QI03063

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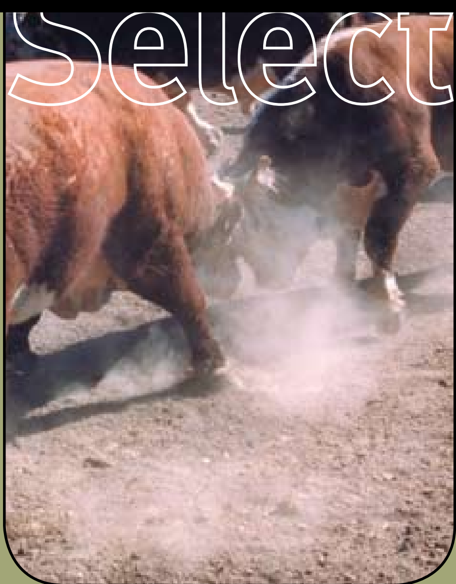

Buying Better Bulls

Queensland Government

QI03063

A product of QPIFs
'Commercial Application of Beef Genetic Technologies' project.

Bull Selection

An aid for beef
producers on

Buying Better Bulls

Compiled by John Bertram
and colleagues

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The former Beef Genetic Improvement Project, the BullPower program 'Bull Selection and use in Northern Australia', (supported by Meat and Livestock Australia) and the Cooperative Research Centre for Cattle and Beef Quality, have provided content for this publication.

This publication is designed to offer a guide to bull selection, utilising the results of years of investment in research and development. This publication provides those in the beef industry with a grounding in both the practical and technical aspects in successful bull selection and use.

On 26 March 2009, the Department of Primary Industries and Fisheries was amalgamated with other government departments to form the Department of Employment, Economic Development and Innovation.

Contents

Foreword

The annual purchase of replacement sires in a progressive beef breeding enterprise is a major investment. The real cost of bulls is not always fully appreciated and the subject has received little attention in the past. It is very important that the purchaser gets **value for money** when buying bulls and can be confident in paying more when there is reliable and useful information about a bull's performance available.

Producers in the past have made their selection of bulls using the best available information at the time. There is now more information available to the breeder which can estimate the true genetic worth of a bull and which has the potential to dramatically change the market acceptance of the bull's progeny.

Selection of bulls should be based on their being:

- reproductively sound so that they can produce an adequate quantity of good quality semen and also have the capacity and desire to serve females
- structually sound with a good temperament
- of superior genetic quality so that their progeny can reflect the desirable features that the cattle breeder requires for a particular market.

Relative emphasis placed on each of these aspects will vary according to the environment and district in which the bulls will be used.

Finally, it is important that **producers define clearly what market they are breeding for and determine the breeding objectives**, or aims, which best satisfy that market.

Any individual trait or criterion that a producer uses in selecting a bull for the market must:

- **be of economic importance (worth $ to the breeding program)**
- **be of reasonable heritability (passed from the sire to the progeny)**
- **be able to be measured (progress from what to what!)**
- **have variation in the trait to enable selection of superior animals.**

Bull Selection is a companion publication to Breeding for Profit, Beef cattle recording and selection, Female Selection and the Australian Association of Cattle Veterinarian's publication, Evaluating and Reporting Bull Fertility.

A bull's worth - cost per calf

Bull selection

Herd bull selection is a major cost for cattle breeders. Costs per calf are increased by lowered bull fertility, reduced cow fertility and by bull deaths. In pastoral areas which are extensive or which have numerous watering places, bull selection costs are exacerbated by the need for higher bull percentages. Bulls have a major influence on the future performance of the herd. A superior bull can increase performance and decrease risk; while a poor performance bull can adversely affect future production and increase your risk as a manager.

In an exhaustive study of bulls in extensive herds across northern Australia, the BullPower Project examined about 1000 bulls, mainly 2 to 4 year old, of Santa Gertrudis, 5/8 Brahman, Brahman, Belmont Red and Belmont Red cross. In addition, 212 bulls were mated in several multiple-sire mating groups (varying from 2 to 12 bulls) from intensive to extensive conditions. As a result of these matings, using bulls that were deemed to be satisfactory sires by experienced beef producers, 7% of bulls did not sire any calves, 58% of bulls sired 10% or less of the calves and 13% sired over 30% of the calves. The use of reproductively sound bulls at the rate of 2.5% bulls: cycling females will not jeopardise herd fertility under most conditions in extensive parts of northern Australia. These results indicate that the process of bull selection requires much thought and consideration of relevant objective information.

Issues of concern when deciding what and how to buy are:

- **What numbers to use?** This may vary according to average bull age, the fertility of bulls as well as the number and diversity of watering points, etc. Lower percentages may be acceptable if subfertile or infertile bulls are not present in the herd. Traditionally, bull percentages of between 3 and 5% have been used in Queensland.
- **How much to pay for replacement bulls?** Is the extra cost recovered from the extra value of subsequent sales? Does paying more get you a better bull anyway? How much emphasis should be placed on objective information?
- **How long to keep them, or how many to replace each year?**
- **Whether to breed some, most or all of your own bulls?**

Let us look at what it costs to provide the bullpower to put a calf on the ground, then for it to grow and match the market requirements of age (dentition), weight, fat and other carcase traits.

Bull costs per calf branded

Bull cost per calf is easily calculated. Bull cost per calf depends on:

- bull purchase price or cost of breeding your own bulls
- bull salvage value at the end of its working life
- how many years he stays in the herd
- bull losses from deaths, strayings and continual mustering failures (This can be similar to insurance costs)
- the number of cows per bull
- branding percentage achieved.

By looking to improve structural soundness and reproductive performance of bulls, it is possible to make significant changes in some of these areas and so change the bull cost per calf.

Table 1 considers three situations which have a direct impact on bull cost per calf.

Table 1. Bull costs per calf as related to initial cost, management and performance.

	Situation 1	Situation 2	Situation 3
Purchase price of bull	$2000	$2000	**$3980**
Bull incurance cost	3% (60)	3% (60)	3% (120)
Transport cost	$ 100	$ 100	$ 100
Cost of bull landed on property	$2100	$2100	$4080
Effective cost of bull	$2160	$2160	$4200
No. of years bull is used	3	**5**	**5**
No. of cows mated to bull per year	25 (4%)	**33** (3%)	**33** (3%)
Branding %	75	**85**	**85**
No. of calves produced by bull during its lifetime	56	**140**	**140**
Salvage value of bull	$ 800	$ 800	$ 800
Effective cost of bull less salvage value	$2160-800	$2160-800	$4200-800
Net cost of bull	$1360	$1360	$3400
Number of calves in lifetime	56	140	140
Bull cost per calf	**$24.29**	**$9.71**	**$24.29**

By using vaccinations and better bull management, improving structural soundness so that bulls last in the herd for 5 years rather than 3 years, improving bull reproductive performance so that bulls can be mated at 3% rather than 4% and with a branding rate of 85% rather than 75%, it is possible to reduce bull costs per calf from $24.29 to $9.71

Alternatively with these same management improvements, the price paid for a bull could be increased from $2000 to $3980 (almost double) with virtually no change in bull costs per calf.

Producers can use the above example to substitute their own figures to determine their own bull costs per calf and how these can be changed through improved structural soundness, improved reproductive performance in their bulls and better bull management.

What are the benefits from buying better bulls?

By purchasing better bulls we hope to achieve these things:

- produce more calves per bull
- produce progeny that grow faster
- produce progeny that have desirable carcase traits
- produce future breeders which will produce more valuable offspring
- produce animals that repeatedly meet market specifications.

Better bulls have a number of impacts on a herd:

- for the years that they are in the herd, these bulls will sire superior male and female progeny
- improvements using genetics are permanent and will continue to accumulate as high performing sires are selected.

All these advantages auger well to minimise beef producers’ risk and increase the enterprise profitability.

The basis of genetic selection

Genetic selection is an old tool which is gaining increasing importance. Beef producers can influence two areas which have major long term impacts on profits and sustainability – genetics and management. Development of new plant varieties and the manipulation of plant characteristics will influence production but will take place mostly off-farm. Animal genetic improvement however will mostly take place on-farm. It will be managed by the producer and will be long term in its effects.

How are traits transferred?

Beef cattle, like all other animals, have many characteristics that make up the whole animal. Each individual characteristic is controlled by a string of protein molecules joined together in a distinctive pattern referred to as a gene. Many genes are linked together to form a chromosome. In the animal's body cells, the chromosomes are found in pairs within the nucleus of each cell as shown in figure 1.

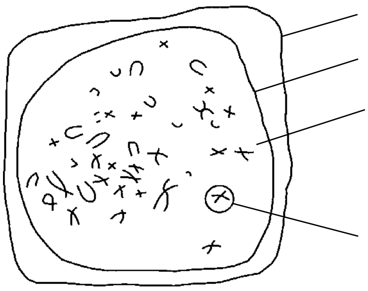


Figure 1. A representative of protein molecules forming genes within a cell in all body tissue.

The appearance and performance of an animal e.g. how fast it grows or what is looks like, is determined by the pattern of proteins (genes). It's all in the genes – referred to as the animal's genetic make-up or genotype.

Each species has a different number of chromosomes. Cattle have 30 pairs of chromosomes while humans have only 23 pairs.

Formation of the ova and sperm cells

When the sperm cells are being produced in the testes and the ova cells in the ovaries, they contain only half of each pair of chromosomes. To accomplish this the chromosome pairs split down the middle and only half the genetic complement is placed in the new cells. The sperm or ova therefore have only one half the chromosome makeup normally found in the body cells. This division is called Meiosis.

Depending of which chromosome each cell receives, there will be differences in the genetic potential of the cell. For example, in the case of the sperm, this gives rise to the 50:50 male: female sex ratio in the offspring – half the sperm cells carry the male chromosome and half the female.

Since the only direct connections between the parents and the next generation are the chromosomes which are contributed from the sperm and the ova during fertilisation, all the characteristics which an animal inherits are therefore represented in the sperm and ova.
At the moment of fertilization when the sperm and ovum unite, they form a complete cell containing 30 pairs of chromosomes. This cell then commences to divide normally, (2, 4, 8, 16, 32, 64 cells, etc.) producing the full complement of chromosome pairs in each cell of the new individual. This division process is called Mitosis. By this method each new generation receives exactly half its chromosomes from the sire and half from the dam.

How do genes determine the animal's characteristics?

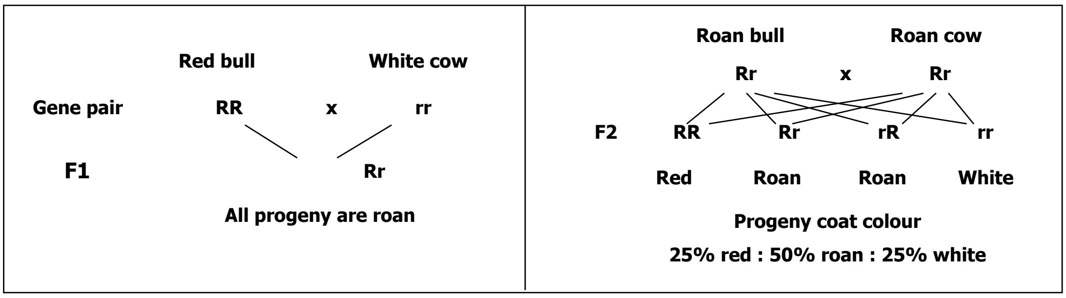
Some characteristics are controlled by single pairs of genes whilst others are controlled by many pairs of genes.

Single gene action

Characteristics controlled by a single pair of genes include coat colour in Shorthorn cattle, and polledness. With single gene characteristics; animals can be divided into discrete classes and are easy to identify and quantify, as can be seen in figure 2, where we have represented the gene types for coat colour as either big R for red or little r which represents white.

From this single pair of genes we have the possibility of three colours. Red, which is represented by two RR genes; white, which is represented by rr genes; and roan, which is a mixture of Rr. If one gene is dominant, then the characteristic will always be expressed when the dominant gene is present, irrespective of the other gene. If red were dominant, then there would not be a roan colour – there would only be two colour types from the single pair of genes – not three. An example of dominance is in polledness, where PP and Pp are polled and pp (the recessive gene) is horned. Horned cattle therefore breed true to type, whereas polled cattle can breed the occasional horned offspring if each parent is carrying one recessive horn gene.

Figure 2. Single gene action



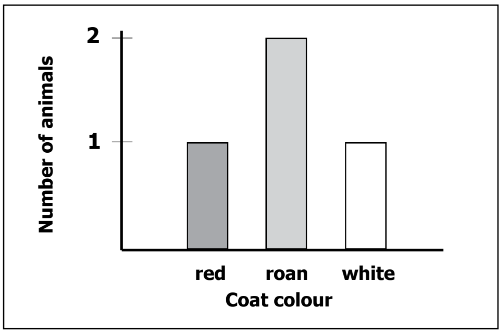


Figure 3. Population distribution from the second generation (F2) of a single pair of genes.

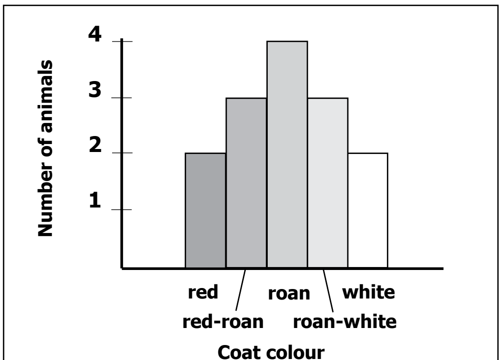


Figure 4. Population distribution for a two pair gene interaction.

Population distribution

Various characteristics of a group of animals can be represented in a population distribution graph. The population distribution from a single gene pair (without either gene being dominant) can be seen in figure 3.

The animal types red, roan or white represent all the possible gene combinations and therefore the types.

Multiple gene pair interactions

As the number of gene pairs in the interaction increases, so the number of types, e.g. with two pairs of genes there would be five coat colours. The population distribution for a characteristic which is controlled by two gene pairs can be seen in figure 4.

With five coat colour types, the colours red and white are still the minority of the group with true roans the largest of the population groups. There are now two more groups of intermediate numbers on each side of the roan colours and of intermediate population number.

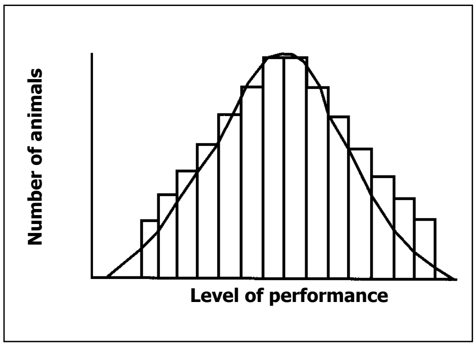


Figure 5. Production distribution from a large number of gene pairs.

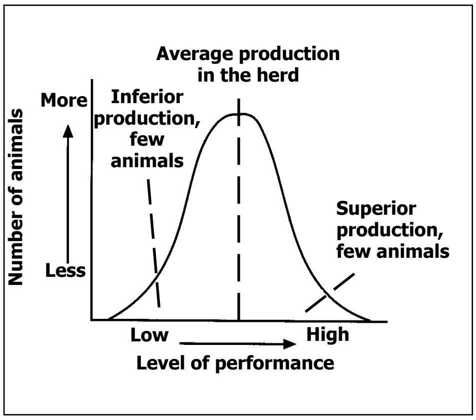


Figure 6. Normal distribution curve for multiple gene interactions.

