Setting directions

Key actions

- Set the breeding objectives for your enterprise.
- Assess merits within breed selection, of changing breeds or crossbreeding.
- Refer to breed societies’ market-based indexes or use BreedObject™ or similar procedure, to develop an index.
- Select bulls (or semen) based on an appropriate $Index.
- Bring genetically unrelated bulls into the herd to avoid inbreeding.
- Review your breeding program and tailor it to your requirements, considering traits that are of individual importance to your program (for example breeding polled cattle).
- Ensure your breeding program matches your production system and market being supplied.

Why is genetic improvement important?

Genetics sets the potential for upper or lower production limits that animals can achieve. This can impact on the goals you set for the beef enterprise, including your market options.

Important beef enterprise profit drivers related to animal performance are influenced by the genetic make-up of the herd. These include

- weaning rate
- cow survival rate
- cow weight
- calving ease
- sale weight
- retail beef yield
- P8 fat depth
- marbling score.

Using the best cattle genetics allows you to improve the animals’ contribution to enterprise profit.

Although animal genetics cannot directly improve non-animal production factors such as pasture and grazing management, it can complement aspects of enterprise management. For example, superior genetics may facilitate a greater capacity for more efficient feed utilisation and growth rates. Genetics can also determine whether you are able to achieve a particular production target, like a high level of marbling or a particular muscle score.

In other situations, genetics can change the way you manage the herd (such as increasing the distance cattle range or graze from water), as well as reducing operational costs (for example, improved ease of mustering and handling because of selection for better temperament).

Simply put, it is about producing the best genotypes of cattle to suit specific beef enterprises and keep in mind that genetic gain is cumulative, permanent and relatively cheap.

Principles of cattle genetics

- Most traits for cattle production are under some genetic control (heritable) and can be exploited to improve profit of the herd. Traits that are economically important and are heritable should be included in the breeding objective of beef herds.
- Variation for economically important traits occurs within breeds, between breeds and some can be created by crossing breeds. All sources of genetic variation should be considered when planning a breeding program.
- Bulls have the major influence on commercial breeding programs because of the number of calves they sire. Selection of sires is therefore a critical control point in the operation of an effective breeding program and genetic improvement.
- Genetic improvement should be considered in conjunction with non-genetic means of improving performance. Non-genetic means, such as current herd selection, improved nutrition or changes to marketing procedures, may be more cost effective.

Heritability explained

Only part of the variation between animals in a contemporary group is due to genetic differences.

The majority of the variation is generally due to non-genetic factors such as differences in environmental factors, such as nutrition or exposure to disease.

The degree to which genetic differences influence performance varies from trait to trait. This is explained by differences in the 'heritability' of traits.

Growth and carcase traits tend to have moderate to high heritabilities - 20% - 60%, whilst maternal traits tend to have low heritability -10% or lower.

What is genetic improvement?

Genetic improvement is the use of genetically superior animals as parents of the next generation.

The definition of genetic superiority will be a function of many variables including the production environment and the market being supplied.

Most measures of genetic superiority will be based on potential profitability of the genotype for the given production environment and market being supplied. Not all genetic superiority needs to be based on profit but in commercial cattle enterprises profitability is likely to be most important.

Genetic improvement can improve your profit by not only increasing productivity and market compliance, but also by decreasing costs.

Genetic improvement should be continuous and the most important variable that will limit continuous improvement is inbreeding which can be managed by implementing a sustainable genetic improvement program.

Other important considerations

A genetic improvement program must be designed in conjunction with culling decisions that influence the current herd, with the management program under which the herd is run and with considerations of markets supplied.

How does this module assist you?

This module assumes that you have made the decision to run a commercial breeding herd. Therefore you need to select a bull to breed calves. Given that decision, this module will help you buy a bull that is value for money because it improves the genetics that are related to profit in your herd. If you are still undecided about running a commercial breeding herd, consider reviewing Module 1: Setting directions.

This module will assist commercial breeders whose main avenue for ongoing genetic improvement is through buying-in bulls or semen. It is not specifically designed for seedstock or stud breeders but the principles of setting a breeding objective are still the same. It takes you through the steps of establishing the breeding program to achieve animal production targets that contribute to enterprise profit. It also considers the implications of changing breeds or crossbreeding and provides a guide to selecting the best bulls for your enterprise and setting up a mating program.

Linkages to other modules

The target markets and proposed herd structure for the beef enterprise are identified in Module 1: Setting directions, in relation to the pattern of pasture growth, long-term market prices, availability of finance and owner/manager goals and constraints. Module 1 also provides guidelines for determining the current performance of the herd. There is a clear linkage to Module 7: Meeting market specifications, as well as to Module 5: Weaner throughput.

Procedures for using best cattle genetics

- Procedure 1 - Use a selection index based on a balanced breeding objective
- Procedure 2 - Select the most profitable breed or crossbreeding system to achieve genetic progress
- Procedure 3 - Buy the right bulls (or semen) to maximise progress toward enterprise profit but always consider inbreeding
- Procedure 4 - Modify trait emphasis in line with individual herd requirements
- Procedure 5 - Implement sound culling (current herd selection), management and marketing policies that complement the genetic improvement program

Use a selection index based on a balanced breeding objective

Selection Indexes allow you to make balanced selection decisions. They take the hard work out of knowing how much emphasis to put on each individual trait by ranking animals on their overall genetic value for a particular production system and value along the entire production chain.

