Using the Genetic Audit and Mate Selection Modules to Enhance Your Genetic Progress

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Seedstock producers are interested in making as rapid genetic progress toward their defined breeding goals as is possible since this will enhance the profitability and long-term success of their breeding operations. These breeders need signals that will tell them how effective their breeding program has been and where problem areas might occur. PIGBLUP tries to provide these signals to breeders through its genetic trends and the Genetic Audit Module.

PIGBLUP genetic trends tell the breeder how much genetic progress has been made over the period that data has been recorded. These trends tell the breeder how average breeding values have changed over time for the traits ticked to be analysed, and the breeder can assess, for example, whether average daily gain has been improved genetically over time or remained relatively constant. These trends tell the breeder what is happening genetically in the herd, but they give little information as to why it is happening. The purpose of the Genetic Audit module is to fill this need.

1 The Genetic Audit

Factors that will affect genetic gain per year include:

- Intensity of selection
- Accuracy of selection
- Generation interval
- Inbreeding effects

and each one of these factors needs to be addressed in a modem breeding operation to maximise genetic gain per year toward defined breeding objectives.

1.1 Intensity of Selection

Selection intensity can be thought of as an indication of how hard a breeder is driving toward the breeding objective. If we consider the measures on all possible candidates for selection, they will form a bell-shaped curve around the average as shown in Figure 1. When we discuss how intense selection is, simply put, we are talking about how far to the right of the curve has the breeder gone in picking replacement animals (when considering selection to increase levels of the trait). For example, were the best two out of ten chosen or the best four out of ten? The shaded region of the graph indicates the animals that have been selected. The difference between the average value of these selected animals and the average of their contemporaries is called the selection differential. This is a measure of selection intensity.

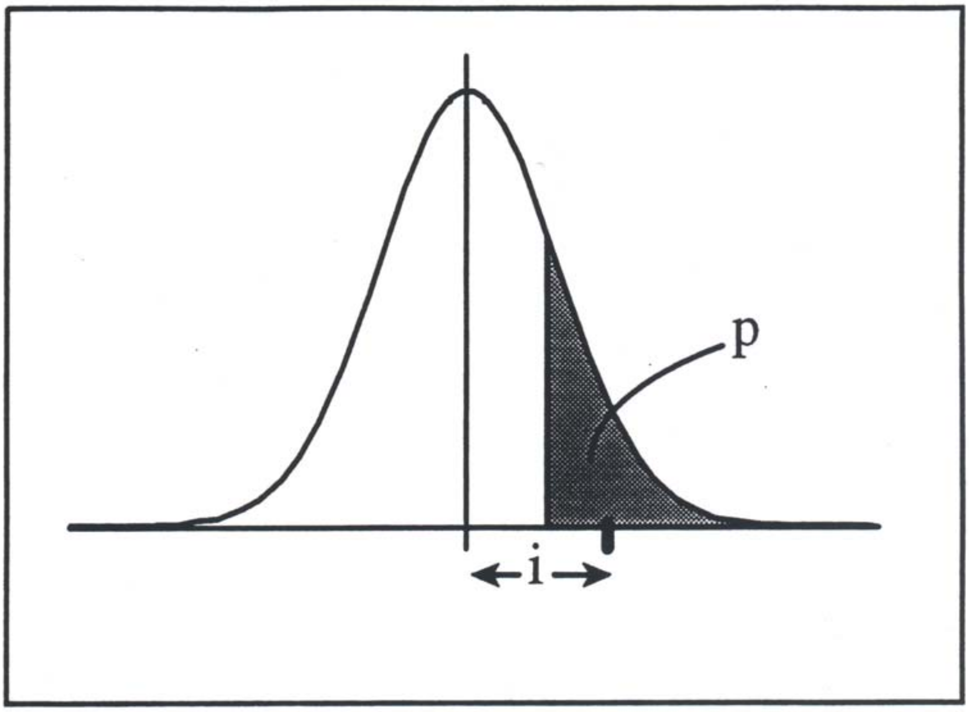

Figure 1. (Source: B. Kinghom, Chapter 19, Animal Breeding - The Modem Approach, 1992)

What signals/output does the Genetic Audit give to breeders to be able to assess the selection intensity they've applied? Tables 1 and 2 give the output from a herd that is "undergoing an audit" for the year 1990. Note in Table 1 that, as expected, selection intensity is higher on the male side than on the female side. Also, it would appear from this output, that the breeder has increased selection intensity for boars in 1990 relative to the average of the previous 5 years. Table 2 gives the selection differentials that were achieved by selecting these animals. The variable. Max SD, gives the maximum selection differential that would have been achieved if the proportion selected in Table 1 had been selected on that trait alone. For example, in 1990 if the top 2% of boars had been selected for ADG out of 678, you would expect the difference between their ADG and the average of the 678 to be about 61 grams/day. We know that very few breeders are doing single-trait selection and candidates for selection are also evaluated for other things, such as breeding soundness, teat number, etc. so the achieved selection differentials will never equal the Max SD that could be attained. These values do, however, give an indication of where selection emphasis was put and how intense it was. In this herd, the main selection emphasis was on ADG with some emphasis on backfat and no selection pressure on litter size.

