary and is gaining acceptance world-wide by commercial producers is the specific 4-breed terminal cross.



With this system maximum maternal heterosis from 2 breeds is utilised in the F1 female and maximum individual heterosis is achieved in the market pigs. This is one of the reasons this system is being adopted by commercial producers. A second reason is that, by using breed/line complementarity, it is easier to produce a more uniform market pig using a specific cross than by using some form of rotational breeding. Having relatively uniform pigs of high quality can be a distinct advantage at the abattoir relative to getting premiums for market pigs.

Producing breeding stock to be used in this system is fairly straight forward with regard to defining breeding objectives. The breeder defines distinct terminal sire lines and dam or maternal lines so can more easily set up selection criteria to address those breeding objectives.

One disadvantage of this system is that it requires production of Fl females, which does remove a proportion of the sow herd from commercial production if done on-farm or can increase breeding stock costs and/or health risks if Fl females are brought into the commercial unit However, the increased production levels of the Fl females over rotational females can offset increased breeding stock costs if health issues are addressed properly.

Another system being adopted by some breeders and commercial producers is the utilisation of synthetics. This self-contained program is based on stock of mixed ancestry (usually Large White and Landrace) possibly originating from a 2-breed rotational crossing program. Many breeders and commercial producers have chosen this system due to health considerations and the ease of maintaining only one population instead of two or more to be used in a specific crossing program. There are two areas which should be addressed regarding synthetics. First, the actual development of the synthetic must be considered. The breeder must:

(i) Use breeds/lines of pigs that have undergone intensive selection for the traits of interest in putting together the original synthetic,

(ii) Develop the synthetic from as broad a genetic base as is possible (use a large number of unrelated sires within each breed/line in setting up the synthetic line, and

(iii) The synthetic population must be maintained at a large enough level so that inbreeding and genetic drift are not a problem.

The breeder must determine the breeding objective for the synthetic line. If the synthetic is to be used as part of a regular crossing program, this is not a problem as it could be defined as a terminal or maternal line. If, however, the synthetic will be the only line used for production at the commercial level, it will be a dual-purpose line. Genetic gain in any one trait will not be as fast as in specialised lines, since selection needs to be for dual purpose. Also if the synthetic line is the only breed being used by the commercial producer, no use of breed/line complementarity is made and the use of heterosis will be sub-optimal. Many breeders have had some success developing synthetics, but when doing so they must keep in mind how the commercial producer will use their seedstock in an overall breeding program as this is the key to the long term success of their breeding business.

We have highlighted some of the issues that need to be addressed in designing a breeding program, and each breeder must consider these issues when developing their breeding plans. Each breeder will have a somewhat different situation (i.e., different testing resources, herd size, breeding goals, etc.) so these plans need to be developed on an individual basis, but the areas discussed above have to be considered in formulating the breeding program as this will enhance the long term success of their breeding business.

References

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NOTES