Selection Indexes are calculated using the BreedObject™ software that has been developed by the Animal Genetics and Breeding Unit (AGBU) at the University of New England. BreedObject™ combines the BREEDPLAN estimated breeding values (EBVs) of an animal with an economic weighting on each individual trait (based on costs of production and returns on output) to produce a single selection index value for each animal.

Selection Indexes enable cattle producers to make 'balanced' selection decisions, by taking into account the relevant growth, carcase, birth and fertility attributes of each animal, to identify the animal that is most profitable for a particular production system.

An animal's selection index value can effectively be interpreted as its EBV for profitability in a particular commercial production scenario and market. Ranking seedstock animals (for example bulls in a catalogue) on their selection index value sorts them based on their progeny's expected profitability for the targeted production system.

Selection index values are expressed as differences in 'net profit per cow mated' and reflect differences in profitability across the entire production chain - from joining to slaughter. In indexes designed for self-replacing production systems (maternal), the long term profit generated by the sire's daughters is also included.

A number of breed societies have generic, market-based breeding objectives and selection indexes available on their respective websites, allowing commercial breeders to search for bulls that fit within their target index specifications (see Tool 4.01). These indexes are a very good guide as the objectives for many enterprises will be similar and rank animals similarly.

The breed-based indexes have been calculated from very good industry feedback on the costs, returns and trait performance levels of the production system and market being supplied. Most commercial producers would be well advised to start with one of the standard breed society indexes and modify their selection procedures using a process described in Procedure 4.

When selecting bulls using dollar index values it is important to also consider the individual EBVs and your herd situation. This concept is covered in more detail in Procedure 3.

If your production system and target market are substantially different to those for which breed society selection indexes are based there is scope to develop your own specific breeding objective and associated selection index using BreedObject™ software

An example of a breed society selection index*

In this example for a *Bos taurus* breed, the genetic differences between animals in net profitability per cow joined are estimated. The breeding goal is a high fertility, self-replacing commercial herd selling feeder steers and heifers for the short fed domestic feedlot trade.

Steers are assumed to be marketed at 445kg live weight (245kg HSCW and 10mm P8 fat depth) at 15 months of age. Emphasis is placed on growth to 400 days and high carcase yield while maintaining fertility and marbling. The key economic traits that are important in this selection index are shown in Figure 1. The different trait emphases reflect the underlying profit drivers in a commercial operation targeting the short fed domestic markets.

Figure 1: Example of the relative importance of objective traits at the genetic level for a specific breeding objective

BREEDPLAN EBV weightings are formed using knowledge of the genetic relationships between the key profit drivers and BREEDPLAN EBVs (Figure 2). For this selection index, there is a high emphasis on greater 400 day weight EBV and shorter Days to Calving EBV.

Figure 2: BREEDPLAN EBV weights for the Short Fed Domestic Index

It is also possible to predict the response in individual traits (EBVs) if the above selection index is used (Figure 3). In this example, the 600 day weight EBV is expected to increase even though there was a negative weighting for it (see Figure 2). This is primarily associated with the strong genetic relationship between 400 day weight EBV and 600 day weight EBV and the strong weighting on 400 day weight.

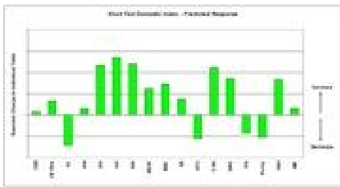

Figure 3: Predicted response in individual traits (EBVs) using the example selection index

***This material in this breakout box has been adapted from material from the websites of BREEDPLAN and the Angus Society of Australia.**

Understanding and interpreting BREEDPLAN EBVs

What is an EBV?

An animal’s breeding value can be defined as its genetic merit for each trait. While it is not possible to determine an animal’s true breeding value, it is possible to estimate it. These estimates of an animal’s true breeding value are called Estimated Breeding Values or EBVs. EBVs are reported in the units in which the measurements are taken (eg kilograms for the weight EBVs).

EBVs are expressed as the difference between an individual animal’s genetics and the genetic base to which the animal is compared. The 'genetic base' can roughly be described as the historical genetic level of that particular breed. For most breeds, their genetic base will have been set in the late 1980’s and is based on the first 200 animals’ records for that breed.

Importantly, the genetic base for each breed will be different, so only EBVs for animals within a particular evaluation can be directly compared. Putting this in practical terms, a 600 day weight EBV for a Hereford bull is not equivalent to the same EBV for an Angus Limousin bull, even if they all have the same EBV for that trait. This means it is difficult to compare EBVs of different breeds.

Interpreting BREEDPLAN EBVs

There are four key considerations when assessing BREEDPLAN EBVs for a particular animal:

- compare with current breed average and percentile bands
- compare EBVs to estimate the difference in output between two sires
- consider EBV accuracy
- visual appraisal

As most breeds have experienced significant changes in their genetic merit for most traits since the mid 1990’s, the first step when interpreting an EBV should be to compare it to the current averages of the EBVs for the breed. This will give you an indication of how the animal compares with the current genetic average for each trait. This can be taken further by comparing the animal’s EBVs to the Percentile Bands Table to assess exactly where the animal ranks within the breed for each trait. As with the breed average EBVs, a Percentile Bands Table should be provided in all BREEDPLAN reports and sale catalogues.