Table 1. Proportion selected in year 90 compared to previous 5 years

	Gilts		Boars	
	85-89	**90**	**85-89**	**90**
Animals tested	3178	734	3055	678
Animals selected	299	69	94	14
Proportion selected	9%	9%	3%	2%

Table 2. Selection differentials in year 90 compared to previous 5 years

		Gilts			Boars		
		85-89	**90**	**Max SD**	**85-89**	**90**	**Max SD**
Average Daily Gain	g/d	15	24	45	13	27	61
Backfat (P2)	mm	-0.1	-0.1	-2.6	0.2	-0.1	-3.4
Number Born Alive	pig	0.0	0.0	1.39	-.02	-.10	1.86
$INDEX - EBV	$	20	21	58	12	23	78

It must be emphasised that these values are calculated from the PIGBLUP data extract. If, for example, in the older part of the data, only the records from selected animals were included and "whole herd testing" had not begun until later, the Genetic Audit would not be able to give an accurate comparison of selection intensity in the audit year versus previous years. Selection differentials for earlier years would not be valid as only selected animals were included. Also, if there is a great deal of pre-selection going on (deciding which animals to test, based on weaning weight, for example), it would affect the selection differentials calculated. Users of the Genetic Audit should have some appreciation of the structure of their date in interpreting results from the Audit, but these results do give breeders a tool many have never had before to assess the effectiveness of their breeding program.

1.2 Accuracy of Selection

The accuracy of selection is a factor which can affect the rate of genetic gain per year and there are many things which can affect accuracy of selection. First, care must be taken that measurements being made on-farm or in the abattoir are as accurate as possible. Measurement error can affect breeding values and genetic gain. Second, genetic parameters, such as heritabilities and correlations, must be estimated as accurately as is possible. David Klassen, during his PhD at AGBU, estimated these values for ADG, BF and NBA using Australian data, and these values are the defaults being used in the current version of PIGBLUP. A project is now underway at AGBU, a component of Susanne Kahtenbrink's PhD project, to obtain Australian estimates of genetic parameters for other traits in the current version of PIGBLUP, as well as meat quality traits. Third, since BLUP uses information on relatives, testing as many animals as a breeders resources will allow is important in increasing the accuracies of EBVs and, therefore, accuracy of selection. The Genetic Audit does not give any output to address accuracy of selection, but it must be noted that PIGBLUP produces EBVs which are the most accurate breeding values currently available to the breeder.

1.3 Generation Interval

Traditionally, it has been accepted that Generation Interval can affect the genetic progress being made in a herd, with the greater the generation interval the slower the genetic gain. The Genetic Audit gives output in Audit Litters, to the breeder regarding generation interval. This gives the breeder an indication of how generations are being turned over such that this factor can be monitored in assessing the herd's rate of genetic gain per year.

1.4 Inbreeding

High levels of inbreeding in a herd can reduce performance due to inbreeding depression and, more importantly, can result in reduced genetic variation such that intensity of selection is reduced. Accumulation of inbreeding is also a function of herd size, where genetic drift can be a problem. Breeders use various approaches to control/manage inbreeding, which may vary in their effectiveness, but it is important that they are able to assess what the level of inbreeding is in the herd to ascertain whether or not a potential problem exists. The Genetic Audit gives the levels of inbreeding in the herd so these can be monitored by the breeder.

2 The Mate Selection Module

When discussing factors affecting the rate of genetic gain in a herd, one factor that is often ignored is how the selected animals are mated. The influence and importance of this factor can be seen in Figure 2. When animals are selected, the potential for genetic gain and the relationships between individuals is established as this is the gene pool the breeder has to work with. When mating decisions are made, the realised genetic gain and levels of inbreeding in the offspring are the outcome. The Mate Selection module gives breeders a tool to aid in making these mating decisions such that genetic gain in the resultant progeny is maximised and inbreeding levels are minimised.