As the number of gene pairs increases then the number of types increases by a factor of twice the number of gene pairs plus one (i.e. 2n+1). It becomes increasingly difficult to classify animals into discrete types. With 12 gene pair interactions for coat colour for example, there would be 25 coat colour types.

Environmental effect

In the case of production characteristics, the environment (as experienced by individual animals) will interact with the character differences and cause overlapping of adjacent genetic classes. The combination of a large number of gene pairs and the effect of the environment will cause a merging of genetic types and the population begins to be represented as a 'continuous' distribution rather than a series of identifiable types. It becomes necessary to find some criterion in order to measure the characteristic. A continuous distribution of a characteristic can be seen in figure 5.

This normal distribution pattern is very well established where characteristics are controlled by many pairs of genes. It is referred to as the 'normal distribution curve' or 'bell curve'. Virtually all the economically important characteristics for beef production are controlled by large numbers of gene pairs and are therefore expressed as normally distributed curves. The normal distribution curve is defined in figure 6.

Features of the distribution curve

- **the mean or average** production of the population.

The average growth rate for a group of cattle on reasonable pasture, for example, may be 0.5 kg liveweight gain/day. The mean or average production will occur at the peak of the population distribution curve. A large portion of the cattle will produce between 0.45 and 0.55 kg/day.

- **the variation** within the population or the total spread of the production.

Considering this same group of cattle, the most productive animal may have a growth rate of 0.9 kg liveweight gain/day and the worst may have a growth rate of 0.1 kg/day. The animals that produce at these extremes will be very small in number.

- **the standard deviation** or distribution of cattle in the group, herd or breed.

The distribution of individuals within a population is so reliable that it can be statistically defined. Statistics defines that 66% of animals in a group selected for any multi-gene controlled characteristic will produce within one standard deviation of the average.

The population distribution of animals within a group or within a breed, will follow the distribution curve similar to the one shown above.

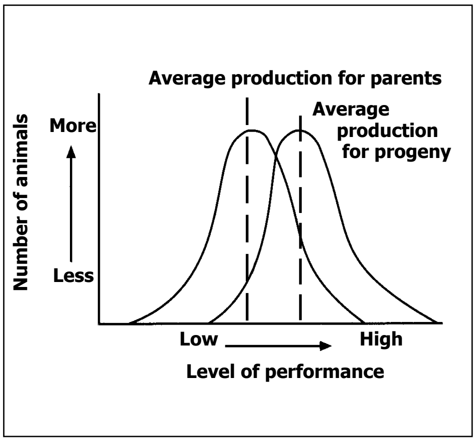


Figure 7. The production distribution curves for parents and progeny.

What happens in the next generation?

When faster growing sires and dams are mated, the progeny will, on average, produce better than the original population. The production distribution will be similar to the original population, but the distribution curve will be based around a higher mean or average. A comparison of the two generations can be seen in figure 7.

Production increase from one generation to the next will be determined by the extent of selection or 'selection intensity' PLUS the rearing and management/environmental differences. If there is no accurate and effective selection in the cows and bulls, then it is unlikely that the average production of the next generation will be superior to that of their parents.

The greater the selection intensity (right hand end of the curve), the fewer the number of animals selected and the better their performance. When mating these superior sires, the mean performance of the progeny will be greater than that of the present mean but probably not greater than that of the sires.

The consequences of this are that:

- all bulls from top sires will not carry genes for higher than average production – even if they are out of top females.
- only slightly more than half of the bulls and females in the next generation will inherit production genes better than the average of their parents.
- using top sires over high performance females, only a very small proportion of the progeny (bull and females) will be better than their parents.
- if the bulls are good, the average production of the progeny will be higher than the original herd, but about 45% will be lower than average.

Principles for genetic improvement

In order to increase production in successive generations, you must take advantage of the normal biological function of variability and use the following steps:

- measure as accurately as possible the production characteristics (traits) you want to improve in the parent herd
- select the best animals with the traits of highest economic importance and use them to breed the next generation
- select for traits of reasonable heritability
- cull the poorest performers
- select animals using the fewest number of 'selection criteria' as possible for the most rapid gains.

These steps must be carried out with each successive generation in order to obtain continual production and profit improvement from genetic means.

Beef genetic improvement

Genetic improvement in beef cattle is the improvement in productivity of a herd through the selection of superior parents for mating to produce replacements.

Genetic improvement is only one aspect of total herd improvement, but it is a very important component, because genetic improvement is both PERMANENT and CUMULATIVE.

The gains that are made in a herd through genetics remain in the herd from year to year and each year's improvement builds on improvements already achieved in previous years. More rapid progress is made in genetic selection when fewer traits are used for selection. If we select for many desirable traits in each animal, the number of animals available for selection in each trait decreases and more of these animals will be closer to the average performance of the population. Make use of traits that are positively related to another trait – in this way, as we select to improve performance in one, we will automatically improve performance in the other, without diminishing response.

Performance measurement is necessary to maximise genetic gain in the beef industry. It will not replace visual assessment for traits such as structural soundness, but is an important adjunct to those assessments.

What traits should be included?

There are four criteria that should be applied to traits being considered for inclusion in any genetic improvement program.

To be successfully included in a program, a trait should:

- be of economic importance
- be of reasonable heritability
- be able to be measured and
- have variation in performance within the trait.

Economic importance

Even though the measurement procedures that are now available for genetic improvement in beef cattle are relatively simple and can be put into practice at a fairly low cost, it is still essential that traits being selected for are of economic importance.

There is no point in putting effort into improving a trait if the improvement will not result in increased economic returns for the producer.

In addition, in most instances, breeders will be attempting to achieve improvement in more than one trait at a time. Each additional trait included in a program means less improvement in each individual trait.

Economic importance can mean different things to different producers. For the commercial beef producer, probably the most important traits from an economic viewpoint will be fertility, growth rate and carcase quality. For the producer of breeding stock for sale, there may be other traits which will improve the returns to be made from the sale of breeding animals.

Heritability

Heritability can be defined as the degree to which an animal will transmit to its offspring the performance it displays in any trait. Hence, how much of the measured variation between animals is due to genetic differences between the animals and how much is due to non-genetic factors such as nutrition, management, disease control measures and all the other environmental factors which affect how the animal performs?

The proportion of the total variation between animals that can be attributed to genetics is what we term heritability. The higher the percentage, the greater the chance that traits will be passed on to the progeny.

Most of the growth traits in beef cattle have heritabilities of between 30 and 50 percent. This means that of the measured differences in growth rate between animals in a group, between 30 and 50 percent are due to genetic factors and 50 to 70 percent are due to non-genetic or environment factors.

Carcase traits generally have heritabilities of between 10 and 50 percent. The heritability of scrotal circumference/size is of the order of 40 percent, while for serving capacity it appears to be between 15 to 60 percent. Female fertility traits tend to have slightly lower heritabilities of the order of 10 to 20 percent. This means that less of the measured differences between animals in fertility traits are due to genetic differences between the animals and so the rate of improvement in a genetic improvement program will be slower for these traits than for the growth and carcase traits.

Heritability estimates for some of the important traits of beef cattle are shown in table 2.

Measurable

Even if a trait is of economic importance and of reasonable heritability, it is of little use in a genetic improvement program if it cannot be measured. Actual objective measurement of beef cattle performance traits enables the producer to compare the traits and further allows the calculation of estimates of genetic worth irrespective of season, bias, year or environmental effects. For this reason, most of the early work to do with genetic improvement programs was with growth rate.

Growth rate is fairly highly heritable and is very easily measured. In the early days of the National Beef Recording Scheme, evaluation was based on weight ratios which compared individual animals on their growth rates or weights at particular ages. When BREEDPLAN was established, the first Estimated Breeding Values (EBVs) were for growth traits.

The next trait to be included in BREEDPLAN was fertility. Emphasis initially was on the two relatively easily measured fertility traits; scrotal circumference/size in bulls (which is related to female fertility) and days to calving in cows. Serving capacity in bulls is gaining attention as a measurable trait and part of fertility traits. In addition, EBVs are now available for calving ease, gestation length and mature cow weight.

Carcase traits are now measurable and therefore are included in the BREEDPLAN analysis. The traits evaluated are 400-day Eye Muscle Area (EMA) and fat (P8 rump and 12/13th ribs) and Intra-muscular Fat % (IMF %).

Variation within the trait

As discussed in the previous chapter, genetic improvement is dependent upon genetic variation within a trait. This variation allows selection of superior animals both as sires and again in the selection of replacement females.

What are the advantages of BREEDPLAN?

There would probably be little argument that objective (measured) evaluations of traits such as fertility, growth rate and carcase quality are more accurate than visual assessment. Whilst progress in genetic improvement has been slow, this is not to say that visual assessment has not served the industry well in the past. It is simply that as more accurate methods of evaluation become available, they should be used to assist in more accurate selection of genetically superior animals. Further, as market demands become more exact, both on the domestic and export scenes, **it is essential that breeding animals be selected that can meet the market specifications**.

The first 'objective' selection methods involved weighing a group of cattle and comparing growth rates of the animals which were all born around the same time and that had been managed as one group. This uniformity of age and management within a group of animals removed many of the management and environmental differences, so that most of the measured differences could then be attributed to genetic differences.

Table 2. Heritability estimates for some traits in beef cattle (bulls)

Trait	Heritability description	Heritability % (BREEDPLAN)*	
		Temperate (AA)	Tropical (BB)
Reproduction			
Conception	low	0 - 5	5 - 20
Days-to-calving	low	0 - 10 (7)	0 - 10 (9)
Calving ease (heifers)	low - medium	15 - 50	na
Semen quality	low - medium	25 - 40	6 - 44
Scrotal size (18 months)	medium - high	20 - 50 (39)	28 - 36 (39)
Serving capacity (18 months)	low - high	15 - 60	na
Mounts and serves	low - medium	na	3 - 62
Maternal ability	medium	20 - 40	na
Gestation length	medium	15 - 25 (20)	(20)
Growth and conformation			
Birth weight	medium	35 - 45 (38)	35 - 45 (45)
200-day weight	medium	20 - 30 (18)	16 - 40 (28)
400-day weight	medium	(25)	(37)
600-day weight	medium	(31)	(42)
Mature cow weight	high	50 - 70 (40)	25 - 40 (39)
Milk yield	medium	20 - 25 (9)	(3)
Hip height (400 days)	medium - high	59 - 66	na
Front feet claw set	low - medium	29	na
Rear legs - side view	low - medium	18	na
Rear feet angle	low - medium	32	na
Dry season gain	medium	na	17 - 30
Wet season gain	low	na	18
Weight gain - birth to weaning	medium	25 - 30	30 - 40
Condition score	medium	44	na
Carcase			
Rib fat (12/13th rib)	medium	(22)	(22)
P8 rump fat	medium-high	29 (27)	18 (27)
Intramuscular fat (IMF%)	medium-high	15 (12)	30 (12)
Eye muscle area (EMA)	medium	20 - 25 (26)	(26)
Dressing percent	medium - high	15	37
Tenderness	high	4-25	16-30
Retail beef yield (RBY%)	high	29 (36)	36 (36)
Carcase weight/day of age	medium	25 - 45 (41)	(29)
Muscle score (400 days)	medium - high	38 - 47	47
Other traits			
Cancer eye susceptibility	medium	20 - 40	na
Eye pigmentation	high	45 - 60 (45)	na
Temperament score	medium - high	25 - 50 (27)	25 - 50
Tick resistance	medium	na	20 - 42
Worm resistance	medium	na	25 - 36
Buffalo fly resistance	medium	na	20 - 30
Pelvic - height (400 days)	medium - high	34	na
- width (400 days)	medium - high	41	na
- area (400 days)	medium - high	42	na

* - BREEDPLAN heritability values for AA (Angus) and BB (Brahman). na - not available

Sources: Hammond, K. et. al. (1981) 'Selecting Beef Cattle for Maximum Production in the 80s, AGBU, UNE.

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Industry validation of current and new traits for BREEDPLAN, MLA project UNE.030, AGBU 1996. (Southern cattle results only)

BREEDPLAN opens new opportunities - it uses information from relatives compares across groups and years, locations and management treatments.

By having the progeny of the same animals compared in different years, herds or management groups, comparisons can be made of their relative genetic potential in those different years, herds or management groups. This widens the group of animals that can be compared for genetic potential and so allows more 'intense' selection i.e. a better chance of picking out the highest performing animals.

By analysing the performance information of relatives, more accurate assessments of true genetic potential can be made. For example, an assessment of an animal that is based on the performance of 10 of its progeny for growth rate, is 50 percent more accurate than an assessment based on the animal alone. This increases the ability to pick out high performance animals based on this more accurate assessment rather than just on the individuals' performance alone.

Similarly, an assessment based on the individual's performance, plus that of 10 paternal half-sibs and 10 progeny, is twice as accurate as that based on the individual's own performance, with a corresponding increase in the ability to select out high performers. BREEDPLAN, then, offers a method of achieving considerably more accurate selection and greater increase in performance.

The commercial producer stands to gain much from BREEDPLAN. It will enable the bull buyer to have confidence about the price paid for a bull as a reflection of the genetic worth of the bull. Beef producers can now take home a draft of bulls with some assurance that they have had the opportunity to select and purchase the best bulls from those available, according to their genetic potential.

BREEDPLAN is based on an integrated pedigree system within breeds that compares all animals with pedigree linkages.

The EBVs of bulls from different herds cannot be compared unless the herds are in GROUP BREEDPLAN. Many breed societies are now producing GROUP BREEDPLAN reports. The first for a tropical (Brahman) breed was published in 1991.

There are now six tropical breeds with GROUP BREEDPLAN analysis. They are the Brahman, Belmont Red, Santa Gertrudis, Droughtmaster, Brangus and Braford breeds. The British breeds with GROUP BREEDPLAN are the Poll Hereford/Hereford, Angus, Murray Grey, Shorthorn, Devon, Red Angus and South Devon, while the European breeds are the Simmental, Charolais, Gelbvieh, Salers, Blond D'Aquitaine and Limousin.

GROUP BREEDPLAN adds significantly to the ability to identify genetically superior animals provided by BREEDPLAN. Again the real winners are the bull buyers who will have the opportunity to select from the best a breed has to offer.

A concern raised by a number of breeders is that, using GROUP BREEDPLAN to choose bulls from within the whole breed could lead to the selection of bulls from one environment that will not perform in a different environment. For example, it is felt that bulls selected in southern Australia may not produce progeny that will perform well in Queensland, or that progeny of bulls selected in central Queensland may not perform will in northern Queensland.

The CRC (Cattle and Beef Quality) results have clearly demonstrated that the performance ranking of bulls' progeny produced on pastures in the tropics remain the same as for those grazed on pastures in the south, in feedlots in the north and in feedlots in the south. We know that bulls imported into Australia from overseas, either directly or as semen, perform in virtually the same ranking order that they did in their country of origin.

There is mounting evidence of the beneficial impact BREEDPLAN is having on the production traits. The power of this selection aid will continue to increase as more data on the national herd are analysed and more breeds adopt this integrated pedigree genetic analysis.

Selecting for fertility

There is no single measurement that can give a guaranteed and reliable measure of the fertility of a bull. Similar to the measure of female fertility, the reproductive ability of a bull can only be measured after sexual maturity has been reached and involves multiple assessment through examination. A complete reproductive examination of the bull is best done by an experienced veterinarian. However, property managers should be able to recognise many of the traits that are normal, those that are abnormal and subfertile.