In the example below using 600 day weight EBV, the breed average for 2011 born calves is +92 whereas the 600 day weight EBV of the animal is +112. The accuracy of the 600 day weight EBV is 73%.

Based on the percentiles reported in Figure 4, the animal is in approximately the top 8% of the breed for 600 day weight EBV.

Comparing the bull’s EBVs below with 2011 born breed average animals shows a difference in 600 day weight EBV of 20kg. As an average, half of this difference will be passed on to the progeny. It can then be estimated that calves from the first bull would be on average 10kg heavier at 600 days than those from a breed average bull for 600 day weight EBV. Extending this to a single year’s drop of 50 calves, this difference equates to a potential production difference of 500kg in live weight by the time the calves reach 600 days of age. It is important to note that in the above example we are assuming both bulls are used over dams of similar genetic value/breed and their progeny are run under similar conditions.

Figure 4: An example of BREEDPLAN EBVs for an animal registered with Angus Australia

Figure 5: Comparing percentiles for each BREEDPLAN EBV and $Index

$Indexes are discussed in Procedure 3.

When evaluating any EBV, it is also important to consider the EBV accuracy. By definition, an EBV is an estimate of an animal's true breeding value. To provide breeders with a measure of the reliability of the estimate, BREEDPLAN produces an accuracy figure with each EBV. This accuracy provides a measure of the stability of the EBV and gives an indication of the amount of information that has been used in the calculation of that EBV. The higher the accuracy the lower the likelihood of change in the animal's EBV as more information is analysed for that animal, its progeny or its relatives.

The following guide may be useful for interpreting accuracy:

- **Less than 50% accuracy** - the EBVs are preliminary. EBVs in this range will have been calculated based on information on parents and relatives only. These EBVs could change substantially as more direct performance information becomes available on the animal.
- **50-74% accuracy** - the EBVs are of medium accuracy. EBVs in this range will usually have been calculated based on the animal's own performance and pedigree information.
- **75-90% accuracy** - the EBVs are of medium-high accuracy. EBVs in this range will usually have been calculated based on pedigree, the animal's own performance plus the performance of a small number of the animal's progeny.
- **More than 90% accuracy** - the EBVs are a high accuracy estimate of the animal's true breeding value. It likely EBVs will remain stable with addition of more progeny data.

As the number of bulls in a team increases the accuracy of the 'group' EBV for the bulls in the team increases (Figure 6). If the accuracy of 3 individual bulls for a trait is 60%, then the group accuracy is 89%. The biggest gains in group EBV accuracy are observed when the accuracy of individual bulls is low. This concept is particularly relevant for cattle producers who are purchasing several bulls or have multiple sire mating as it provides strong evidence that across the team on average the genetic merit has been accurately estimated.

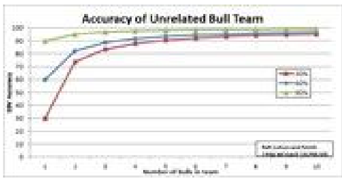

Figure 6: Increase in EBV accuracy as number of bulls in a team increases

Although the accuracy of an EBV should be considered, animals should be compared on EBVs **regardless of accuracy**. However, where two bulls have the same EBV and there are no obvious visual faults, the bull with the higher accuracy would normally be used more heavily than the bull with the lower accuracy because the results can be predicted with more confidence.

What to measure and when

Annually review any changes that have been made to your production environment or target market. If significant changes have occurred, you may need to reset your breeding objective.

Select a profitable breed or crossbreeding system to achieve genetic progress

Guidelines for selecting the breeding system

Consider selection of the best genotype for your enterprise as part of setting the enterprise direction (refer to Procedure 1 of Module 1: Setting directions.

Assess merits of a change in breed or crossbreeding compared to within-breed selection only.

Evaluate the merits of changing breeds, crossbreeding or within-breed selection alone. In general, the genetic variation within breeds is large and will allow many breeds to compete in a range of markets, so the decision about whether to move to an alternative breed or cross will be based on an assessment of whether the size of the changes needed in the traits of your current herd is so great that it will take too long to achieve by simply selecting better bulls within your existing breed and/or source of bulls.

It is important to calculate the costs, time and effort required to implement a new breeding system to ensure that the advantages outweigh the difficulties.

Changing breeds may cause large changes in some traits and may change the relativity between traits such that a decision to change breeds will require refining the breeding objective and calculating a customised selection index using BreedObject™.

Options include:

- Replacing the existing herd by buying in an alternative breed. This is the quickest method, but also the most costly. Embryo transfer is also an option, although this may be cost prohibitive for most commercial operations.
- Building up to the desired breed or combination by crossing with bulls from the chosen breeds. This option is slower, but will generally be less costly and brings with it the complementary hybrid vigour that comes from crossing genotypes during the transition to the new breed or breed combination.
- Building up by buying in replacement heifers of the desired breed/cross breed. This strategy can be applied when/if restocking after drought or other significant destocking events, or more slowly each year to simply replace cull cows and mortalities.

