agriculture
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PROVINCE OF KWAZULU-NATAL

Beef Production: The Basics

Breeding and Selection in the Beef Herd

The late Dr Geoff Harwin stated that a preoccupation with high absolute production levels coaxed breeders beyond the bounds of functionally efficient cattle, and that genetic resources must be matched to the production situation. The problem is exacerbated by the preoccupation of managers with setting goals, often without a prior, but essential, resource evaluation. All too often, goals are set well beyond the physiological bounds possible given the breed of cattle involved under the relevant environmental conditions. Although it is acceptable for a farmer to maintain cattle for other reasons than marketing, where selling for a profit is the goal, goals must be market related and set within the bounds of available resources.

When contemplating beef breeding, the farmer

- must have clear and realistic breeding goals,
- have a thorough understanding of the principles underlying inheritance
- and general herd management and nutrition in his herd must be of an acceptable standard.

Origin - environmental or genetic?

Since the discovery that characteristics are transmitted by genes, there has been argument and speculation, as well as research, to determine the importance and contribution of environmental factors in relation to inherited factors as determinants of different characteristics, especially production related factors.

The following considerations are used as a guide to find out whether a characteristic is genetic in origin or not:

- Previous studies are useful to decide how heritable a characteristic is and how important environmental influences are in causing or modifying the relevant characteristic. The advice of experts can be obtained or the literature of previous studies consulted.
- If the characteristic appears only in some breeding groups and not in others, further questions need to be asked. If different bulls were used and all the animals were subjected to the same environmental influences, the bulls must be investigated. On the other hand, if environments were different, the origin of the characteristic could be the result of environmental factors.
- If there was inbreeding in a group of animals, recessive abnormalities are very likely to appear.

- Problems that arise when there is a change in the environment, for example animals are moved into a new grazing paddock, must be investigated to try and isolate possible environmental causes such as the presence of a different plant in the new paddock.
- Stress can cause problems and if a farmer is aware of the presence of stressful situations, these must be eliminated to exclude stress as a causative agent of the characteristic or problem.
- When a phenomenon occurs after the environment was changed, then an environmental association is likely.

Unique aspects of beef breeding

Beef breeding is a relatively simple undertaking, although, as Tom Lasater said, the difficult part is to keep it simple. Selecting suitable animals for meat production is assisted by the new carcass classification system which allows virtually any type of animal to achieve the most desired carcass classes.

Selection for beef characteristics is usually effective because:

- Characteristics of economic importance have medium to high heritability and can be measured in both males and females.
- Many characteristics can be measured in young animals before sexual maturity.
- Some characteristics of economic importance can be seen phenotypically.

The measurement of certain traits is difficult. Thus, carcass merit can only be fully evaluated once an animal is dead. The selection of breeding bulls on carcass merit is therefore only possible through progeny testing.

A major difficulty faced by beef producers is the problem of keeping the consumer happy. Consumers vary in their preferences and beef producers cannot satisfy changes in demand rapidly because beef production is in essence a long-term undertaking where overnight changes are not possible.

Industry structure and beef breeding

In many countries it has been shown that the beef industry has a tiered structure. At the top of the structure are the bull-producers, which can be stud herds, with increaser herds below that and the mass of commercial meat producers forming the basis of the structure. Ideally, genetic material should flow freely from the top of the structure to the bottom, and it should be possible to move superior genetic material from the base of the structure to the seedstock herds at the top. Unfortunately, there is a tendency to create a barrier between the stud herds and commercial herds, which allows genetic material to move down towards the commercial herds, but prevents or limits the upward movement of genes to the stud herds. This barrier is often based on perceived economic advantages, which are in no way related to genetic improvement. A common misconception is that the cattle in commercial herds are of an inferior quality, whereas it has been shown that there are very high performing cows and bulls in most commercial beef herds.

In South Africa the beef industry does not have a clearly definable structure. In KwaZulu-Natal there are well established stud breeders and a number of farmers providing a very large variety of different bulls, including pure-bred bulls as well as so-called "types" and "composites". A recent change has been a movement towards using home-bred bulls. The number and variety of bulls available can be confusing to commercial producers. When commercial producers suddenly change their choice of breed, flooding of the bull market with certain bulls follows, with a concomitant shortage of bulls of other breeds.