There are a number of traits that are used to assess bull fertility. These include:

- examination of the testicles (palpation of scrotal contents and measurement of scrotal circumference/size)
- examination of the penis, prepuce and sheath
- collection and evaluation of semen
- palpation of internal sex organs
- assessing the bull's desire (libido) and ability to serve females (serving ability)
- structural soundness of the bull's legs, feet, eyes and general structure.

We would encourage all producers to request a Bull Breeding Soundness Evaluation prior to purchase of every bull. This will include palpation of testicles, penis and prepuce, semen examination and preferably a serving capacity assessment performed, prior to the bulls inclusion in a mating team.

There are minor differences between Bos taurus i.e. British and European breeds and Bos indicus breeds i.e. Brahman and Sahiwal and the Bos taurus crossed with Bos indicus i.e. Droughtmaster and Santa Gertrudis type breeds.

Scrotal conformation

Anatomical appearance of the scrotum and its contents can vary widely (figs. 8 and 9). In general, the scrotum and its contents in Bos indicus bulls is longer and narrower (fig. 8a) than in Bos taurus bull (fig. 8b). Lateral rotation of the testicular axis occurs in some Bos indicus bulls (fig. 8c, rotated testes) which, whilst probably not functionally important, usually causes unfavourable comment from bull buyers. To date there is no evidence relating testicular shape with udder conformation in the female progeny. Incomplete separation of the scrotal septum (fig. 8d) is also occasionally seen and is a blemish of little consequence rather than of functional importance.

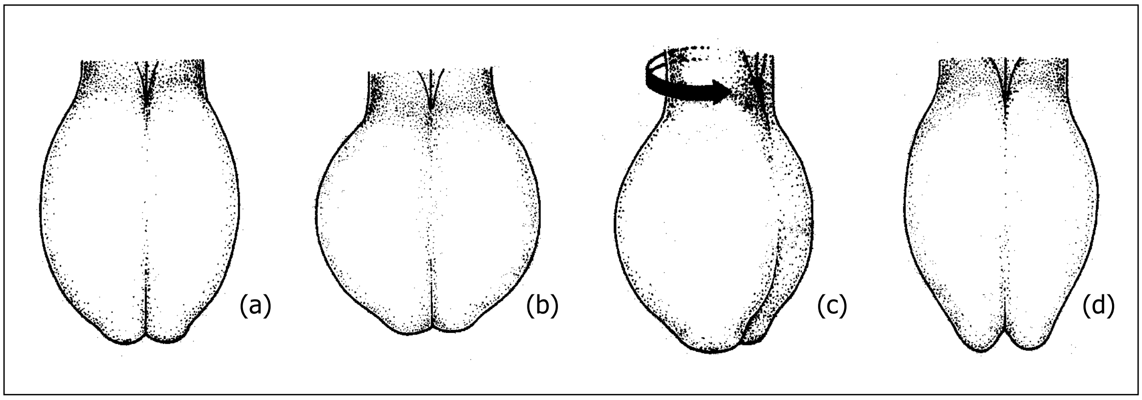

Figure 8. Scrotal conformation: (a) normal (elongated), (b) normal (round), (c) rotated, and (d) Y-balls/cleavage.

Several other common scrotal abnormalities are shown in figure 9. Bulls with testes held close to the body (fig. 9a) should receive further checks on fertility. Smaller testes are frequently associated with poor quality semen and lowered fertility, which probably reflects an impaired testicular temperature regulating capacity. However there is a need to recognise that a short scrotum is common on cold days and that some nervous bulls pull up the scrotum as a protective mechanism.

Another scrotal abnormality is 'tied scrotum' where the testes are held more horizontally to the body. These bulls are usually functionally sound but should be checked by a veterinarian.

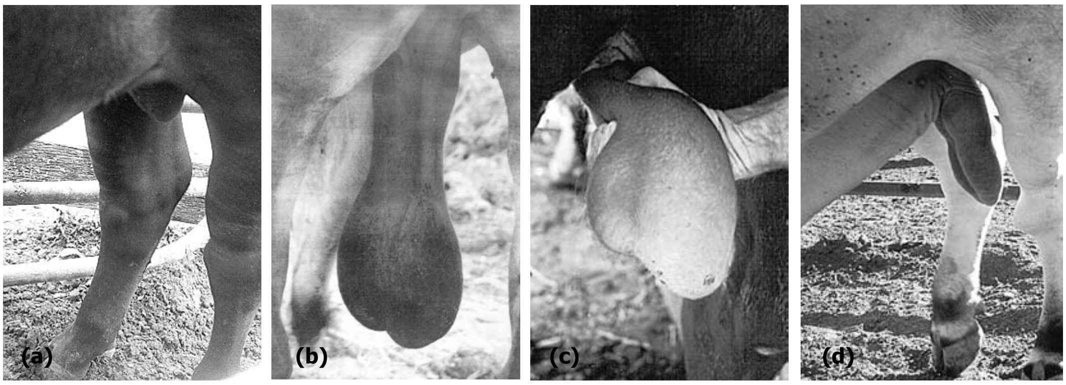

Figure 9. Scrotal conformation: (a) cold bath scrotum, (b) long scrotal neck, (c) unilateral hypoplasia, (d) scrotal hernia.

Bulls with an extremely long scrotal neck, where the testicles are down at about hock level (fig. 9b), tend to have more problems with injuries to the testicles and should be avoided. Short, tied and excessively long scrotums are probably heritable defects.

One small testicle (unilateral hypoplasia, fig. 9c) and two small testicles (bilateral hypoplasia) are the two common abnormalities found in young Bos indicus bulls. The syndrome is heritable and associated with reduced sperm production capacity and hence reduced fertility. Scrotal hernias (fig. 9d) are not common but relatively easily diagnosed. Partial or complete cryptorchids (rigs) are occasionally found on examination. The latter conditions are heritable and such bulls should not be mated.

Palpation of the scrotum and contents

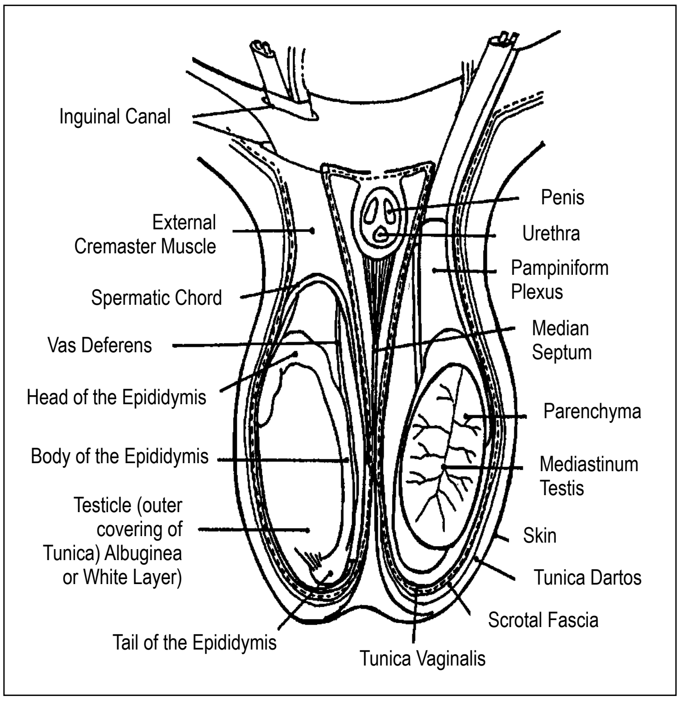

Figure 10. Cross section of the testicles and accessory sex glands.

The scrotum should not only be observed but also palpated by standing behind the restrained bull with some form of safety gate. If bulls are caught but not squeezed hard by a head bail, most will stand and will not object to their scrotum being palpated. Figure 10 shows the relative position of the testicles; head, body and tail of the epididymis; penis and the skin of the scrotum.

The procedure is:

1. Palpate the neck of the scrotum. It should be much narrower than the testicles. Fat deposits in the neck of the

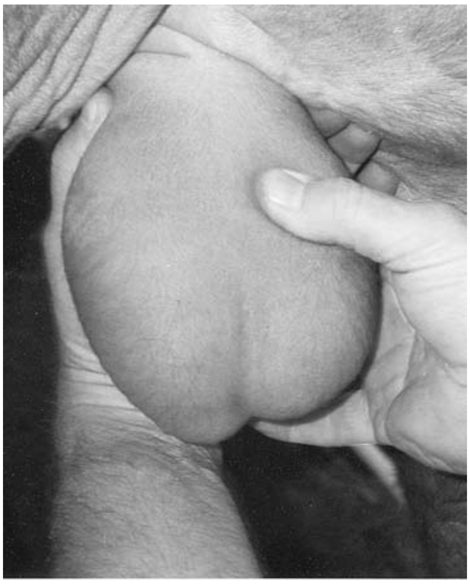

Figure 11. Palpation of body of testicles.

scrotum indicate over fat bulls. Be aware of an inguinal hernia in the neck of the scrotum and enlargement of the mass of veins (Pampiniform plexus) also in the neck of the scrotum.

2. The testicles should move freely within the scrotum. Using thumb and forefinger of both hands, palpate each testicle for tone and consistency (fig. 11). Testicular tone indicates degree of filling of the seminiferous tubes. Good tone is one where there is firm resistance to pressure and each testicle should spring back to its original shape. The contrast is flabby or rock hard testicles. Bulls with abnormally soft or hard tone should be examined further for semen quality, either by manual palpation or by electroejaculation. (Soft portions often produce abnormal sperm cells, firm portions may indicate blockages). Normal tone in testicles is similar to the thick muscle at the base of our thumb when the hand is closed. Soft testicles or part thereof are similar to that muscle when our hand is open and relaxed.

   Some conditions such as ephemeral fever and lantana poisoning can temporarily cause abnormal testicular tone and genetically valuable bulls should not be culled if this occurs. **Healthy bulls with good testicular tone generally have good quality semen**.
3. Palpate the head, body and tail of the epididymis.
4. Skin lesions may indicate trauma or inflammation.

Measuring scrotal size

Scrotal circumference/size is measured using a tape at the site of the widest part while holding the testicles in the hand. Avoid pulling the scrotum down and distorting the shape (fig. 12).

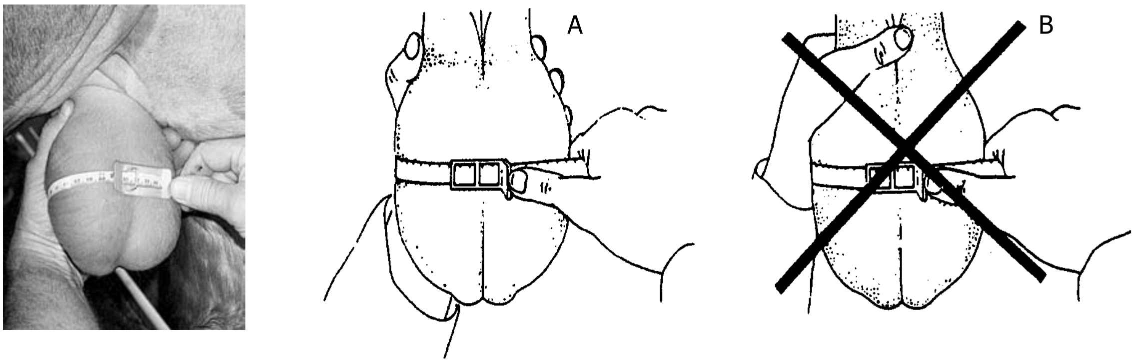

Figure 12. Correct technique for firmly holding neck of scrotum to measure scrotal size.

Correct method for measurement of scrotal size

The testes are pulled firmly into the lower part of the scrotum by encircling its base with the hand and pulling down on the testes (A). The scrotal tape is formed into a loop and slipped over the scrotum and pulled up snugly around the greatest diameter of the scrotal contents. The thumbs and fingers should be located on the side of the scrotum rather than between the testes (B) to prevent separation of the testes and inaccurate measurement. The scrotal tape should make a slight indent in the skin of the scrotum to ensure a consistent firm pressure by the tape.

(From Ott, RS: Breeding soundness examination of bulls. In Morrow, DA ed: Current Therapy in Theriogenotogy 2. Philadelphia. WB Sanders, 1986. p 131.)

There are a number of vital points to remember when considering scrotal measurements:

- Scrotal size is one of the important traits related to calf-output of the bull.
- **Scrotal size is closely related to daily sperm production**. Small scrotal size indicates less sperm production.
- **It is best to define minimum acceptable standards for scrotal size in different ages of bulls**. For example, 32 cm is the minimum in 2 year old British breed bulls; 30 cm is the minimum in 2 year old Brahman type bull in **paddock condition**. There appear to be genetic correlations between the bull's scrotal size and the age of puberty in their female progeny. One caution is that scrotal size has been reported to vary up to 4 cm depending on body condition. Young bulls go through a testicular growth spurt from about 8-10 months of age up to 18-24 month of age during which they should be on a rising plane of nutrition.
- **To make faster progress in scrotal size and subsequently age of puberty in female progeny, a bull must be selected using scrotal size EBVs** which take into account relatives and environment influences. The greater the EBV for scrotal size in the sire, the earlier the female progeny will reach puberty. The actual scrotal measurement is influenced by a host of variables which can alter scrotal size and are not a true reflection of the genetic potential of the bull.
- **Scrotal size is moderately heritable**. It is correlated with liveweight, i.e. at the same age, heavier bulls tend to have larger scrotal size.
- **Young Bos indicus bulls have smaller scrotal size than Bos taurus bulls at 2 years of age** because of their later age at maturity.
- **As a general rule when palpating the scrotum, the left testicle should equal the right in size, shape and tone**.

As a guide to changes in scrotal size relative to age, the following tables (3 and 4) show scrotal size for bulls moderately to well fed which often equates to bulls being presented for sale in Queensland. These are meant purely as potential indicators of what has been reported.

Table 3. Minimal scrotal size for moderate to well fed *Bos taurus* bulls.

Age (months)	Minimal scrotal size (cm)
12 - 14	28
14 - 16	30
16 - 18	31
18 - 20	32
20 - 24	33
24 +	34

The average scrotal size for mature Bos taurus bull is 35 to 37 cm.

Table 4. Minimal scrotal size for Bos indicus (Brahman) bulls in Texas USA and north Queensland

Age (months)	Minimal scrotal size (cm)	
	feedlot conditions Texas	grazing spear grass Queensland
12		18
14	22	20
14 - 17	27	23
17 - 20	29	24
20 - 23	31	25
23 - 26	32	28
26 - 30	34	30
30 - 36	35	32
36+	37	34

Source: Dr D Morris, Texas A & M and S Wildens et.al., Swan's Lagoon, Queensland.

The BullPower study found that scrotal size in 2-yr-old Brahman, Santa Gertrudis and Belmont Red bulls averaged 33.7, 36.4 and 34.5 cm respectively when all bulls were in paddock grazing conditions.

Examination of the sheath, penis, prepuce and navel

The sheath (fig. 13) is made up of the navel area to the front, the residue of the umbilical cord lying vertically in the middle and the penis with the pink mucous membrane and associated muscles to the rear. The place where the umbilical chord entered the skin is the 'rosette' which in some animals in Bos indicus breeds can be an inverted fold of skin. The prepuce surrounds the penis and attaches to the shaft of the penis internally and externally at the lower hair-line of the sheath. The penis is retained within the sheath by the retractor muscles located above the neck of the scrotum and in association with the sigmoid flexure to the rear of the pelvis. The overall shape of the sheath and navel has been described with 'sheath scores' that range from 2 = very pendulous sheath, 6 = acceptable sheath hanging at a 45 degree angle and 9 = very tightly attached sheath to the abdominal wall.