Although ongoing advantages can be achieved by implementing a planned crossbreeding program, you also need to consider the potential disadvantages, such as:

- additional herd management associated with crossbreeding
- discounts that might be experienced when selling crossbred animals, particularly for some breeds when sold through the saleyard system or to specialised markets that specify breed composition
- time and cost required to bring the herd into 'equilibrium'

Crossbreeding is better suited to larger herds, with more bulls and bigger lines of cattle for sale but could be a good option for smaller herds to utilise some hybrid vigour and optimise breed combinations.

After deciding on breed and whether to crossbreed, further genetic progress relies on selection of replacement bulls within the available genotypes. This is discussed in Procedure 3.

What to measure and when

Consider a change in genotype when:

- potential genetic improvement, of traits that are economically important, within breed isn't adequate to make the changes you need for your program
- potential for marginal return on investment for an alternative breed is greater than for other investment options
- cash flow during the transition period to the new breed or cross can be maintained at acceptable levels
- before significant restocking events.

This is a strategic decision. The measures that are needed for an economic evaluation of options are described in Module 1: Setting directions.

Advantages and considerations for crossbreeding

Planned and well managed crossbreeding systems will deliver significant benefits to beef producers through hybrid vigour. Hybrid vigour, also known as heterosis, is the difference between the performance of the progeny and the average performance of the parents. In general, the more distantly the parental breeds are related, the greater the amount of heterosis that can be expected.

The main benefits result from:

- higher performance than expected for a range of traits through hybrid vigour

- combining the benefits of breeds is called 'breed complementarity'.

The main benefit of hybrid vigour occurs for traits with low heritability such as reproduction and adaptability traits.

Table 1 illustrates the relationship between heritability and hybrid vigour regarding different categories of beef cattle traits. Reproduction and maternal traits have low heritability and response to selection will generally be slower compared to high heritability traits. At the same time, significant improvement in these traits can be made through programs that maximise hybrid vigour.

Table 1: Heritability and hybrid vigour comparison.

Traits	Heritability	Hybrid vigour
Fertility, mothering ability, calf survival	Low	High
Birth and weaning weight, milk	Medium	Medium
Carcase	High	Low

Quantifying the benefit of hybrid vigour

A comprehensive crossbreeding trial undertaken by United States Department of Agriculture at the Meat Animal Research Centre highlighted the benefits achieved through a structured crossbreeding program for weaning weight per cow joined. This trial included crosses of Hereford, Angus and Shorthorn.

Compared to the purebred calves, the F_1 crossbred calves showed an 8.5% increase in weaning weight per cow mated on average. This was a direct function of hybrid vigour. While significant, a larger increase of 23.3% in calf weaning weight per cow joined was observed in the F_2 calves compared to the purebred. These calves were bred from first cross cows and obtained the additional 'boost' from maternal hybrid vigour (Figure 7).

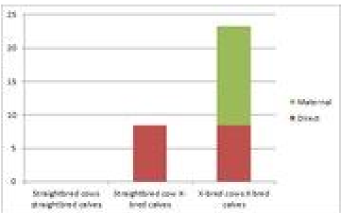

*Figure 1. Responses in weaning weight per cow mated from different crosses (*Adapted from information in Gregory, KE and Cundiff, LV (1980))

Crossbreeding design and hybrid vigour

The amount of hybrid vigour achieved will depend on the type of crossbreeding or composite system implemented. A composite breeding program is a crossbreeding system that is stabilised (inter-mating the crossbreds). Table 2 lists the types of crossbreeding systems, the levels hybrid vigour (both individual and maternal) retained and estimates of increases in weaning weight per cow mated.

Table 2: Crossbreeding systems and estimated levels of hybrid vigour

System	Individual (%)	Maternal (%)	% WT calf/cow
2 breed cross	100	0	8.5
3 breed cross	100	100	23.3
Rotational cross			
2 breed	67	67	15.6
3 breed	86	86	20.0

4 breed	93	93	21.7
Composite			
2 breed	50	50	11.6
3 breed	67	67	15.6
4 breed	75	75	17.5

Selection and crossbreeding

Crossbreeding should not be seen as an excuse for using ‘low’ performing genetics (ie bulls). Regardless of hybrid vigour, the performance of the crossbred herd will depend largely on the performance of the parent, the management level and the environment that is used.

Tool 4.02 can assist you in deciding whether crossbreeding appropriate for your enterprise.

References

- Southern Beef Technology Services *Tools of the Trade - Cross Breeding fact sheet*
- NSW DPI Primefact 624
- Gregory, KE and Cundiff, LV (1980) *Crossbreeding in beef cattle: Evaluation of systems.* J. Anim. Sci. 51,1224-1242.

Guidelines for buying the right bulls

The purchased bulls, or semen for an artificial insemination program, need to provide the best value for the financial outlay. Regardless of the breeding program, the genetic value of a bull to an enterprise is based on how well its individual attributes fit the herd's breeding objective.

At any point in time, EBVs are always the best estimate of the genetic potential for a trait. Accuracies that accompany the EBV value indicate how much information has been recorded for a particular animal for the reported trait. As more information is collected the accuracies improve (see Tool 4.04).