Purebred bulls and cows imported from other countries are the basis of most pure-bred herds in South Africa. Upgrading assisted most breeds to increase numbers rapidly, also leading to broadening of the genetic base of most breeds compared to their overseas counterparts. In the early 1950's to 1960's, there was a trend to close breeds *i.e.* only allow the use of pure-bred breeding stock into registered herds. This did not last very long and upgrading was re-introduced for most breeds. Based on research, many breed societies allowed a substantial shortening of the upgrading route prior to acceptance of cows as full stud. Recently a number of breed societies have allowed the use of related breeds to be used for the improvement of certain traits in their own animals *e.g.* the use of Gelbvieh to improve certain conformational characteristics in the South Devon.

Apart from certain exceptions like the Afrikaner, prior to 1950 indigenous cattle were not fully accepted as worthy of consideration for beef production. Lately, indigenous cattle are becoming part of the South African beef production scene and breed societies looking after the interests of local cattle breeds have arisen.

Seedstock herds

Although seedstock herds include producers of breeding material who operate independently of stud associations, most bull breeders are affiliated to a breed association. Certain advantages are available to members of breed societies, including the opportunity to spread costs of progeny testing, advertising or participate in group breeding schemes.

Improved breeding in seedstock herds is aimed at the production of bulls for use in commercial herds. As such, traits important to beef production overall should be included in their breeding goals. Often there is a tendency to pamper both cows and bulls in stud herds. The practice to overfatten bulls for auctions could render the animal useless for breeding purposes for some time. The breeders cannot be solely blamed for this problem, because buyers persist in paying higher prices for fat bulls.

Commercial herds

Cross-breeding is practised in many commercial herds in South Africa. Although the objective is usually to exploit heterosis, heterotic effects are often absent because the additional inputs demanded for enhanced performance to take place are lacking. Additive gene action, the other advantage of cross-breeding, is rarely cited by beef producers as a reason why they cross-breed. However, mixing the desired characteristics of different breeds in progeny is a rapid method to adapt to change without having to go through a long process of breeding and selection.

Some traits that commercial breeders consider for selection goals, include:

- Low birth weight for ease of calving.
- Weaning weight or pre-weaning rate of gain.
- Post-weaning rate of gain.
- Efficiency of feed conversion.
- Mature mass.
- Mothering ability.
- Carcass traits.
- Conformation.

Communal and small herds

A relatively large number of cattle in KwaZulu-Natal are run as communal herds where the cattle in a herd are the property of two or more owners. Although these herds are not as yet production orientated but are kept largely for cultural reasons and as a method of banking, there is an emerging trend to sell surplus progeny from these herds.

Especially in the northern parts of KwaZulu-Natal, a large proportion of the communal cattle are indigenous Nguni cattle which are well adapted to local conditions. A trend to use exotic bulls is eroding this genepool and in many other parts of the province only vestiges of indigenous cattle remain. The major breeding problem in these areas is that herds are run as groups and the bull present serves all the cows. The owner of a cow is therefore often not able to choose the breed of bull he wants as a sire of the progeny in his herd.

In communal areas and on smaller farms and small-holdings there are individual owners who own a limited number of cattle. This is a group difficult to describe because of the diversity of practices found. Most of these small owners dream of owning large herds of cattle, and a limited number of them achieve this in time. The experience gained running small cattle numbers where the animals are seen and worked with almost daily assists in providing valuable experience.

Maximising profits from beef production

Maximising profits and maximising production are not always one and the same thing in beef farming. Profit is the difference between input and return. Thus, breeding larger bulls (higher growth rate) or selecting for higher weaning mass, could be necessary for some production systems. In other production systems, bigger animals with higher weaning weights could be a liability because larger animals eat more and mature later, which could narrow the margin between input and return.

Genetic merit will not make up for poor management or create a profit by the ability of superior breeding material to overcome deficiencies in feeding. Genetically superior animals only make it possible for a farmer to exploit good management maximally.

One- and two-factor inheritance, Population genetics

Mendelian genetics (one- and two-factor inheritance) is the basis of many concepts in breeding and must be fully grasped in order to understand population genetics and ultimately breeding and selection. Genetics is a study on its own and because many good handbooks on the subject are available, only aspects critical for beef breeding will be examined here. Although a study of genetics will provide the reader with a better understanding of the concepts touched on in this discussion, such a study is not essential to grasp the ideas put forward.