The sheath and its components are an essential part of the delivery of the bull's genetics to the point of fertilisation in the female. Abnormality and malfunction of any of these can result in the bull being either subfertile or even infertile. The average sheath depth of 2-yr-old bulls is about 200mm (table 5) with the residue of the umbilicus in most Bos indicus derived bulls being between 1 to 1.5cm diameter. 2-yr-old Belmont Red bulls have a much thinner residue of the umbilical cord - 0.5 to 1.0cm diameter. A thicker residue of the umbilicus tends to be associated with a larger inverted fold of skin in the rosette. An acceptable sheath is shown in figure 14a.

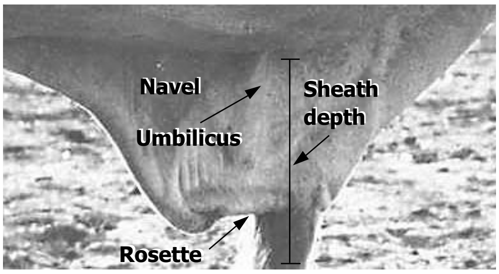

Figure 13. Relative sheath measures used in the bull.

Table 5. Liveweight, sheath depth and sheath scores for four tropically adapted genotypes by age.

		Liveweight (kg)	Sheath depth (mm)	Sheath score
Brahman	2-yr-old	441	200	4.7
	3-yr-old	480	172	5.1
Santa Gertrudis	2-yr-old	586	206	4.6
	3-yr-old	788	217	4.6
5/8 Brahman	4-yr-old	580	142	6.5
Belmont Red	1-yr-old	265	75	7.9
	2-yr-old	565	102	7.9

Prolapse of the prepuce is a problem in some Bos indicus bulls (figs. 15a and b). Pendulous sheaths are often associated with injury to the prepuce and can result in the bull being less functional in mating dexterity. Selection against poor sheath structure (fig. 14b) will result in both immediate and long term benefits by reducing the incidence of injury and providing a more functional sheath at mating. Despite our practical knowledge over the last 20 years of

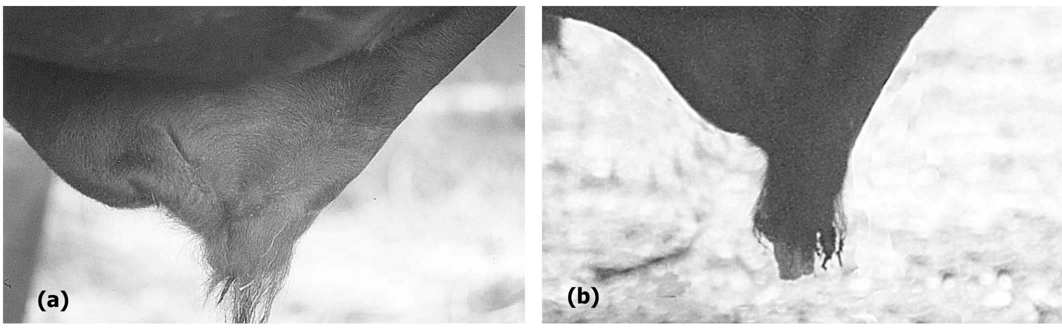

Figure 14. (a) Acceptable and (b) unacceptable sheath conformation in a bull.

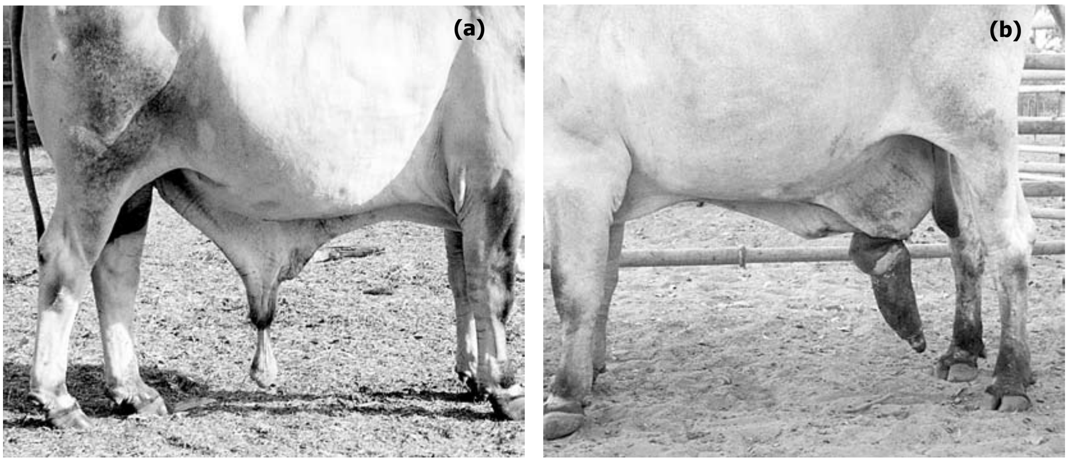

Figure 15(a) and 15(b). An early and severe prolapse prepuse in Bos indicus bulls.

relationships between sheath structure and physical injury, a disappointingly large number of bulls are still presented for sale with poor sheath structure.

A number of penile abnormalities (figs. 16a, b, c) are occasionally encountered including persistent frenulum, stenosis of the penis, lateral or ventral deviation, warts on the glans penis, penile haematoma, 'broken' penis and premature spiral deviation of the penis (fig. 20). The prepuce and penis can be palpated whilst the bull is in the crush. The penis may protrude during a rectal examination and during electroejaculation. The presence or absence of premature spiral deviation is not necessarily defined by crush side examination.

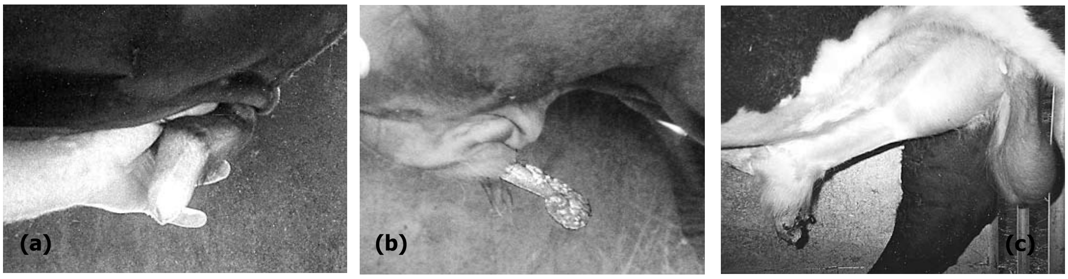

Figure 16 (a) Stenosis of the penis (b) warts on the glans penis and (c) penile haematoma adjacent to the neck of the scrotum.

Collection and evaluation of semen

Before considering semen collection and evaluation, the testicles should be palpated because healthy bulls with good testicular tone invariably have good quality semen.

Figure 17. Semen collection of a bull using electroejaculation.

Semen can be collected by rectal massage, electroejaculation (fig. 17) or serving into an artificial vagina.

Rectal massage will often allow a collection of a sufficient quantity of semen for assessment, but electroejaculation may enable protrusion of the penis and larger volumes of semen. This method is sometimes used for collection, preceeding processing into straws for artificial insemination.

Collection of semen by artificial vagina is probably the best way to obtain a sample representative of the bull's capability under natural service. The bull needs training to use

Figure 18. Crush-side examination of semen for motility and % progressively motile.

an artificial vagina. This method is used in AI centres. Semen from beef bulls is in many cases collected by electroejaculation, since these bulls have not been trained to use an artificial vagina.

Semen should be examined initially at crush-side and then subsequently examined in the laboratory.

Examination of semen is a specialist task. Factors such as volume, colour, density, motility and percent normal spermatozoa can be assessed. Staining and counting methods are used to determine the percentage of normal sperm and percentage of live normal sperm in an ejaculation. Good semen should preferably have greater than 70% normal sperm. It must be remembered that a semen test reflects fertility at the time of testing only and is not a guarantee for some point of time in the future.

An examination of individual sperm and their structure gives an indication of whether faults lie in the actual sperm producing cells of the testes or is a fault in the collection procedure or that the bull has not ejaculated in the short time prior to collecting the sample.

Studies from the USA with large numbers of bulls suggests the British breed bulls with high quality semen have better fertility. In the past decade, studies in the USA have focused on the need for high heparin binding proteins in semen and seminal fluid to effect a possible 15% increase in the female conception rates. Results of trials in beef bulls in northern Australia have not been able to support this finding. Of the 73 bulls examined in the BullPower project, 93% had the recommended heparin-binding profiles of A or B. However, in the majority of the mating groups, % normal spermatozoa was related to calf-output of the bull.

Palpation of the internal sex organs

This is done by rectal examination and can be used to detect a number of abnormalities, such as:

- inflammation of the seminal vesicles
- presence of tumours
- abnormally small or missing portions of the reproductive tract.

Pain on palpation is abnormal and is most frequently an indication of inflammation.

Libido and serving capacity

Libido is the sexual desire of a male to serve a receptive female.

At Swan's Lagoon Research Station in north Queensland, some 11% of 2 year old Brahman cross bulls which passed a reproductive examination of palpation and semen examination were subsequently found to sire very few offspring. It was considered that these bulls probably had poor libido or an inability to mount and serve. In other trials with a Bos indicus derived breed, where bulls have been mated in multiple sire groups, individual bulls have sired from 3% to 60% of the progeny. This large variation may in part be explained by differences in the bull libido. In the northern BullPower project, serving capacity was only one of many traits that influenced calf-output. In particular, the measures of number of mounts and number of mounts plus serves influenced the bull's fertility in between 40 and 50% of the reported mating groups. These conditions may be detected by a serving capacity test.

The serving capacity test

The serving capacity test provides:

- an indication of a bull's ability to mount and serve a cow/heifer and includes both reproductive and structural soundness (legs, feet, sheath, penis and overall anatomy)
- a measure of the sex drive (libido) or eagerness of a male to seek out a female on heat
- an indication of the subsequent pregnancy rates achieved following a restricted mating period (more particularly in Bos taurus breeds).

The test has proved very effective with Bos taurus breeds and has enabled many unsound sires to be identified and culled before the producer suffers a serious financial loss.

The test is repeatable for bulls and is of medium heritability. That is, a bull with a high serving capacity is likely to produce sons who also have a high serving capacity. As more producers are using short term mating periods and single sire mating, there is an increasing importance placed on a bull's ability and desire to serve.

The serving capacity test in the past has proven less useful with Bos indicus type bulls. The test has been found to be more repeatable when conducted at shorter intervals e.g. 1-month apart rather than at annual intervals. Serving capacity as a trait is independent of other fertility traits e.g. scrotal size. Larger scrotal size does not equate with increased libido of the bull. Work with Bos indicus cattle indicates that a short period of sexual experience of 24-72 hours, provided for immature bulls pre-test, is effective in identifying serving capacity in these animals.

Serving capacity ideally is used to match bull power (in Bos taurus bulls) with the number of females to be served. When combined with scrotal size and % normal spermatozoa, the aim for the cattle manager is to develop a Mating Potential (MP) for each individual bull. Currently in Queensland however, the test is used mostly as a 'capacity to serve' test and the emphasis is placed on detecting abnormalities which prevent the bull from completing a successful service.

Assessment of libido

The desire by the male to serve oestrus females in the paddock can now be assessed using a simple test in the cattle yard. The test provides a serving capacity score incorporating the bull's libido. This serving capacity test (fig. 19) was developed by Dr Mike Blockey in Victoria to relate a controlled and managed yard test (table 6) to the performance of the bull in a paddock mating situation over a 6 week period. The yard test is based on the number of times a bull will mount and serve in a set period - usually 20 minutes for Bos indicus bulls and 10 minutes for Bos taurus bulls.

With more producers using improved management practices such as a shorter mating period, tighter calving spread, more uniform turn-off of animals and identification of females of superior fertility, there is a greater need to select bulls with high fertility in terms of both

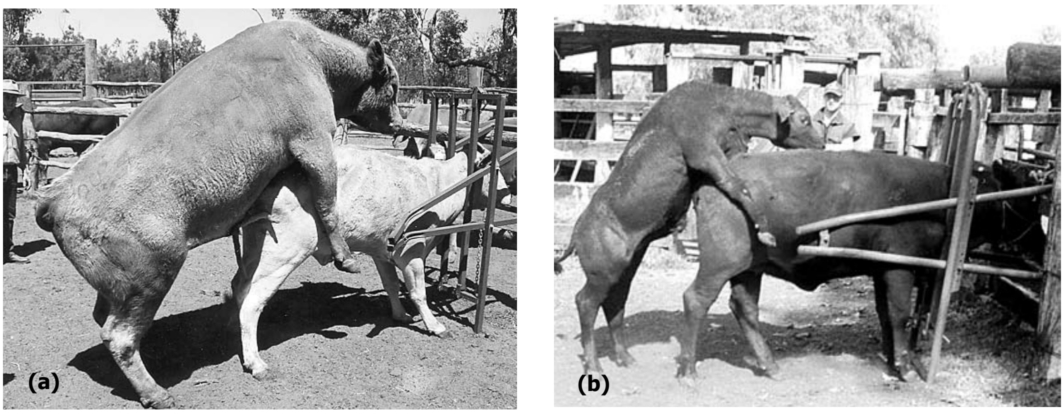

Figure 19. A serving capacity test (a) Bos taurus bull and (b) tropically adapted yearling bull.

Table 6. Relationship between serving capacity results and conception rate at mating in Bos taurus breeds.

Serving Capacity (Numbers of services in 20 min yard test)		First oestrus % conception rate		Pregnancy rate % in 10 weeks mating	
		average	range	average	range
Low	0 - 1	25	18 - 40	40	27 - 66
Medium	2 - 3	61	55 - 68	91	89 - 93
High	4 - 6	72	70 - 78	95	90 - 100

Source: Dr M.A.Blockley, 1989.

scrotal size and libido. The variation that has been demonstrated between individual bull performances in the paddock, would suggest that some bulls are capable of up to 200 serves in the first 3 weeks of mating, whilst others do not serve at all. Libido appears to be independent of scrotal size. As mentioned earlier, libido has medium heritability but its demonstration in the test can be modified by structural soundness and nutritional levels of the bull at the time of testing.

Results in Table 6 give an indication of the potential changes in conception rates relative to serving capacity that can be achieved in Bos taurus breeds.

Studies conducted in Queensland beef herds indicate that the average number of services per 20 minute yard test for Bos taurus breeds is between 3.0 and 4.0 services. This is in contrast to the averages for Bos indicus derived breeds that are between 0.4 and 1.6 services. To assist in a decision regarding the relative mating behaviours for bulls of various breed groups, the data in table 7 represents the average number of mounts and serves by genotype and age in a 20 minute assessment. Bos indicus bulls can perform well in the yard test with restrained females. Young virgin Bos indicus bulls do need a degree of sexual experience, particularly when they have been kept separate from the females from weaning to 2-3 years of age.

Table 7. The average number of mounts and serves by genotype and age in a 20 minute assessment (BullPower studies).