Use EBVs related to the traits identified in Procedure 1 as being important to the breeding objective to select the best bulls for the breeding program.

Measure the value of a bull by its fit with your breeding objective.

Relate the price you can 'afford' for a bull to the bull's potential earning capacity. The most profitable bulls for your herd will be those with the greatest difference between predicted earning capacity and purchase price. These bulls may not always be those with the highest genetic merit.

Use the dollar index ($Index) value for all bulls you are considering buying to compare the prices. The index value is in dollars per cow mated so, as a guide to the bull's value, multiply the index value by the likely number of cows he will be mated to in his working life. For example, the bull will be used for four years over 50 cows per year (200 cows). This value is a good guide for comparing bulls. A bull with an index value of 100 compared to a bull with an index of 50 is worth $5,000 extra (200 cows x $50 index points x 0.5). The index is an EBV so only half of the value comes from the bull.

This doesn't set the price because it depends on the average for the sale and that depends on many other factors (Tool 4.05 has a better guide to valuing your bull purchase). It is important to note that the $Index value is the estimate of genetic merit for all of the supply chain. The cow-calf breeder will not realise all of the additional value for the higher $Index value as this is shared across all participants in the beef supply chain, including agents and processors.

Using this information you can select the bull with the highest genetic value for your herd's breeding objective from those with the greatest difference between estimated earning capacity and purchase price. Tool 4.05 will assist you to avoid two common pitfalls when buying bulls:

- paying too much for the apparent 'super bull' when economically the second best bull may be better value and better fit your operation/property
- buying the worst bull in a sale catalogue because he was 'cheap' but then 'paying' for his poor performance.

When selecting bulls using $Index values it is important to also consider the individual EBVs and your herd situation. Table 3 demonstrates how two bulls can have very similar $index values (+$98 vs. +$101) but contrasting EBVs for individual production traits. For example, the bulls differ by 69kg for 600 day weight EBV (+50 vs. +119).

Table 3: Two widely used Angus bulls with similar Long Fed/CAAB index value but showing large variation in many traits.

Trait	Bull A	Bull B	Breed Average
Calving Ease Dir (%)	-1.6	-1	0
Calving Ease Dtrs (%)	+0.4	+0.2	+0.3
Gestation Length (days)	-1.4	-1.4	-3.1
Birth Wt. (kg)	+3.5	+5.4	+4.5
200 Day Wt (kg)	+24	+53	+39
400 Day Wt (kg)	+49	+90	+72

600 Day Wt (kg)	+50	+119	+92
Mat. Cow Wt (kg)	+37	+121	+83
Milk (kg)	+3	+21	+12
Scrotal Size (cm)	+3.3	+2.6	+1.5
Days to Calv. (days)	-4.8	-8.5	-3.1
Eye Muscle Area (cm^2)	+3.6	+3.2	+3.8
Rump Fat (mm)	+3.7	-3.4	0
Retail Beef Yield (%)	-1.9	+2	+0.4
IMF (%)	+3.8	+0.6	+1.1
Long Fed/CAAB Index	+98	+101	+97

Ensure that your bull supplier is accurately recording all possible traits associated with traits that are economically important to your breeding program. If a bull breeder is recording all important traits, it will be reflected in the accuracies of the EBVs presented (see Tool 4.04). As a guide, young bulls should have all EBVs displayed (if EBVs aren't displayed it generally means that trait hasn't been recorded) with accuracies between 50-60% for weight traits. Traits of lower heritability will have lower accuracies.

Choosing the bull is the point at which inbreeding should be considered. In commercial herds a rule of thumb is to avoid successive bull purchases that have a common parent. Another way of saying this is to definitely avoid mating cows to bulls that have a parent in common. Other relationships are likely to be less severe. Inbreeding is a major impediment to genetic improvement by bull breeders so most times they will try to introduce new genetic lines on a regular basis.

Also, remember that the physical ability of bulls to sire many calves is a primary consideration. The selection of bulls for maximum fertility based on structural soundness and libido are discussed in Procedure 1 of Module 5: Weaner throughput. Management can also play a large role in bull fertility. Prevention of infectious reproductive diseases is outlined in Procedure 1 of Module 6: Herd health and welfare.

Check bulls for structural soundness at purchase and annually before mating.

The Australian Poll Gene Marker test

Unlike many traits of importance to beef producers, whether an animal is horned or not is completely controlled by genetics - environmental factors have no impact on the occurrence of horns.

The Australian Polled Gene Marker test has recently been developed and can identify some of the genes controlling the trait, with high accuracy for some breeds. The test was developed in tropically adapted breeds, though results suggest it may be applicable to some *Bos taurus* breeds. Through the Australian Poll Gene Marker test, producers have a tool to identify breeding animals which will consistently produce polled progeny as well as carriers of horned genes.

The test reports on the likelihood of an animal being homozygous 'true polled', or heterozygous poll (meaning the animal may appear polled but generate progeny that are horned). If the aim of a breeding program is to increase the frequency of polled genes and reduce the proportion of horned animals, the use of 'true polled' sires (carrying poll genetics only) will allow the desirable polled gene to dominate the herd more quickly than using a heterozygous polled sire (carrying both poll and horn genetics but visually appears polled).