Most traits of economic significance, like growth rate and milk production, are multigenic in character *i.e.* are subject to the principles of population genetics. The importance of one- and two-factor inheritance is mainly related to traits such as coat colour, horned versus polled cattle and the inheritance of unwanted recessive traits like bulldog calves and dwarf calf syndrome, amongst others.

A trait is multigenic in character when:

- its inheritance cannot be predicted in a simple manner based on Mendelian principles
- it is quantitative in character.

With Mendelian genetics, once a carrier of a recessive lethal gene has been identified, the relevant animal can be used to diagnose the presence or absence of the relevant gene in a population. In practice, using marker bulls to detect the presence of specific genes in a cattle population is only used in the artificial insemination industry.

Selection in the beef herd
The most powerful tool available to the breeder to bring about changes in the genetic composition of a population, is selection. It is noteworthy that change is not always progress. Thus selection for high growth rates could produce beef animals exhibiting late carcass maturity. If steers are intended for feedlotting, this could be an advantage, whereas pasture-based production systems require early maturing types.

For effective selection to take place, it is necessary for the breeder to set goals. The characteristic the breeder intends to select for will influence what selection procedures must be followed. The set goals will determine the management practices which will be most cost and time effective.

In the setting of goals, the gene frequency of the gene directing the characteristic under consideration affects the effectiveness of the selection procedure (Formula 1 - if h^2 (heritability) of a trait is high, genetic change (G) is increased, and the converse is true). If the gene is not present in the population, no degree of selection will achieve an increase in gene frequency because $h^2 = 0$. On the other hand, when gene frequency is very high or the desired gene is a recessive gene, breeding progress will be slow. The response to selection is best where the desired gene is present at intermediate frequency levels.

Research has shown that genetic change (G) is described by the following formula:

$$G = h^2 \text{ X Selection differential} \qquad \qquad \text{(Formula 1)}$$

Through mathematical manipulation of Formula 1, it can be shown that:

$$G = \frac{\text{Accuracy x Intensity x Genetic variation}}{\text{Generation interval}} \qquad \text{(Formula 2)}$$

For the purposes of the following discussions, when examining Formula 2 one need not put actual values to the factors to the right of the equal sign, but it must be noted that increasing any factors above the division line, will increase G, whereas increasing factors below the division line, will decrease G. The converse of these statements is true.

Accuracy of selection
For the beef breeder, accuracy has two meanings *i.e.* accuracy in itself and accuracy as it is affected by how applicable a measurement is to the trait it is intended to evaluate.

Accurate measurement in itself is necessary for a number of reasons. Farm scales are built to be robust rather than accurate. The problem is compounded by the inaccuracies caused by gutfill. Weighing animals at the same time of day and at the same stage of the grazing cycle, will assist in reducing differences caused by gutfill. The removal of food and water overnight prior to weighing is a procedure often advised in research, but is not necessary under most practical farming conditions, unless cattle numbers are small in the groups to be compared.

Accuracy of selection is tied directly to the heritability of the trait. If heritability is high, selection will achieve the desired genetic change reasonably rapidly. If a trait is not directly measurable, selection must be based on:

- Making use of correlated traits.
- Measurements on relatives.

Thus carcass merit cannot be assessed with an acceptable degree of accuracy in the live animal and reliance must be placed on visual appraisal, which is subjective and subject to beliefs and ideas that are not always well supported by scientific evidence. Or selection for carcass merit can be based on the carcass characteristics of a sample of slaughtered progeny of the relevant bull.

Intensity of selection

The intensity of selection is measured by the magnitude of the selection differential (what percentage of a group of animals is included in the group retained). A high intensity of selection is when a small percentage of animals is selected or a high proportion culled.

With heifers, intensity of selection is dependant on the reproductive rate in the relevant herd, which places an upper limit to the number of replacements selected. When selecting bulls, intensity of selection can be much higher at similar reproductive rates because only one bull is required for a number of females. It is generally accepted that where conception rates fall below 70%, selection intensity in heifers is too low. Assuming 70% conception and a 50% male:female ratio, only 35 heifers are available for selection in a herd of 100 breeding cows. If the replacement rate in the herd is 20%, and infertility in heifers as well as mortalities are taken into account, at best, 20 heifers must be selected out of 25 to 30 heifers. This represents poor selection pressure, especially if overmating is practiced.