Genotype	Age (years)	Mounts	Serves
British	2+	-	3.0
Brahman	2	2.3	0.4
	4+	3.3	0.7
5/8 Brahman	4+	2.2	1.0
Santa Gertrudis	2	5.5	0.9
	3	5.8	1.6
	4+	4.4	1.2
Belmont Red	2	6.9	2.5
	3	6.2	2.9

In several trials using multiple sire matings, one trial found that where bulls of similar age were mated to 150 heifers, the bulls varied greatly in performance. The number of calves produced by each bull ranged from 2% of progeny to 34%. Another trial using 3 bulls in multiple sire matings revealed that one sire produced 60% of the calves, another 30%, and another 3% of the calves. In Bos indicus bulls, the number of mounts plus effective serves are a more useful indication of the bull's ability to sire progeny.

Abnormalities detected during testing

- **Premature spiral deviation of penis**

Spiral deviation of the penis is a genetic problem in a percentage of bulls (fig. 20). It varies in incidence between horned and polled bulls and between herds and breeds. One survey reported an incidence of up to 25% in an individual herd. It frequently occurs in about 2-

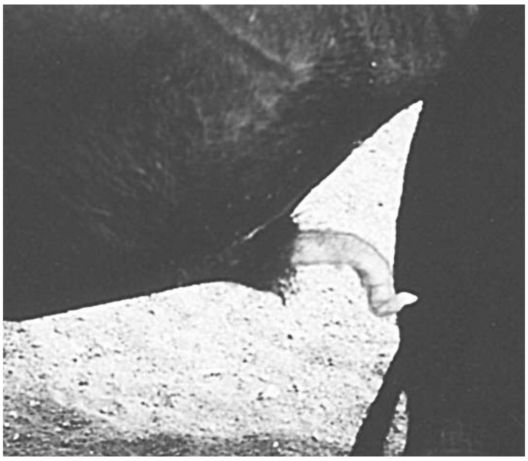

Figure 20. Spiral deviation of the penis viewed from the side of the bull.

5% of bulls over 4 years old in northern Australia.

Spiral deviation is a condition where the erect, free end of the penis of an affected bull prematurely spirals to the right hand side in an anticlockwise direction. The effective width of the penis doubles, thus preventing service. A characteristic of the early stages of spiral deviation is that it occurs intermittently. It appears to be more common in beef than in dairy bulls and in polled rather than horned bulls and gets progressively worse as the bull reaches 5 to 6 years of age. Young bulls (12 to 24 month old) with the early stages of the condition will achieve conception rates of 60-65% in 2 months of mating. This will drop to 20-30% conception rates as the bull reaches 4 to 5 years of age.

Results showed that four bulls with moderate to severe spiral deviation of the penis attained pregnancy rates of only 43%, 33%, 3% and 3% respectively. Corkscrew or premature spiral deviation of the penis (fig. 20) has been reported in a range of breeds in Australia. Other abnormalities identified during the serving ability test include:

- **Other deviations**

In some bulls the penis, upon erection, may deviate down or to one side as a result of a previous physical injury. Following injury, an adhesion may develop between the penis, prepuce and sheath. As the penis becomes erect, the adhesion restricts the free extension and causes the penis to bend to one side or down ('broken' penis).

- **Penile haematoma**

Injury to the penis can cause the blood vessels to rupture causing blood to permeate surrounding tissues causing a massive 'blood blister' or haematoma (fig. 16c). This inhibits effective erection, causing pain to the bull and lowered fertility.

- **Retained frenulum**

This is a 'tag' of tissue on the free end of the penis that normally releases during maturity. The end of the glans penis may be deviated back, reducing effective mating if the tissue is not severed. This is apparently a heritable condition as it is seen more frequently in some herds.

- **Pampilioma**

Warts on the penis are reasonably common, but unless excessively large, will not affect the bull's sensitivity and ability to effectively serve cows (fig. 16b). These may disappear with time.

- **Granular posthitis**

Granular infection of the prepuce is a common venereal disease, particularly in young bulls in southern Australia which reduces the bull's desire to serve because of the pain. It can be treated with antibiotics and older animals may develop immunity.

Does serving capacity have a role in extensive northern Australia?

The serving capacity test as an assessment of mating potential has polarised producers in their attitudes due to:

- the extensive nature of the pastoral industry with a range of management problems
- the predominance of Bos indicus cattle
- the ability to produce a tightly controlled mating season in Queensland is masked by wide seasonal variation

- the lack of demand by producers for the test to be performed on bulls - What you ask for is what you get!
- the conservative nature of the beef industry.

The BullPower project has demonstrated the positive benefits of serving ability testing and the relationships between various measures of serving capacity and calf output of bulls.

Summary

There is no one complete bull evaluation test which will predict accurately that a given bull will produce a certain number of calves per year.

The physical examination, together with the scrotal size, semen morphology and sheath structure have proven to provide a practical test in the field. However, a pass in this test does not automatically mean a given number of calves on the ground.

A bull's capacity to serve is now being recognised as an additional necessary test prior to mating to identify a bull's mating potential and to detect any problems or abnormalities.

Producers are recognising that to operate a profitable beef enterprise, all cows must conceive within about 84 days of calving i.e. six weeks calving to first oestrus and six weeks to go into calf. Cows conceiving outside this time frame are not within the same constraints as the TAXATION system or INTEREST RATES. We can no longer afford to buy a bull and forfeit a drop of calves before we know that he is not functioning. A refund or repayment for a bull is not an alternative since it is profits that suffer and long term viability undermined. Serving capacity testing is part of the information on the label we must expect!

The Australian Association of Cattle Veterinarians (AACV) provide the above details on a Bull Breeding Soundness certificate. Bull buyers should ask to cite a copy of this certificate BEFORE purchasing any bull. Failure to seek out this necessary fertility information may lead to the purchase of one of the 7% of bulls that do not sire any calves or the 58% that produce less than 10% of calves.

Selecting for structural soundness

Bulls represent half the genetics of the breeding unit, but in many herds, much less time is spent on the detail involved in bull selection and bull management. Eyeball selection of bulls, without any clear regard to functionally important reproductive traits, is still the most common procedure for many bull buyers. As a consequence, all bull sales have some bulls with reproductive, structural and walking abnormalities which are presented for sale and purchased for use in breeder herds. Such bulls contribute to sub-optimal herd fertility levels and break down at a younger age. The use of several bull soundness evaluation methods assists in the identification of problems. The physical examination is quick and easy to carry out and should be a routine procedure any time bulls are being inspected, for example, pre-sale, pre-joining and at on-property culling. It has been suggested that 35 to 40 percent of all unsound and sub-fertile bulls can be identified just by a thorough physical examination. Any abnormalities that depress the bull's fertility during mating should be identified. All bull buyers should ask for an AACV Bull Breeding Soundness certificate **prior** to purchase of a bull.

We need to continually remember that the bull should be regarded as a 'sexual athlete', i.e. an animal completely sound and with the necessary ability and desire to perform the task he has been purchased for - the production of plenty of calves of sound genetic merit.

Structural soundness

A breeding bull should be a worker who is never 'off duty'. He should be able to walk (trot) long distances, see, smell and have the urge and ability to detect females on heat. He should be able to maintain his body condition.

Under extensive conditions of north Australia, bulls have to be capable of walking long distances and of serving large numbers of females in a short period of time when females 'cycle' following a 'break' in the season. Hence, limb and body conformation is important not only for these reasons, but because these also contribute to the bull's longevity and usefulness as well as being transferred to the progeny.

Important points of functional anatomy include:

- limb conformation, particularly hind limb
- hoof structure
- scrotal conformation and size
- sheath size, shape and contents
- shoulder and forelimb conformation
- body condition/weight
- pelvic size/opening
- eyes.

Conformation of the legs, feet and joints

Examination of hind leg conformation is an essential phase in evaluating bulls. Some limb conformation defects are often regarded only as minor defects. However for some bulls, minor defects often lead to functional problems as they age e.g. interdigital fibroma between the claws.

Sound hind legs are vital to the breeding capacity of bulls, since during mating, most of the bull's weight is supported by the hind legs. A bull with hind leg defects may suffer pain on moving or mounting and this may interfere with his desire to mate. As bulls with faulty conformation grow older, defects become more apparent and tend to interfere to a greater extent with serving ability.

Frequently, young bulls are observed in which conformation of the legs and feet is poor. Look at these carefully before making a decision to buy. Common problems in the legs include:

- sickle hocks and post legs (figs. 21b and c)
- bow legged (fig. 22b)
- cow hocked (fig. 22c)

Post legs or straight hind legs predisposes the bull to swollen hocks and to arthritis in the hip and stifle joints. Swollen hocks can also result from grain feeding and physical injury from fighting. In each case the swelling may be associated with pain and reduced mating performance. Sickle hock bulls tend to be clumsy, particularly at service and when dismounting. Each condition can adversely affect the bull's serving capacity in the longer term. Conversely, the bull will 'break down' earlier in life if it has straight legs or sickle hocks as shown in figure 21d.

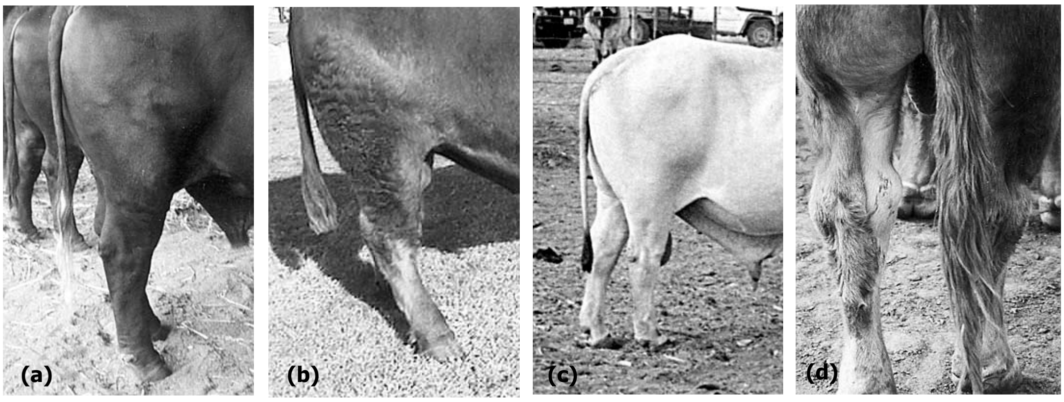

Figure 21. Hind limb conformation (a) normal (b) sickle hocked (c) post leg (d) swollen hocks.

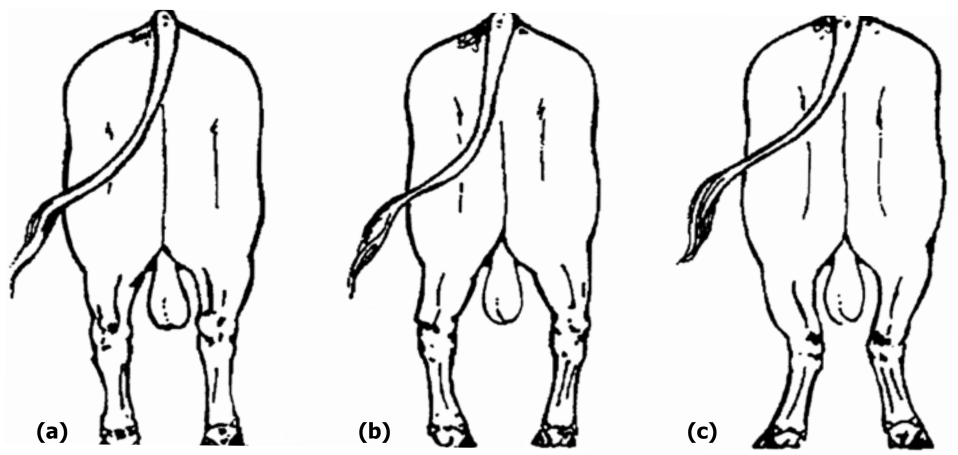

Figure 22. Hind limb conformation (a) normal (b) bow legged (c) cow hocked.

Many of these conditions are heritable and given the enormous stresses placed on the hind limbs during serving, it is little wonder that bulls with these physical defects frequently break down in the joints, leading to arthritic conditions, particularly in older bulls.

Common problems in the hooves relative to normal size and shape (fig. 23a) include:

- long, narrow hooves with shallow heels, often associated with weak hocks and pasterns (figs. 21b and 23b) and sometimes form scissor hooves.
- short hooves, worn at the toe, often associated with straight hind legs (figs. 21c and 23c)

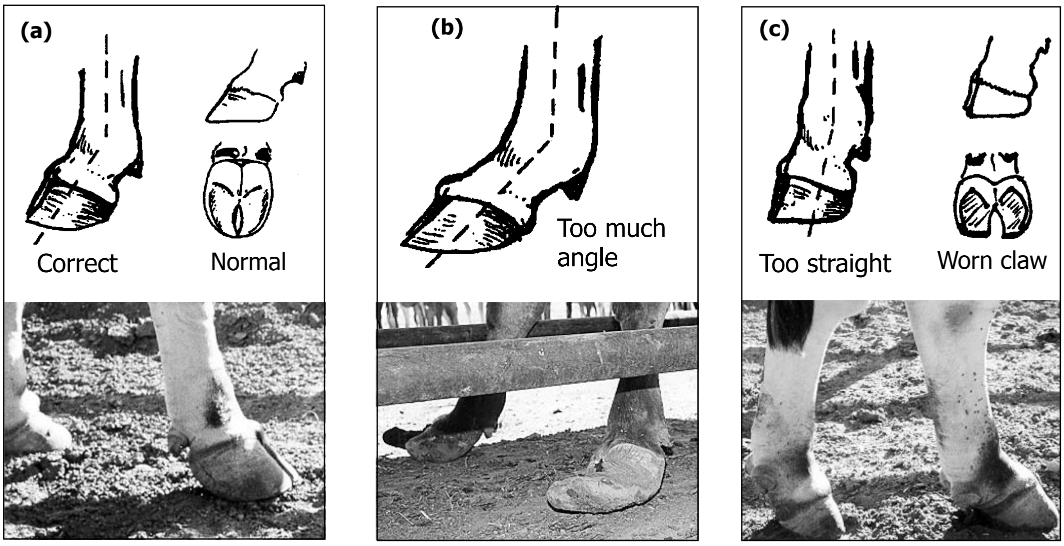

Figure 23. Pastern angle of front and hind legs and associated claws; (a) correct structure (b) weak in the pastern/long toes (c) too straight and worn toes.

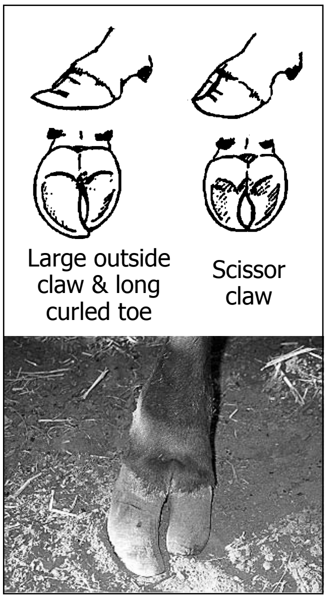

Figure 24. Uneven toe length and scissor claw

Figure 25. Interdigital fibroma

Avoid overgrown scissor or curved claws. Curved claws (fig. 24) can also be the result of soft soils, e.g. black soil country or over feeding. However, overgrown claws are usually indications of poor limb structure or early signs of hip arthritis; particularly in the hind limbs.