As with any trait, breeding for higher proportion of polled animals is only one consideration in making a balanced selection decision.

Read the *Australian Poll Gene Marker test fact sheet*.

What to measure and when

Predict the value of bulls for improving enterprise profitability.

When a new bull purchase is being considered and before mating each year:

- assess the genetic merit of prospective bull purchases

- estimate the earning capacity of bulls based on the index value and the projected pattern of use (number of cows per year x number of years used), see Tool 4.05
- assess structural soundness of the bull battery
- assess the accuracy of information given to you by your bull breeder. Tool 4.04 has information that is recorded on sale bulls and the subsequent accuracies associated with the EBVs.

Setting directions

The process of developing a breeding objective is an essential and very sound genetic improvement principle. Even taking the easiest and most practical approach of using an index developed by a breed society (and therefore the objective developed during the development of that index) will be a sound first step in designing a breeding program. However, in all breeding programs there will be individual requirements brought about by differences in the production environment, markets and personal preferences.

A few examples that may require modification of trait emphasis are:

- the desire to minimise calving difficulty because of inability to handle calving difficulties or the unwillingness to do so (due to extensive enterprise or difficult topography for example)
- the desire to breed towards a polled herd
- the desire to improve cattle temperament
- the need to meet market specifications of higher yield or different maturity types
- personal estimations of future market requirements (bulls selected today won't produce sale progeny for at least 18 months and in most cases 2-3 years).

Requirements such as these can easily be catered for within the bulls that are high ranking on an index. Bulls may achieve high index values for different reasons so applying an independent cut-off on individual traits will only marginally reduce progress towards a profit objective. As an example, the bulls represented in Table 4 would allow selection of high indexing but quite varying birth weight.

Table 4: Five young Angus bulls with similar index value but showing variation in other traits.

	Bull A	Bull B	Bull C	Bull D	Bull E	Bull F	**Breed average**
Calving Ease Dir (%)	2.4	-3.6	2.7	0.3	-2.6	2.5	**0**
Calving Ease Dtrs (%)	1.7	0.8	0.8	1	0.6	0.9	**0.4**
Gestation Length (days)	-5	-0.5	-3.5	-1.4	-2.8	-3.2	**-2.6**
Birth Wt. (kg)	**1.9**	**6.3**	**3.6**	**3.2**	**7.3**	**1.7**	**4.5**
200 Day Wt. (kg)	40	45	42	40	52	34	**37**
400 Day Wt. (kg)	86	79	90	80	94	88	**69**
600 Day Wt. (kg)	112	104	107	101	115	105	**88**
Mat. Cow Wt. (kg)	85	73	71	73	91	76	**81**
Scrotal Size (cm)	1.2	0.4	1.8	1.7	1.2	2.3	**1.3**
Days to Calving (days)	-4.3	-1.8	-3.2	-3.4	-2.8	-4.2	**-2.6**
Eye Muscle Area (cm^2)	9.4	12.9	9.6	11.4	11.2	9.9	**3**
Rump Fat (mm)	1.2	0.8	0.5	2.2	0.3	0.4	**-0.1**
Retail Beef Yield (%)	0.4	1.6	0.6	0.7	1.3	1	**0.2**
IMF (%)	3.3	3.5	3.3	3.6	3.3	3.3	**0.9**
Long Fed CAAB Index	159	158	158	158	157	157	**90**

There are also traits that are important to the breeding enterprise for which there are no EBVs and therefore aren't included in the index. An example of these are the structural traits such as teats and udders. There is little option other than imposing independent culling on these traits.

Another decision point for control of the individual traits and for inbreeding is when allocating bulls to the mating groups.

When allocating bulls to mating groups, reduce the risk of inbreeding and dystocia and match traits if required by:

- mating bulls with the highest EBV for calving ease to heifers but remember that half of the genetics for calving ease comes from the maternal grand sire so reducing calving ease may take more than one generation. Even older cows shouldn't be mated to extremely high birth weight bulls because if you keep heifers resulting from that mating, they will carry genes for high birthweight
- possibly mating bulls from a breed with a lower mature size to heifers (especially effective in a crossbreeding program where differences in mature size and hybrid vigour can cause increased birth weights and therefore increased calving difficulties)
- matching strengths and weaknesses of cow groups by allocating different sires. An example may be earlier maturing (low frame size) cows mated to later maturing bulls or vice versa if maturity type is important to your objective
- minimising inbreeding through preventing the mating of bulls with their daughters or with cows that have a common parent (half-brothers and half-sisters).

What to measure and when

- Calving ease EBV for bulls allocated to weaner heifers or birth weight EBVs when calving ease EBVs are not available.
- Male parentage of all cows in the herd. This may only be done in age groups if individual identification is not recorded.
- Monitor growth rates, turn-off age and turn-off fatness (see Module 7: Meeting market specifications).
- Monitor feedback from kill sheets and note any unwarranted trends that may need correction (see Module 7: Meeting market specifications).

Setting directions

For some traits, it may be more cost effective to make improvement by culling non-performers or by management.