Genetic variation

The larger the gene pool selected from, the greater the probability of finding animals carrying the desired trait. The size of a gene pool is influenced by:

- The number of animals in a herd.
- The genetic variation in the population in which selection is taking place.

In large herds with relatively high genetic variation, genetic gain is greater than in relatively small herds. Gene pools can be enlarged by bringing in genetic material from other herds, for example buying in a bull. Highly inbred cattle have relatively little genetic variation so that even large herds do not exhibit adequate genetic variation to allow genetic change.

Generation interval

By definition, generation interval is the average age of parents when their offspring are born. In beef production where seasonal breeding is applied and the bulls are of average age, the mean age of the cows in a herd at a set date in the calving season, provides a good approximation of generation interval.

Allowing heifers to calve at two years of age will reduce generation interval by one year compared to calving heifers for the first time at three years of age. However, age at first calving has a lesser role as a determinant of generation interval. The major effect on generation interval is replacement rate in the breeding herd. Replacing 20% of the cows in a herd annually, will imply that cows remain in the herd for 5 years from date of first calving. Replacing 25% of cows annually will mean that cows remain in the herd for 4 years from date of first calving, thus reducing generation interval by one year. Where cows remain highly productive to a relatively old age, replacement rate can be reduced to 10% and although generation interval is then low, selection pressure on heifers is high.

Interactions between factors

It is noteworthy that increasing generation interval affects selection differential. As replacement rate increases, selection intensity decreases.

Progeny testing is a powerful tool for increasing accuracy of selection, but has an adverse effect on generation interval. A good example is found in the AI (artificial insemination) industry. The semen of bulls can be stored and records kept of the performance of its progeny. If the progeny performs well, the semen of this proven bull can be used again, often long after the bull has ceased to produce semen. It is then possible to predict the result of breeding accurately, but a generation or two could be lost in the process.

Selection methods

1. Individual selection is the selection of the individual based on its own performance. Selecting bulls on their corrected 205 day mass is an example.
2. Pedigree selection is when selection of the individual is based on the performance of its forebears. The relative importance of sires is illustrated in Figure 1.
3. Progeny selection is where the performance of progeny is used to determine the breeding merit of an individual.

Family selection is often discussed as a separate way of merit selection, but is in reality the same as pedigree selection in importance and its effects.

It has been said that: "Individuality tells us what an animal seems to be, his pedigree tells us what he ought to be, but the performance of his progeny tells us what he is".

Of all the selection procedures, individual selection has had the greatest impact on genetic gain for a number of years, merely because it is the most commonly used method of selection. The other selection procedures have had their main impact in the stud industry and with AI (artificial insemination). With the availability of computerized data processing (including BLUP: Best Linear Unbiased Predictor), pedigree and progeny selection can be expected to become increasingly important in beef breeding.

Selection for several traits

It is accepted by most breeding experts that selecting for an inordinately large number of traits at one time is bad practice. Not only does it impair genetic change, but implementation is difficult. Ideally not more than 6 traits should be selected for at a time.

When selecting for more than one trait at a time, there are three practices commonly used:

- Minimum culling levels, where a value is attached to all the traits selected for and a minimum index level set. Any individual falling short in one or more traits is culled.
- Tandem selection, in which one trait of an array of traits is selected for and once the trait is established within the herd to the breeder's satisfaction, the next trait receives attention. The process is maintained until all the traits in the array have been accounted for.
- Index selection, whereby all the chosen traits are measured concurrently and the relevant measurements included in a formula which is used to obtain a selection index (breeding value) for each individual on which selection is then based.

In most beef herds minimum culling levels are used. The main disadvantage is that where an individual is weak in one trait but strong in one or more other traits, the relevant individual and its strong points are culled. With tandem selection, the practical problem is that when selection for the second or higher level traits in the selection array are being

selected for, the traits selected for previously tend to sag. To overcome these difficulties, index selection was developed and, although genetic gain on any one trait is slow, overall gain is maximised using this selection procedure. Farmers are advised to make use of an expert to design their selection indices because correct design is important to ensure good results.

Selection and culling
With reference to genetics, the question a breeder must ask is:

Does a breeder select for a certain trait, or does he cull against a trait?