In addition to the shape of the hoof, buyers should beware of growths between the claws. These growths start as horn like lesions near the hairline of the hoof and can result in a proliferative lesion. This lesion can cause the claws to part and result in damage to the soft tissue of the hoof by sticks and stones (fig. 25). Cracks in the hoof particularly vertical cracks should be avoided by bull buyers.

Finally, the gait needs to be that of a well-coordinated animal. Particular care needs to be taken in evaluating older animals to ensure that arthritic problems in the rear limbs, joints and back, as well as congenital (probably heritable) defects, such as stringhalt are not present.

The walk

Bulls should normally place their hind feet in the prints of the front feet and carry straight through as they walk out freely. When looking at a bull from behind, the legs should be straight - up and down - and not too bow legged (fig. 22b). Overstepping or understepping may be linked to serving inability of the bulls. Bulls that understep often have straight hind legs and have increased problems in seeking the vulva and in the final thrust for ejaculation. Continued problems result in arthritis and serving incompetence. Worn toes, an indicator of dragging the hoof, would suggest straight hind legs (figs. 21c and 23c). Uneven toes can be the result of an arthritic condition in the hip or stifle joint as well as abnormal leg movement.

Structural soundness of limbs is not only important for bulls but also for heavy weight steers. In the past there have been reports of up to 30 percent of steers fed over 150 days in feedlots for the heavily marbled Japanese market which have not been able to be finished appropriately and have had to be marketed elsewhere. Ensuring steers are structurally sound before entering the feedlot can help overcome some of these problems.

Eyes

Viruses, animal age, genetic background, UV light and solar activity have been implicated in the development of eye lesions. Bos taurus type cattle have a higher proportion of squamous cell tumours in unpigmented or partially pigmented regions around the eyes.

Pop eyes protrude from the profile of the head, predisposing the bull to cancer eye or injury to the eye.

Eye cover has had little attention from some breeders whilst pigmentation has received a lot of attention from Poll Hereford and Hereford breeders alike. From practical observations, eye cover or hooding with well set eyes (fig. 26) would appear to not only provide greater physical protection, but also ensure decreased glare, ultra violet light and reduced fly related problems. In general, eye diseases are more prevalent in white-faced breeds rather than Bos indicus breeds. The disease most frequently encountered is Infectious Bovine Keratoconjunctivitis (IBK) which commonly results in ulceration of the central corneal area. This may eventuate in scarring of whole or part of the cornea-pink eye or 'blue-eye' as it should be called. Entropion, a condition where the eyelashes contact the cornea of the eyes, can cause irritation and weeping of the eye. It is likely a heritable condition and is found in several breeds.

Figure 26. Well hooded eye on a Droughtmaster bull showing eye lashes extended free of the eye ball.

While eyes gain considerable attention, the severe economic impact from other less obvious traits may indicate the need for a more balanced selection procedure.

Selection using a Bull Breeding Soundness Evaluation certificate

Selection of bulls that meet minimum fertility standards has been a difficulty to many beef producers for a long time. For some time, limited reproductive information has been included in sale catalogues. Limited, because many seedstock producers only supply the information that buyers either ask for or are prepared to pay for. The BullPower project focused on northern Australian conditions and particularly tropically adapted breeds and has identified many important reproductive traits critical for the bull to transfer his genetics to the breeder herd.

Subsequent to this study, the Australian Association of Cattle Veterinarians has incorporated these findings into a Bull Breeding Soundness Evaluation (BBSE) certificate. This certificate provides a standard of assessment for veterinary evaluation of the various reproductive traits important to beef producers. This evaluation should be conducted prior to sale and details the identification of the sire, date and location where the evaluation was conducted, the assessments made and relevant disease information (as shown in the example in fig. 27). It is purely an evaluation of a range of measures on that date on which it was done and does not provide any guarantee or imply the number of calves that the bull will sire in either single or multiple sire matings. It is not a genetic evaluation of reproductive traits, but an indication of the animal's present reproductive function. However, this certificate is far superior to 'the lack of' or 'distorted information' that is frequently available to many bull buyers at present. This evaluation can also be conducted on property as an annual bull test prior to mating to identify any bull that is declining in fertility.

These certificates should be sought out by bull buyers when choosing between bulls as they also provide details of aspects of the evaluation that cannot be seen in the live animal e.g. percent normal spermatozoa and serving capacity details. In the sale catalogues, bull sellers are able to provide in association with each bull in the catalogue / or list, a summary of the tests conducted by the examining veterinarian. An example of this summary will be in the form of:

AACV

Scrotum	Physical	Semen	Morphology	Serving
35.5	✓	✓	**P**	**nt**

35.5 = Scrotal size in cm, ✓ = Pass, **P** = OK under natural mating, × = Fail,
na = Not applicable and **nt** = Not tested.

Bullville Veterinary Clinic

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Station Road,
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Mobile 04 2747 8239 Email: bullivets@email.com.au

Veterinarians
Dr Maree Jones
Dr Tom Smith
Dr John Citizen

Report: Bull Breeding Soundness Evaluation

This report was compiled exclusively for the use of the person to whom it is addressed. No other person or corporation has any authority to make use of any or all of this report.
This report is valid only when signed by the evaluation veterinarian and the bull's owner or agent.

Summary

To: Mr Jack Sheperd Handsome Station, Julia Creek, Qld 4000

Place of examination: Handsome Station **Date**: 03 March 2003

Brand: GB on offside **Breed**: Brahman

Bull:
Number/name: Charter Stowers 1965
Age Yr:Mn 2:02

Scrotum	Physical	Semen	Morphology	Serving
35.5	✓	✓	✓	✓

I hereby certify that information included in this report is in full accordance with the standards for evaluation and reporting bull breeding soundness as published by the Australian Association of Cattle Veterinarians.

Veterinarian:
Signature:

I hereby certify that there has been no medical or surgical intervention of congenital abnormalities of the listed bull(s), whether genetic or not, to enable the above-mentioned standards to be met.

Owner/Agent:
Signature:

Data Recorded:

Physical		**Serving**	
Condition Score	4	Serves	5
Testes Tone	3	Penis	Normal
Penis	Slightly deviated	MS function	MMMSMSMSSS
Feet	Normal		
Legs	2		
Leg joints	Normal		
Gait	Acceptable		
Head	Normal		
Semen			
Density	4		
Mass Activity	3		
Motility	80%		
Morphology			
Normal Sperm	76%		

General comment: This bull will function well in multiple sire matings but has not been vaccinated for the venereal diseases.

Figure 27. A Bull Breeding Soundness Evaluation (BBSE) certificate.

Selecting for growth

Objective selection for growth can be based on weight, average daily gain and weight ratios as well as BREEDPLAN estimates of genetic merit. Selection of animals using an animal's actual measure of weight and daily gain do not allow for differences in management, age, etc, between animals. Weight ratios only allow accurate ranking of animals within a group where all animals are treated the same and are similar in age. The best method of selecting is that based on an EBV which is calculated in BREEDPLAN.

For growth related traits, BREEDPLAN provides information about:

- 200 day growth, recorded between 81-300 days of age
- 200 day milk, recorded between 81-300 days of age
- 400 day yearling weight, recorded between 301-500 days of age
- 600 day final weight, recorded between 501-700 days of age.

Each of these ranges are recorded by the breeder during the periods shown above and adjusted to the 200, 400 and 600 days.

The 200 day Milk EBV is the kilograms of growth due solely to milk, compared to the 200 day growth that is kilograms of actual growth from the growth genes. Birthweight EBVs may also be available but are optional for the breeder to record. They are useful to bull buyers where dystocia or calving difficulty is a problem in the herd. Selecting a bull for higher 200 day milk EBVs may increase the female progeny's milk production but decrease their subsequent fertility as nutritional levels become limiting in times of reduced pasture availability.

How can the producer use the 600 day EBV figure and what does it mean?

Buying a bull with the aid of EBVs can be likened to picking a bull after having checked out all the relatives. The EBV for each trait is a measure of the animal's own performance as well as the performance of as many of the animal's relatives as possible.

For example:

Comparing EBVs for 600 day weight in kg

Comparing **Bull A** (EBV = +40kg) with **Bull B** (EBV = +20kg)

The progeny get half their genes from each parent.

therefore: [**Bull A** +40 x ½ = +20kg] – [**Bull B** +20 x ½ = +10kg]

Progeny from Bull A should weigh 10 kg more on average at 600 days than those from Bull B.

Currently BREEDPLAN provides EBVs for six growth traits, five fertility traits and six carcase traits (table 8). The growth traits of most interest to northern cattle producers will vary depending on the genotype of their herd and the market they are producing for. For example, birth weight EBVs at present are of less interest to Brahman breeders than to those using Bos taurus genotypes.

Table 8. BREEDPLAN EBVs presently available

Growth	Fertility	Carcase
Birth weight (kg)	Scrotal size (cm)	Carcase weight (kg)
200 day milk (kg)	Days to calving (days)	Eye Muscle Area (EMA) (cm^2)
200 day weight (kg)	Gestation length (days)	Rib fat - 12/13th rib (mm)
400 day weight (kg)	Calving ease (direct)	Rump fat - P8 (mm)
600 day weight (kg)	Calving ease (daughters)	Retail Beef Yield % (RBY %)
Mature cow weight (kg)		Intra-muscular Fat% (IMF %)

How can the producer compare and recognise the benefits of EBVs on two bulls?

Remembering that the bull only passes half his genetics on to the progeny - half this EBV is used to make the comparison.

For example: A comparison of 2 bulls

	EBVs (kg)			
	200 Day Milk	**200 Day Growth**	**400 Day Growth**	**600 Day Growth**
Bull A	+2	+10	+20	+40
Bull B	+6	+4	+10	+20

Conclusion: Bull A's progeny will be on average:

- lower milk producers
- 3 kg heavier at weaning (due to own growth genes)
- 5 kg heavier at 400 days
- 10 kg heavier at 600 days.

Bull A would be more suited to the northern environment, assuming the bull buyer was looking for bulls to breed heavy steers. On the other hand, Bull B would be suitable where the bull buyer wishes to increase the milk production of his females and still increase the potential for improved growth. These decisions would then be influenced by the productivity of the existing herd for the respective traits. Hence the producer defines the required breeding objectives.

In addition, when selecting a bull on EBVs, consideration should be made of the breed average EBV for that trait in order to identify the relative merit of that bull. "Percentile bands" are also published by each breed society to identify the relativity of EBVs in 10% increments.

Accuracy information

Whilst EBVs are calculated with the best possible information to give a measure of the animals genetic merit, 'accuracy information' is a measure of risk and is quoted as a percentage.

For example:

	EBV (600 day weight)	**Accuracy %**
Bull A	+40 kg	95%
Bull C	+40 kg	63%

The higher the accuracy %, the more confident the producer can be that the bull will perform according to the EBV. The more records available on any animal and the more records on known relatives, then the greater the accuracy on that individual. The accuracy figure of 63% means that the 600 day EBV could be between 35 and 45 kg, compared to a 95% result which confirms that the EBV is +40 kg. For example, older sires and sires used for artificial insemination (AI) tend to have higher accuracy figures, because there is more information available. Sires appearing in the GROUP BREEDPLAN summaries have accuracies of 75% or better for at least one trait.

The potential longer term gains through the selection of sires with the aid of BREEDPLAN has been identified by Heather Burrow and Tom Rudder. They used a herd model for a commercial herd of 1000 adult equivalents in central Queensland to estimate the effect of using bulls with high EBVs for 600 day weight on the profitability of the herd.

Table 9 shows that in their calculations, the use of bulls with high EBVs for 600 day weight increase annual gross margins by 6.4, 7.6 and 8.3% after 5, 10 and 15 years respectively.

This increase in gross margin could be achieved while running fewer cattle, leading to greater sustainability of the enterprise.

Table 9. Profitability of using bulls with high EBVs for 600 day weight.

Annual income and costs	Years after start of selection			
	0	**5**	**10**	**15**
Gross income ($)	192 600	205 200	207 700	209 100
Less direct costs ($)	11 100	12 200	12 300	12 500
Gross margin ($)	181 500	193 000	195 400	196 600
No. head	1361	1332	1295	1271
Gross margin/head	**133**	**145**	**151**	**155**

Gross income includes bull purchasing and direct costs.

Direct costs include animal health, supplementation and transport costs.

The gross margins referred to here are based on the assumption that there has been no change in feed efficiency associated with the improvement in growth rate. Results are now coming in from feedlots which indicate that improved EBVs for growth rate will often be associated with improvements in feed conversion efficiency. This could lead to even greater improvement in gross margin in the above situation and has also led to the feedlot industry seeking steers with higher EBVs for growth rate. These growth rates can then be expected to give improved feedlot performance.

Put simply, if the producer is faced with the choice between two bulls; one a +20 (600 day weight) EBV bull and the other a +4 (600 day weight) EBV bull (the time that we sell our steers), the initial bull is more profitable. When placed over some 33 cows with 85% branding rates and kept for 5 years, then the higher EBV bull will produce 1120 kg of extra beef. At $1.10 net/kg, the bull can be expected to produce progeny that are heavier and return an additional $1232.00 in the progeny over the life of the bull. In addition, the +20 bull will leave genetically superior females in the herd.

Producer demonstration sites across Queensland using Brahman, Belmont Red and Santa Gertrudis genotypes have clearly demonstrated that gains of $47.00 per head or a premium of 10% was achieved as a result of using higher EBV sires in one calf drop. The combination of selection for greater growth plus increased reproductive performance resulted in greater than a 400% increase in weight of calves weaned per sire (see Beef Cattle Recording and Selection, pages 39-42).

Cumulative profit

Using BREEDPLAN, any genetic gain in one generation is passed onto the next generation so that this genetic gain and the associated profits are cumulative. If, for example, you feed a supplement or use a hormonal growth promotant in order to increase growth rate, you only get the improved results in the animals that you treat. In the next generation you have to repeat the treatment and the cost in order to get the same improvement. With genetic improvement, each successive generation receives the gains from the previous generation absolutely free because selection has fingerprinted the improved production into the animal's genetic bank.

Through the continued use if BREEDPLAN, each successive generation has its additional gain tacked on to the previous gains. Furthermore, the bull with extra genes for growth (higher EBVs for the particular market characteristic) will pass these genes onto all progeny each year while the bull is in the herd, not just the immediate year of use as is the case with supplementary feeding and hormonal growth promotants. A gain of $1232 per bull in the first selection round which has been demonstrated above, becomes $2464 in the second and $3696 in the third, provided that the selection is based on similar EBVs. This doesn't happen with many other forms of on farm improvement.

Feed efficiency

In addition to growth, the Net Feed Intake (NFI) of an animal describes the ability of an animal to convert kilograms of feed consumed to kilograms of beef. More efficient animals eat less for each kilogram of carcase gain. NFI has been measured using feeding trials conducted over a 30-day feeding period. More recently, the CRC (Cattle and Beef Quality) research has identified an Insulin like Growth Factor (IGF-1), a hormone, in the blood to be positively correlated with the animals' net feed intake. Therefore, a more negative NFI is more efficient.

Ultimately, an EBV for net feed intake will be appropriate for selection in the beef industry. More efficient animals tend to have more muscle and less fat, which could have some undesirable side effects in the more harsh environments relative to the fertility of the subsequent breeder herd.

Selecting for carcase attributes

Stud breeders regularly say ... 'We supply what the commercial breeder pays most for'.