Repeatability can be as important as heritability for traits that are repeated annually, such as calving success and weaning weight of the calf. Fertility traits tend to be lowly heritable but economically important in most breeding programs.

In some enterprises it is more efficient to improve fertility by culling non-performers or by improving nutrition or management.

Management influences, especially nutrition, can overcome some genetic deficiencies. For example, lower fattening ability may not be a problem if you are producing store or feeder animals, which will receive adequate nutrition to fatten at other supply chain stages.

One of the most important nutritional considerations is the time just prior to mating (conception) and calving. It is important that breeding cows are on a rising plane of nutrition at conception so that they are able to support the developing foetus. Cows also have their greatest nutritional demand during lactation, which usually coincides with the time of conception, if you aim for your cows to have a calf every year. Therefore in principle, the period of calving and mating should coincide with the time of the year of reliable high quality feed (see Module 2: Managing your feedbase).

The chosen market should also be considered as a variable in the enterprise mix. Strategic decisions on which market to target should be made based on sound economic considerations. Chasing a high priced market may be a false economy if major changes to the breeding program are required.

As a case study example; herds that already have high calving rates (greater than 85%), a program of selecting heifers by short joining (6 weeks) at a young age (15 months) will select for heifers with early age at puberty. Then if culling empty cows on pregnancy testing for the second calf, the cows that remain in the herd will be those that are short post-partum anoestrus. Both early age at puberty and short post partum anoestrus are associated with improved lifetime reproductive performance. A culling procedure based on these principles will only make small genetic improvement but will improve the herd productivity for these traits. Selecting for repeatability of a trait (i.e. selecting young animals for traits that will be repeated at older ages) is important when also selecting sires with higher fertility EBVs (shorter, more negative days to calving and higher more positive scrotal size).

Calving ease may be used as a second case study; heritability is again low and the trait is very complex. A single pronged approach will be unlikely to result in large changes while a multi-pronged approach including genetics, culling and nutrition can be very rewarding.

Maximum returns will result from integrating genetic improvement programs, culling and management.

What to measure and when

- Performance level of economically important traits such as:
  - calving rate
  - calves born in first cycle
  - compliance to market specifications (weight, fat, marbling specification)

- Nutrition and climatic conditions. decisions to change should not be made in extremes such as droughts or extremely good seasons.

- Age and weight at sale.

Commonly used genetics terms

Breeding objective: the goal of the breeding program and the traits that need to be improved to contribute to the overall enterprise objective, which is presumed to be primarily economic gain.

Selection Index: a single EBV that describes how well animals suit a particular purpose (objective). It is a weighted combination of all available EBVs into a single $EBV.

BreedObject™: a software package that can calculate a ‘dollar index’ value for animals specific to the breeding objective for a herd.

Estimated breeding value (EBV): the estimate of an animal’s breeding value or ‘genetic worth’ for a particular trait. The estimation can be based on (phenotypes of) the animal itself and/or its relatives, for the same and/or different traits to the trait of interest. This is made possible by knowing the genetic relationships between animals and the genetic correlations between and the heritabilities of traits.

The bull and cow each contribute a random sample of their genes to their offspring, half from each, meaning that *half* of the EBV of each parent is the contribution to their progeny.

Setting directions

Download BreedObject™ software.

The site contains a live version of the program with the capacity for dollar index development online for immediate use. There is online interactivity with the breed databases that ensures use of the latest EBVs, and also EBV and standard dollar index display. The information section has a list of useful references and the home page includes links to all the breed sites.

A number of breed societies have generic, market-based breeding objectives and selection indexes available on their respective websites, allowing commercial breeders to search for bulls that fit within their target index specifications.

- Angus
- Hereford
- Poll Hereford
- Shorthorn
- Limousin
- Charolais
- Brahman
- Murray Grey
- Simmental

Setting directions

When designing a crossbreeding program, it may be wise to seek professional help. There is a course, developed by MLA, specifically for designing breeding programs. This includes a major section on crossbreeding that could provide valuable assistance with the design of a crossbreeding program. The "More Beef from Breeding" course is designed to support More Beef from Pastures clients who want to study beef breeding in more detail.

How breeding systems can exploit genetics

Forming the right breeding program design is important to reaching your goals. The potential within breed and between breed gains that can be achieved are detailed in Table 5 with considerations for breeding program design displayed in Table 6.

Table 5: Sources of genetic differences

Economically important traits	Within breed*	Between breeds**			Hybrid vigour***	
		British (BB)	European (E)	*Bos indicus* (BI)	BB/BB or BB/E	BB/BI or E/BI
Growth	✓	✓	✓✓	✓✓	✓	✓✓✓
Reproduction	✓	✓	✓	✓	✓	✓✓
Yield (carcase quantity)	✓	✓	✓✓✓	x	0	0
Marbling (carcase quality)	✓	✓	x	x	0	0

*Selecting the best within one breed – the variation is calculated as the top 10% of the breed compared to the bottom 10% in a group BreedPlan summary

**Determining if there is a better breed for the key profit factors (these figures assume starting with a British breed base).

***Determining if the crossbred animal is superior to the average of the two parent breeds.

- ✓ represents approximately 5% gain
- ✓✓ represents approximately 2.5% gain
- ✓✓✓represents a 5% loss in desired trait
- 0 represents no gain

Table 6: Potential to change key factors for a southern production system tailored to a longfed export market.