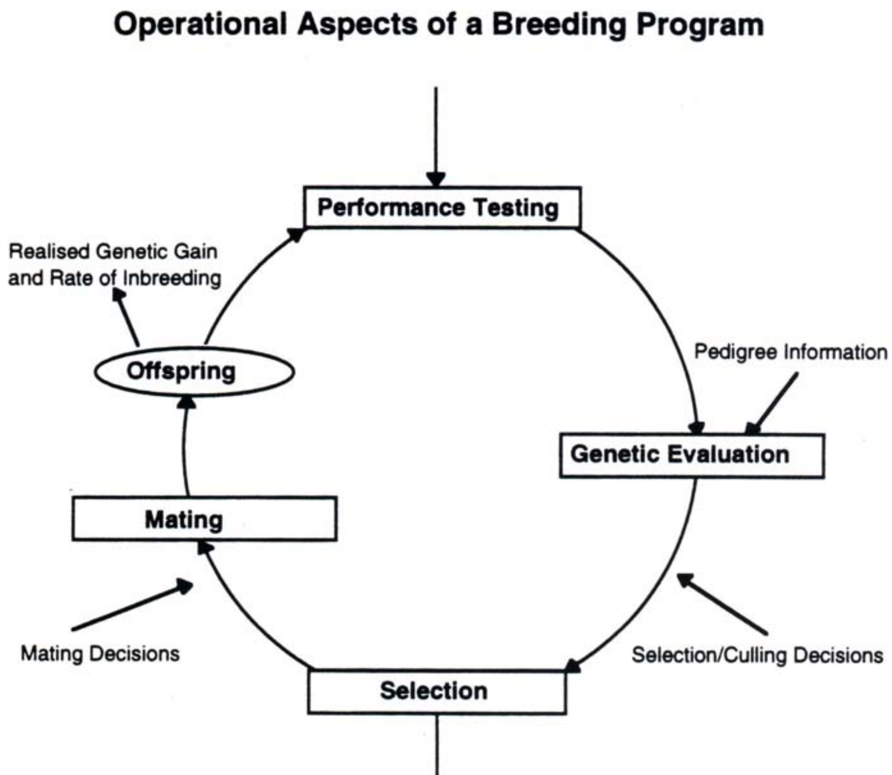

Figure 2. Operational Aspects of a Breeding Program (Source: K. Bunter, 1992)

This module uses linear programming techniques to accomplish this. Potential mates are identified in the PIGBLUP data extract. This is done using the herd management parameters which can be set from the menu and must be done prior to a full PIGBLUP run. The user can modify which potential mates to include with regard to the week of mating a sow is in and the number of matings a boar can perform in a week. The user can also specify undesired matings such as older, large boars with a young gilt or if "corrective" mating is being done. Levels of concern about inbreeding can also be set prior to a run. The levels are designed to increase penalties applied to mating pairs according to the inbreeding coefficient of their offspring, depending on the breeder's situation. What the module is doing can best be seen by examining an example detailed by Bunter et al., 1992. In this example there are three boars and 5 sows to be mated. The EBVs of boars, sows and potential progeny are given in Table 3 and the inbreeding levels of potential progeny are given in Table 4.

Table 3. Expected average breeding value of potential progeny for all possible matings

Sow No. EBV		4 +15	5 +20	6 +30	7 +32	8 +40
Boar No:	EBV					
1	(+40)	27.5	30.0	35.0	36.0	40.0
2	(+40)	27.5	30.0	35.0	36.0	40.0
3	(+45)	30.0	32.5	37.5	38.5	42.5

Table 4. Percentage inbreeding of potential progeny for all possible matings

Sow No. EBV		4 +15	5 +20	6 +30	7 +32	8 +40
Boar No:	EBV					
1	(+40)	0.0	6.25	0.0	0.0	50.0
2	(+40)	0.0	0.0	12.5	0.0	0.0
3	(+45)	12.5	0.0	0.0	12.5	12.5

For this example, we allow each boar up to 3 matings although each sow can only be bred by one boar. The total genetic merit of the progeny (GMP) is defined as a combination of the EBVs of the potential progeny, penalised for related matings according to progeny inbreeding coefficients. Optimal matings are given in Table 5 for various penalties placed on inbreeding. By looking at EBVs alone, a breeder might use boar 3 (the best) to mate 6, 7 and 8 and use either 1 or 2 to mate the two remaining sows. This is the result we get with no or a very low penalty on inbreeding. However, as the penalty on inbreeding goes up, we can see that inbreeding can be reduced without loss of GMP for g = 1.0, or, in this example, removed with a slight loss in GMP for g = 10.0, by using boars 2 and 3 in different combinations.

Table 5. Expected total genetic merit (GMP) and average percentage inbreeding (AF) of progeny produced from matings determined by mate selection, with different penalties (g) placed on level of inbreeding in progeny

Penalty	Mating Pairs	GMP	AF
0.0	3-6;3-7;3-8;1-4;1-5	176	5.0%
0.1	2-4;2-5;3-6;3-7;3-8	176	5.0%
1.0	2-7;2-8;3-4;3-5;3-6	176	2.5%
10.0	2-4;2-7;2-8;3-5;3-6	173.5	0.0%
F alone	1-4;1-6;1-7;2-5;2-8	168.5	0.0%

* Considering only minimising inbreeding to determine mating pairs

This example briefly demonstrates what many breeders have tried to do mentally whilst standing out in the breeding shed. It must be realised that many of the practices employed by breeders to control/manage inbreeding have the potential to reduce genetic gain. The Mate Selection Module gives breeders a tool that they have not had before which gives them the opportunity to maximise genetic gain while maintaining a handle on inbreeding.

Both the Genetic Audit and Mate Selection Modules are 1st generation versions designed to address key aspects of a modem breeding operation. The majority of breeders have never had this type of information before to aid in the decision making process of developing the breeding program, and future upgrades and enhancements to these modules will aid breeders in remaining competitive in today and tomorrows marketplace.

References

Bunter, K.L., Long, T. and B. Tier 1992, "Application of mate selection to pig breeding programs", *In Proceedings of the 4th Biennial Pig Industry Seminar*, Wollongbar, March, 23-26.

NOTES