The sad fact of life is that many commercial producers complain that the studs over-feed their bulls and that they have to be 'let down' before they will work. Yet they still pay high prices for the fat bull.

Most beef producers want 'feedback' but fail to see that they are sending the wrong feed-back to studs themselves. Unfortunately there are still some cattle buyers who have difficulty in visualising 'what is fat' and 'what is muscle' in the live animal.

Over-fat bulls do not work as well as bulls in forward store or working order. Obese bulls tend to have lower libido or desire to serve cows, arthritic conditions and deteriorating semen quality. This is no surprise since people find work more difficult the more obese they become! On the other hand, the feeding of bulls in preparation for sale is a major unnecessary cost borne by the industry.

The Australian beef industry is fast adopting value based trading. More animals are being objectively measured in the meatworks and the buyer is purchasing according to measured specifications. Measurements recorded focus on: fat, in relation to depth, colour and distribution; muscle, in relation to, colour, texture, pH and eye muscle area; and carcase weight. As a result, there are an increasing number of carcases which are traded with records of Retail Beef Yield % (RBY%).

In order to make positive gains using the genetic differences between animals, producers must be aware of how to make use of EBVs for fat depth at the 12/13th rib and P8 site, EBVs for retail beef yield %, intra-muscular fat % and the other indicators based on genetic differences in the herd.

There will still be many occasions when producers will have to buy or select bulls without this information and they must then rely on an alternative method of selection.

Cattle producers need to have a mental picture of the skeleton of the bovine in order to visualise just what is muscle and what is fat. Information in figure 28 illustrates the bone structures and placements which are common to cattle and in fact are very similar for most large farm animals.

From the skeleton and our knowledge of cattle, there are several parts of the animal where the bones have only a covering of skin, cartilage and connective tissue. From the front to the rear, these are the head and tail. As the animal increases in weight, the ribs and loin are covered with increasing amounts of fat. Animals under a fattening phase form a layer of fat between the connective tissues covering the bones and the skin layer. When an animal is handled in these areas the majority of tissue felt under the hide is fat.

Where is fat deposited in large amounts?

From figure 28, the relative placement of the brisket to the point of the elbow can be seen.

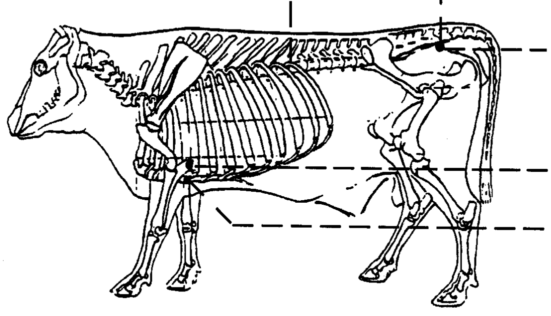

Figure 28. Relationship between the sternum, the elbow and P8 site.

The sternum (brisket bone) is approximately 5-9 cm below the point of the elbow. The sternum is covered predominantly with fat and to a lesser extent with about 2-3 cm of muscle at the navel end. A low hanging, full brisket contains large amounts of fat. Looking at the animal from the front, a fat animal has a rounded, full, deep brisket (fig. 29b).

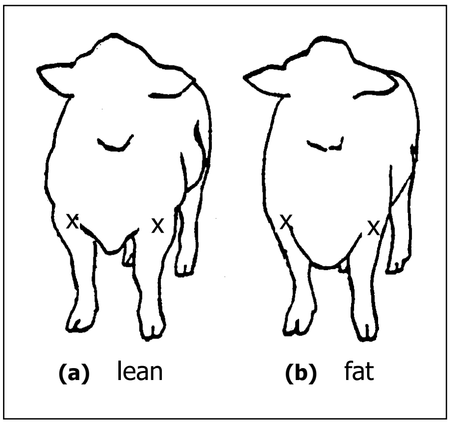

Figure 29. Front view of two animal types: (a) lean, with good indication of muscle, (b) fat, with poor indication of muscle.

What do we see in the flank of a fat animal?

The flank contains very little muscle, possibly 1.5 cm. The flank also tapers upward toward the stifle joint (knuckle) of the animal. As an animal gets fatter, the flank region thickens, filling with fat deposits and causing the animal to have a straight underline as shown in figure 30b.

The rear view of a fat animal reveals a 'full cod' and with the space between the 'topside' between the legs filling with fat as shown in figure 31b.

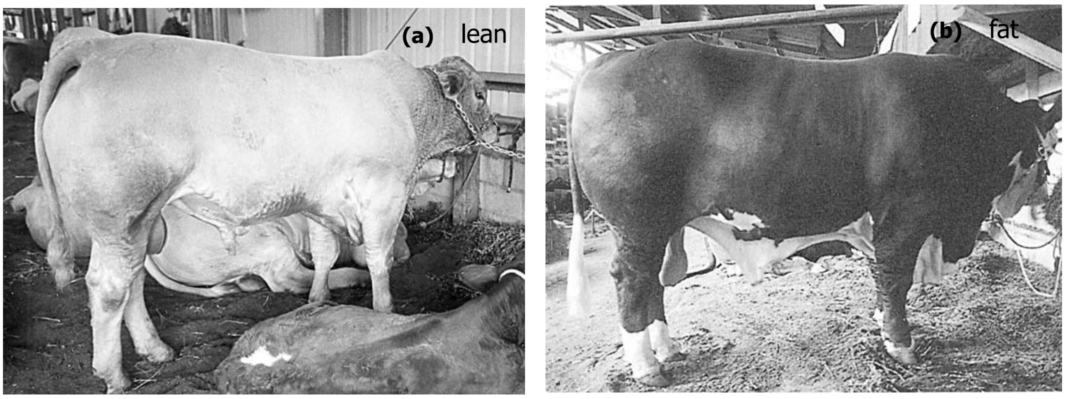

Figure 30. Side view of two animals: (a) lean animal (b) a fat bull showing a deep brisket and a full flank.

What parts of the animal are mostly all muscle?

From figure 29, site X illustrates the forearm and indicates the area on all animals that contain minimal amounts of fat with mostly muscle covering the bone in the centre.

Similarly the site indicated by X in figure 31 from one side of the animal to the other is only muscle with a very small layer of fat just under the skin. This is a line from just behind the stifle passing through the silverside and topside - topside and silverside, which are the major cuts of meat we are familiar with.

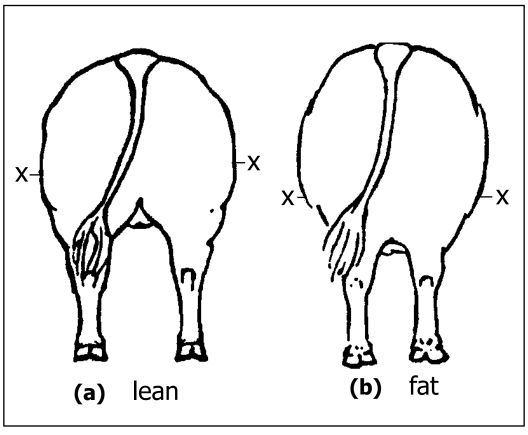

Figure 31. Rear view of two animals of different conditions showing: (a) lean, with a good indication of muscle (b) fat, with a poor indication of muscle.

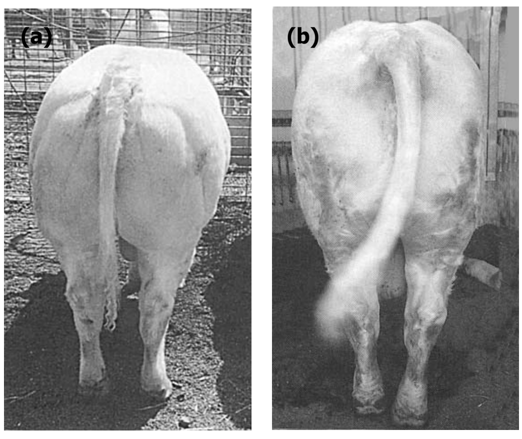

Figure 32 (a) Well muscled bull - muscle score B (b) less muscled bull - muscle score C+. Note the width of the placement of the back feet at the hocks and on the ground.

A convex or bulging muscle down either side when looking from behind would suggest a well muscled animal which stands with his feet well apart. Figure 32 shows two bulls – one well muscled bull (muscle score B) and one with less muscle (muscle score C).

What about eye muscle area?

The eye muscle lies neatly above the ribs and beside the vertical spinal processes on either side of the back bone. As an animal fattens, fat deposits are laid down around this muscle which can often give a false impression of the musculature or muscling of that animal.

Evaluation of a bull is therefore best done from the ground up. Look at his feet, his underline fat deposits and then upwards. Do not be misled by the nice round back, the square tail head with no muscle seams. These all indicate the bull may be carrying high levels of fat, be over fed and potentially have poor fertility.

The actual eye muscle area can be measured by scanning in the live animal using ultra sound equipment. The size will be reported as an EBV for eye muscle area in cm^2. This provides an additional indication of the degree of muscling in the animal. At the same time, the fat depth can be measured at both the $12/13^{th}$ rib and P8 site. These measurements are used in the calculation of retail beef yield and ultimately the EBV for RBY%.

What is the 'retail beef yield' in an animal?

The aim of all beef producers is to increase the amount (kg) and quality of beef sold off the limited area and pasture resources of the property.

Retail beef yield is the percentage of saleable beef measured for a 300 kg carcase, with 2-3 mm fat trim and 85% chemical lean.

Retail beef yield is primarily determined by the weight of the animal, the degree of fatness and to a lesser extent by eye muscle area. Eye muscle area influences the retail beef yield by about 9% and has therefore only minimal impact relative to the weight and fatness of the animal. For a constant retail beef yield %, the liveweight and therefore EBV for turnoff weight has significant influence on the retail beef yield %.

To modify fat in progeny, bull selection can be based on EBVs for fat at both the 12/13th rib and P8 site. In addition, this will be reflected in the distribution of fat.

Selecting for tenderness

Tenderness of beef is one of the traits frequently identified by consumers as a desirable trait for eating quality. The CRC (Cattle and Beef Quality) has clearly identified that beef tenderness can be modified genetically. Tenderness can be improved by selecting bulls that have a longer 'flight time' or are more docile. Like marbling, producers may also note the DNA test results for tenderness. This test focuses on the Bovine Calpastatin gene where the results will be reported as 0-star (2 tough alleles), 1-star (1 tender, 1 tough) and 2-star (2 tender alleles). The use of sires carrying 2-star results will reduce the number of progeny with tough beef. However, producers are reminded that this selection decision should be relative to the market requirements for their beef. An EBV for tenderness will ultimately be of greater value in bull selection.

Selecting for marbling

The amount of intra-muscular fat is scored in carcases as a Marble Score (MS). In the live animal the ultrasound measurement at the $12/13^{th}$ rib provides a percentage of intra-muscular fat in the eye muscle. This measurement is then converted to a genetic difference of an EBV for IMF%. In addition, beef producers can note the DNA marker results that will provide 0-star, 1-star or 2-star results to increase the marbling potential in their herds.

Selecting for temperament

Temperament is one trait that beef producers frequently identify as being very important in their selection criteria. Temperament is invariably equated with 'docility' or 'an estimate of how quiet the animal is'. Temperament is also an economically important trait in beef cattle production through its effects on factors such as growth rate and meat quality as well as labour requirements, incomplete musters and potentially on workplace health and safety.

Temperament, like many other traits, is composed of the genetic make-up of the animal and the environmental effects of 'handling'. Selection for more desirable 'temperament' or more docile animals must be focused on the genetic component for it to be passed on to the progeny. While many bulls selected in the past as being docile were merely the product of a long period of intensive handling, other bulls have been dismissed for apparent undesirable temperament, which may have merely reflected the adverse environment at the time of selection e.g. 'sale yard conditions'.

Recent studies by the CRC (Cattle and Beef Quality) into alternative approaches to measuring 'docility' have identified three simple and useful quantifiable options that are related to each other. These options are:

- flight time,
- crush test and
- yard test.

Flight time is the time an animal takes to pass out of the crush and move through a predefined distance. The greater the time, the more docile the animal as shown in figure 33.

Figure 33. Flight time measurement equipment and an animal passing the second light sensor.

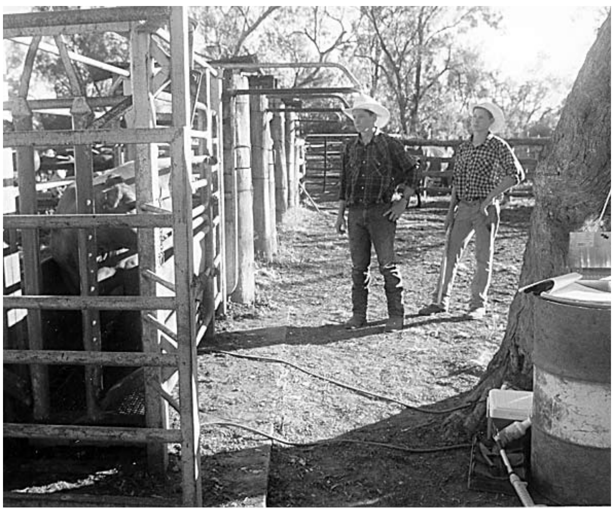

Figure 34. Recording docility in the crush test.

The crush test involves restraining the animal in the crush and recording the animal's response as the handler approaches as shown in figure 34.

1 = docile,
2 = restless,
3 = nervous,
4 = flighty and
5 = aggressive.

In contrast, the yard test requires the animal to stand in the corner of a large yard and the animal's response is recorded whilst approached e.g. 1 = stands quietly to be touched, 2 = restless but can be touched at a distance, 3 = nervous, 4 = moves away from the approaching person and 5 = aggressive to the approaching person.

The CRC (Cattle and Beef Quality) results have demonstrated that flight time is correlated with the crush score measure. The heritability of each measure is in the order of: flight time 0.31 and crush score 0.19. This means that temperament has medium heritability and can be improved by applying selection pressure to this trait using various selection methods.

The benefits of selecting more docile bulls are now more clearly defined and are consistent with earlier beliefs of beef producers. The selection for improved temperament or more docile animals results in many favourable benefits in other traits such as:

- Nervous animals grow at a slower rate in feedlot conditions applicable to the domestic trade (e.g. each 0.1 second increase in flight time increases ADG by 0.04 kg/day),
- Fewer docile animals are 'pulled' for hospitalisation while in the feedlot (e.g. 42% of nervous animals are taken to the hospital pen at some time in the feedlot),
- More docile animals have heavier final weights and carcases (e.g. 0.1 second increase in flight time resulted in a 2.3 kg increase in HSCW),
- More docile animals produce more tender beef (a lower 'meat shear force'), lighter coloured beef, a higher percentage of retail beef yield and have higher eating quality scores.

Assessment for docility is best made while the bulls are young (preferably around 12 months of age). An appropriate time to assess young bulls is at the end of weaning after they have recovered from the initial shock of separation from their mothers. Their behaviour at this time is less influenced by the absence of their dam. This coincides with the first major phase of selection of replacement bulls carried out for any drop of bulls. The selection intensity applied to this trait should reflect the relative importance of the trait compared to other traits in the herd and the degree of the problem that poor temperament is causing in the herd.

True genetic progress for temperament is difficult when buying a bull if based on subjective assessment practices. What is observed may be solely the product of handling or unfamiliar conditions and not reflect the genetic attributes of the bull. When available, EBVs for temperament provide a more reliable genetic indicator of 'how docile the bull is'.