	Trait			
	Liveweight (point of sale)	Weaning rate	Carcase yield	Carcase quality
Relative importance of trait* (1 = most important)	2	3	4	1
Within breed selection feasible**	✓✓✓	✓	✓✓✓	✓✓
Selection criteria	Yes 600 day 20kg above breed average	Scrotal size EBV above breed average	No EMA EBVs below breed average	No
Between breed opportunities	Yes	Yes	Yes	Yes
Between breed opportunities being exploited	No	No	No	No
Hybrid vigoour would help	✓✓✓	✓✓	x	x
Hybrid vigour being exploited	No	No	No	No
Suggested actions	BreedObject		Look at EMA EBVs	IMF EBVs - new to breed***

*Indexing programs such as BreedObject, assist to determine the relative importance of traits more accurately.

**The trait is heritable.

***As marbling is the most important factor, any change in breeding system would have to ensure no loss of marbling performance. Crossbreeding with Shorthorn or Wagyu could be considered.

Setting directions

Selecting a profitable crossbreeding system that will work within the many constraints that most beef cattle producers operate under can be complex.

When selecting a possible crossbreeding system, producers need to:

- consider the overarching constraints such as:
  - market options
  - environment (pastures, seasonal conditions)
  - existing preferences (for breed, selling methods, etc.)
  - overall goals for the business
- recognise profit drivers (a key profit drive is gross income, which is a direct reflection of number of animals sold multiplied by the average value).

Before setting breeding objectives for the herd and developing a breeding plan, beef producers need to focus on the traits that are important in regard to the target market. Traits most likely to be important include:

- weight
- fat depth
- yield characteristics (muscling)
- intramuscular fat (marbling)

The ranking and weighting of these traits will change according to the target market. Broadly, the beef market may be broken into four segments:

- high marbling trade (marble score greater than MS2)
- table beef trade (high eating quality)
- manufacturing beef
- live export

Market segment	**Important traits (profitability ranking)**	**Possible breed type/breed options**
High marbling	■ intramuscular fat ■ carcase weight ■ yield	■ British breeds with some ability to marble (Angus, Shorthorn, Murray Grey etc) ■ British breed selected for marbling (high EBVs) ■ Japanese breeds (Wagyu)
Table beef	■ carcase weight ■ fat ■ yield ■ intramuscular fat	■ British breeds (Hereford, Angus etc) ■ European breeds (Charolais, Limousin etc) ■ *Bos indicus* breeds and crosses

Setting directions

BREEDPLAN provides information to support those who require more information on BREEDPLAN and its related products including BreedObject.

The BREEDPLAN website should be accessed for information on EBVs and BREEDPLAN products and services.

Further support is available from Southern Beef Technology Services (SBTS) or the companion service in the north, Tropical Beef Technology Services (TBTS). Online resources available include fact sheets and webinars.

Setting directions

The bull earning capacity calculator will help you predict the estimated earning capacity of each bull based on the dollar index value and estimated number of cows to be mated.

This tool will help you avoid two common pitfalls when buying bulls:

- paying too much for the apparent ‘super bull’ when economically the second best bull is better value
- buying the worst bull in the catalogue because he was ‘cheap’, but ‘paying’ for his poor performance later.

Use the index values as an initial screening tool and then scrutinise the individual EBVs to refine selections based on the needs of your enterprise.

When calculating indicative value, a price needs to be nominated that you consider reasonable to pay for an ‘average bull’ of the particular breed, which is then equated to the average index value for the breed.

The indicative value of any bull of that breed is then derived from this average price, taking into account the difference between the bull’s index value and the average index value and the number of cows he will be mated to in his working life. The equation for determing indicative value is:

(index value - average price) x 0.5 x no. of cows mated + average price = Indicative value

The index value is multiplied by 0.5 as EBVs of a bull only account for half the genetics with the other half coming from the cow.

Worked example

A bull with an index value of 80 in a breed where the average index value is 40, mated to 100 cows in his working life with an average bull price of $4,000 will be worth:

(80 – 40) x 0.5 x 100 + $4,000 = $6,000

Indicative values reached using this equation are break even purchase prices and as such are the upper limit of what should be paid for the marginal genetic worth of the bull over and above breed average.

It is important to remember that the chosen index needs to be based on costs and returns similar to those in your enterprise to be relevant. While it is unlikely to be the same actual value if you use a ‘generalised’ index, such as those developed by breed societies, the ranking of bulls should be very similar by both methods.

Capturing the benefits

The $Index value is the estimate of genetic merit for the whole of the supply chain.

Cow-calf breeders will not realise all of the additional value for the higher $Index value as this is shared across all participants in the beef supply chain.

When investing in ‘superior’ genetics (particularly for carcase traits) it is important to consider your ability to capture the expected economic benefits generated across the supply chain as a result of the improved performance of future progeny.

For example, if you are selling on the open market there may be little opportunity to capture a share of the added value from improved carcase performance. Where possible, it is best to seek arrangements that will allow you to recoup the benefit of the investment in superior genetics, for example through retained ownership programs.