In the case of bull selection, there is no doubt that a breeder goes out and selects a bull he believes will impart the desired trait or traits to his herd. He is therefore selecting for a desired trait.

Because there is evidence that the emphasis in breeding has moved from bull selection to cow selection, the question arises whether this principle holds for the cow herd.

Say a farmer wants to improve weaning weights in his herd. If he is selecting for high weaning weights, then he could find that only the top 10% of cows are producing suitable progeny. On the other hand, if he follows the approach of selecting against cows producing poor weaners, he would only cull the bottom 10% to 20%

It is clear that he is selecting against poor performers and not selecting for good performers. The difference is very subtle, but has very important repercussions. Not only does an approach of "culling against" reduce the number of good cows lost to a herd, the approach also enlarges the size of the gene pool the farmer is working with.

From these considerations, it can be concluded that breeders will gain the most by deciding on a goal, selecting against animals lacking the desired trait and spending their valuable time on the most important aspect of beef breeding, namely management. The principle is:

Cull poor doers and leave selection of the best cow to the hobbyist.

Correlated traits
The use of correlated traits in selection is often the only way in which genetic gain can be achieved for characteristics which cannot be readily measured. An example is to use hip-height as an indicator of carcass maturity type. After all, once an animal is slaughtered, it cannot be used for breeding, unless semen is drawn previously.

There are hidden dangers in using correlated traits in selection. The most important is that a correlation only exists within the population in which it is measured. Once selection has taken place, we are no longer working with the same population and it is possible that the correlation no longer exists. In practice this difficulty does not often cause problems, but should be kept in mind because in cases where correlation between traits disappeared, genetic gain suffered severe setbacks when it was assumed that selection for the correlated trait continued to promote the desired trait. Breeders should therefore always continue to check that the correlation has not been lost before major decisions on breeding policy are taken.

Environment and selection
Jan Bonsma will be remembered for his many contributions to the breeding industry. One of his main contentions was that genotypes must be adapted to the environment within which they live. When deciding on a selection procedure, the effect of environment must be

considered and it is ideal for selection to take place within the environment where production will take place. Thus, should the intention be to increase daily mass gains for feedlot cattle, the best way to measure their genetic merit is to feed them to their full genetic potential in a feedlot.

Results of selection

The implementation of the correct selection procedures will result in genetic change *i.e.* the frequency of the desired gene within the breeder's herd will change. Once the breeding goal has been achieved, a process that could take a number of years, the breeder may decide to set new goals. The whole breeding process then starts all over again. The difficulty facing the breeder at this stage is to keep the level of the trait previously selected, at the desired frequency, while selecting for the new trait. With index selection, some traits could be deleted from the index formula and/or others added.

Breeders are often faced with the fact that if selection for a trait is continued for a long time, that trait reaches a level beyond which further improvement is limited and slow. Geneticists say a selection plateau has been reached. The breeder need not despair, because genetic variation continues to exist and variation is the joy (and the despair!) of the breeder.

New technology

Since the development of the PCR (polimerase chain reaction) procedure in 1986, it has become a very simple laboratory technique to isolate DNA from whole blood and use the associated information in breeding. Thus many genetic markers correlated to traits have already been identified and the search for more markers is in full swing. Using DNA technology, the genetic distance between genepools can be determined and parent identification is a useful breeding tool. At the time of writing, DNA procedures are still relatively expensive. However, it is hoped that as technology improves, costs will become more realistic, assuming that patent rights do not keep costs at a relatively high level. A very useful application of DNA fingerprinting is its use in theft cases, where meat found on the possession of a suspcet can be linked to skins or previously stored DNA samples.

Setting goals for beef cattle breeding

With reference to the differences of opinion and controversies surrounding the setting of beef breeding goals, a well-known breeder once said that differences are mostly about aims, less about methods and not at all about theory. A short list of traits for selection in beef breeding would include:

Fertility
Birth weight
Weaning weight
Yearling weight
Calf birth weight : cow weight
Calf weaning weight : cow weight at weaning
Mature live mass
Draught ability
Heat tolerance
Characteristics of fat deposition
Eye muscle area
Cold carcass mass
Weight of hind quarter : weight of front quarter
Muscling and Dressing %
Bone
Conformation

Structural soundness
Breed standards
Temperament
Disease tolerance
Tick tolerance
Mothering ability
Structural soundness
Growth rate