Selection using DNA fingerprinting and gene markers

What is DNA?

DNA or deoxyribonucleic acid is the foundation genetic structure determining the 'makeup' of all life. DNA is arranged in structures in the cell nucleus called chromosomes, which are arranged into 30 homologous pairs in cattle. Each chromosome has many genes that determine the characteristics exhibited by the animal. DNA is found in every cell in the body. It determines the physical characteristics of an animal and carries the genetic information (genetic code) from parent to offspring. It is the reason one animal is different to another. As recently as April 2003, the human genome sequence was completed, unravelling the entire human DNA sequence and identifying all of the approximately 30 000 human genes. DNA carried within the bull's sperm cell is the basis of every selection decision made in achieving a beef producer's breeding objectives. What we see in 'the bull' (i.e. the phenotype) is solely the expression of the animal's DNA (i.e. the genotype) in association with the environmental factors affecting that animal.

DNA fingerprinting (DNAfp): a tool for parentage identification?

DNA fingerprinting is a tool that allows the identification of sire or dam to an animal when a tissue sample has been collected from progeny and parent. The sample most frequently used in the beef industry is hair with the follicle. DNAfp is a test of exclusion. DNAfp cannot identify a 'phantom sire'. This means that all possible sires or dams must have a DNA sample collected and the test will exclude all animals that do not have matching DNA. DNAfp is now widely used to identify the sire of a calf as a result of multiple sire matings and provide the breeder with a defined pedigree for BREEDPLAN purposes. DNAfp uses 10-15 highly variable genetic markers to establish a unique genetic 'fingerprint' for an animal.

What is a DNA marker?

A genetic marker is a known DNA sequence (single nucleotide polymorphism - SNP) that is believed to be located physically near a gene, in a specific region, that has a measurable effect on traits, called quantitative trait loci (QTL). The marker and the gene will be inherited together most of the time. The gene marker is a step toward finding the actual gene for a trait; but in some cases markers are used for selection before the precise location of the gene is known. The effect of the marker becomes more consistent as the marker gets physically closer to the actual gene.

DNA markers available for bull selection?

Despite the widespread recognition of the potential value of DNA markers for selection, we are still a long way from having access to a wide range of economically important traits. The CRC (Cattle and Beef Quality) has initially focused on the development of marker technology for meat quality and production efficiency traits. At the moment there are commercially available markers for marbling and tenderness.

There are currently tests provided by Genetic Solutions Pty. Ltd. for marbling using the thyroglobulin gene that detects a form that has a positive effect on marbling. The results show differences in marbling in animals that have 0, 1 or 2 copies of the gene. GeneSTAR® is a diagnostic test for tenderness using the calpastatin gene that has a negative effect on meat toughness. 0-Star animals have significantly tougher meat than 2-star animals. Animals carrying 2 copies of the gene have a greater potential to pass on that trait to the progeny than those with 0 copies.

It is important to remember that there are many genes that control the majority of traits, including marbling and tenderness. For example, at present two genes have been identified to be associated with tenderness and even more genes have been suggested to influence the expression of marbling. Therefore, selection of animals based on individual DNA marker test results alone may not guarantee tenderness or marbling within the herd.

Current and future selection opportunities with marker technology

Research is progressing in the search to expand the range of markers for economically important traits. In addition to the existing markers, new markers are likely to be identified for other genes that collectively function within an animal to influence a trait. It is anticipated with future developments that markers will be available for retail beef yield, resistance to ticks and worms and feed efficiency.

The gene marker technology is likely to be most useful by increasing the EBV accuracy for traits that are difficult or expensive to measure, expressed later in life or measured after the animal is dead. The current high cost of these technologies usually limits their wide scale adoption to the seedstock sector and as a failsafe tool in monitoring the traceability of meat.

Putting selection decisions into a package – Breeding objectives

When buying bulls or selecting bulls to use in their own herds, breeders make their choice by 'weighing up' many factors, including their current herd performance, the environmental constraints for the herd and the market specifications for the final product. The selection decision then comes down to selecting which bull/s, from the range on offer, will meet these needs, while balancing the incremental differences in one trait relative to another. The selection is based on intuitive decisions about the relative value of a range of traits, including fertility, growth, structure and carcase, with the breeder comparing all the relative traits in all the bulls on offer to come to the choice of one, or a few bull/s. The process of combining a number of attributes or traits into a single breeding decision is setting a breeding objective. The breeding objective should be comprised of all the traits that effect profit plus some indication of the relative emphasis each trait should receive.

Throughout this booklet selection has focused on individual traits in isolation. Maximum genetic improvement in any one trait can be achieved by selection of the bull with the greatest performance for that trait – single trait selection. Many breeders recognise that the best bull for their herd and target market may not be the highest performing bull for any one trait, but the one that 'puts the package together' in the best combination of traits. The combination of many traits into a single breeding objective is provided using BREEDOBJECT.

Indexes allow balanced selection in the true sense of the word - they balance the amount of selection pressure that needs to be applied for fertility, growth, maternal and carcase traits to give you the most profitable herd over the long term – high indexing animals will rarely have the highest EBV for any single trait!

BREEDOBJECT is a computer software package that can help breeders make these important decisions more objectively and more accurately. It is a selection tool for both the seedstock and commercial beef producer and requires the breeder to be able to objectively describe:

- the current herd performance for a range of traits,
- the costs of production in the current herd,
- the target market specifications,
- the returns for the traits affecting market specifications,
- the heritabilities of particular traits and the genetic correlations between traits and
- the alternative sires available to achieve these selection decisions.

The BREEDOBJECT output is a $Index that applies the weightings to a range of traits in combination to produce a single EBV value. These weightings apply pressure to the right EBVs to achieve the **greatest long-term herd profit**. The bulls can then be ranked for their $Index. The selection decision is based on the purchaser's assessment of the worth of the bull and ensuring that the bull has met the immediate fertility standards defined in a bull breeding soundness evaluation.

For example, a seedstock producer of a European genotype can produce an index for use on Brahman or Brahman cross females producing grass fed export steers and where the crossbred females are used for breeding. The relative emphases are displayed in figure 35. The growth EBV (600 day) and maternal calving ease get most pressure but scrotal size receives some attention because of its association with female fertility and as this is for a European breed there is some positive emphasis on fatness.

Since Indexes use BREEDPLAN EBVs, the weightings are calculated to maximise profit by

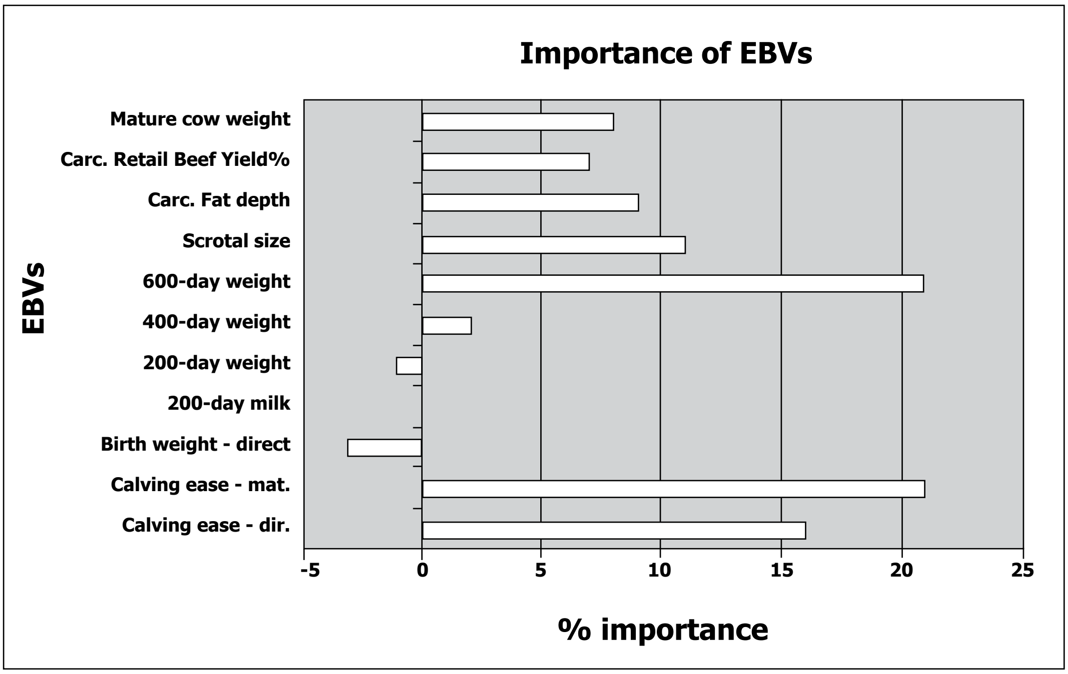

Figure 35. Weightings on the various traits to provide a $Index EBV.

emphasising the EBVs that are most related to profit. Simultaneously, they compensate for antagonisms (correlated responses) between traits e.g. the quest for higher yield may encourage a negative emphasis on the fat EBVs but the positive emphasis between fatness and females fertility will moderate the downward pressure.

Indexes can be constructed for any market production environment combination but the practicality is that standard (generic) indexes are used to represent the most common situations. These generic indexes are very useful for sorting potential sires on profitability for your herd. It may be necessary to slightly modify selections by looking at individual EBVs once you have examined the top ranking bulls on the index closest to your situation e.g. you may decide to reject a top ranking bull because he has birthweight that is too high.

BREEDOBJECT analyses have been available to the beef industry through accredited users of the package. In the near future, a customised web based version may be available for calculating a $Index. For further information contact your local Commercial Applications of Beef Genetic Technologies, QPIF officer or ABRI at Armidale, NSW.

Bull management

Having selected replacement bulls, there are a number of management practices that can be used to gain the most from them.

Dominance

In multiple sire herds, dominance by one bull may be such that a large proportion of calves may be sired by a small percentage of bulls. This can be avoided by using bulls of similar age and similar libido in the one mating group. Dominant bulls may endeavour to keep less dominant bulls away from the cows, yet they may not serve the cows themselves. High libido bulls often have a way of serving the females on heat and going before they are threatened. Therefore, all bulls used on property should be assessed using a BBSE.

Age

The older the bull becomes, the more prone he is to subfertility or even infertility, either due to some damage to the reproductive organs or physical problems, for example arthritis, which may interfere with service. Bulls also become more difficult to handle.

The longer it is possible to keep a bull in the herd, the more calves his purchase price can be spread over and a lower bull cost per calf results. It must be remembered, however, that while a bull is in the herd his own genetics is not improving and the benefits from keeping bulls longer, in terms of cost per calf, must be balanced against the opportunity to replace that bull with one that is genetically better.

Therefore to retain a bull in the herd to an old age, the bull must be fertile and be equal to, or better than, the most recent bull replacements for all genetic traits used in selection.

Disease

Bulls can transmit venereal disease such as vibriosis and trichomoniasis. Both cause either delayed conceptions or abortions. Only vibriosis can be prevented by vaccination and it is recommended that bulls be given complete vaccinations prior to first mating. All bulls should be vaccinated annually prior to mating or time of peak conceptions. Heifers may also be vaccinated for vibriosis with a similar vaccination program to that of bulls. Both diseases tend to be more prevalent in older bulls, although this is not always the case. If breeders are vaccinated for leptospirosis, the bulls should be vaccinated also to reduce the effect of infection at, or during, the mating period. Infection of a bull during a short mating season can have a serious effect on the herd conception and subsequent branding rates.

Other vaccinations may be worthy of consideration. These include tick fever, ephemeral fever (3-day sickness), mucosal disease and vaccination with the 5-in-1 package against the clostridial organisms such as blackleg and tetanus.

Bull percentages

Bulls should be mated according to their ability and the paddock characteristics, as there is no set percentage. Whilst a figure of 5% is often quoted, work at Mt Bundy Station in the Northern Territory found that high pregnancy rates could be achieved with a lower percentage providing infertile bulls were identified and culled. Field trials are indicating that bull percentages of less than 3% can be used, provided that the bulls are examined with a full bull soundness examination prior to mating.

The size of the paddock and the distribution of watering points also have an effect on bull percentages independent of the fertility of the bull.

As the number of bulls increase in any one multiple sire group, the percentage of calves sired per bull decreases. As the number of bulls decrease e.g. 2-7 bulls per mating group, the maximum percentage of calves per bull has ranged from 24 to 94%.

Culling bulls

Regular replacement maintains continued genetic progress. Whether they be purchased bulls or home bred, bulls should be given an annual screening prior to the peak mating period for conditions affecting their ability to produce offspring.

Nutrition

Not only should buying fat bulls be avoided, but bulls should also be maintained in good forward store working order (condition score 3 to 4) to achieve the best performance. It is interesting to note that working bulls can suffer some weight loss with little or no impact on libido. Over-fed and over-fat bulls often demonstrate depressed libido and can be at risk of contracting metabolic disease if required to work and with poor feed quality in the pasture.

The relocation of bulls from one site (at purchase) to another (your property) can not only result in depressed bull fertility due to a change in nutrition, but also exposure to a range of new diseases that can affect the bull's fertility. Therefore, we recommend that bulls be relocated in advance of when they will be used in the breeding program.

Bull purchase

Ask the vendor, where you buy your bulls, for their genetic information. If it is not available, endeavour to obtain that information as it will influence your future returns. Moreover, ask for the AACV Bull Breeding Soundness Evaluation certificate which will provide a basis for insurance and any subsequent changes in the bulls fertility.

In conclusion

In order to make good progress in your herd, wherever possible, select bulls based on sound breeding objectives with economically related genetic information in the form of EBVs, select for as few traits as necessary and those that are highly heritable. Above all, select bulls that are fertile and capable of passing the desirable genetic traits to the progeny.

Notes:

Bull Selection

Will assist you to:

- **Use key fertility measures included in a bull breeding soundness evaluation (BBSE).**
- **Define and seek the necessary genetic traits when selecting a bull.**
- **Use sound breeding objectives and**
- **Select more profitable sires for your herd.**

Bull Selection **examines the three traits to review when selecting; fertility, growth and carcase. The relative importance of each of these trait groups will vary according to the performance of the individual herd, the environment where the animals are managed and the producers target market.**

Performance measurement is necessary to maximise genetic gain in the beef industry. Enterprise profitability is intimately linked to the fertility of the herd and thereby the fertility of the sires as assessed by the BBSE. This publication gives you an invaluable insight into the use and implementation of performance measures available to assist you. It will guide you in carrying out visual, subjective assessment for traits that currently do not have easily defined standards set by cattle breeders. Selection decisions should be based on traits that are economically important, heritable, measurable and characterised by variation.

When selection decisions are based on values that reflect the true genetic potential of animals, the progress achieved will be permanent and cumulative. Programs such a BREEDPLAN assist with this. A fundamental part of BREEDPLAN is the pedigree system operated by breed societies in association with the individual animal records submitted by breeders. Bull selection and other titles in this set will assist you to understand and make the best possible use of this available information.

Information contained in this publication is the result of many decades of research and development by the Queensland Primary Industriesand Fisheries and organisations such as the Cooperative Research Centre for Cattle and Meat Quality. The latest outcomes of some of this work, such as DNA fingerprinting, gene marker technologies and net feed efficiencies, have been incorporated into this publication.

Along with Bull Selection there are three other companion publications produced by the Department of Primary Industries. These are:

- ***Breeding for Profit***
- ***Female Selection in Beef Cattle***
- ***Beef Cattle Recording and Selection.***

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