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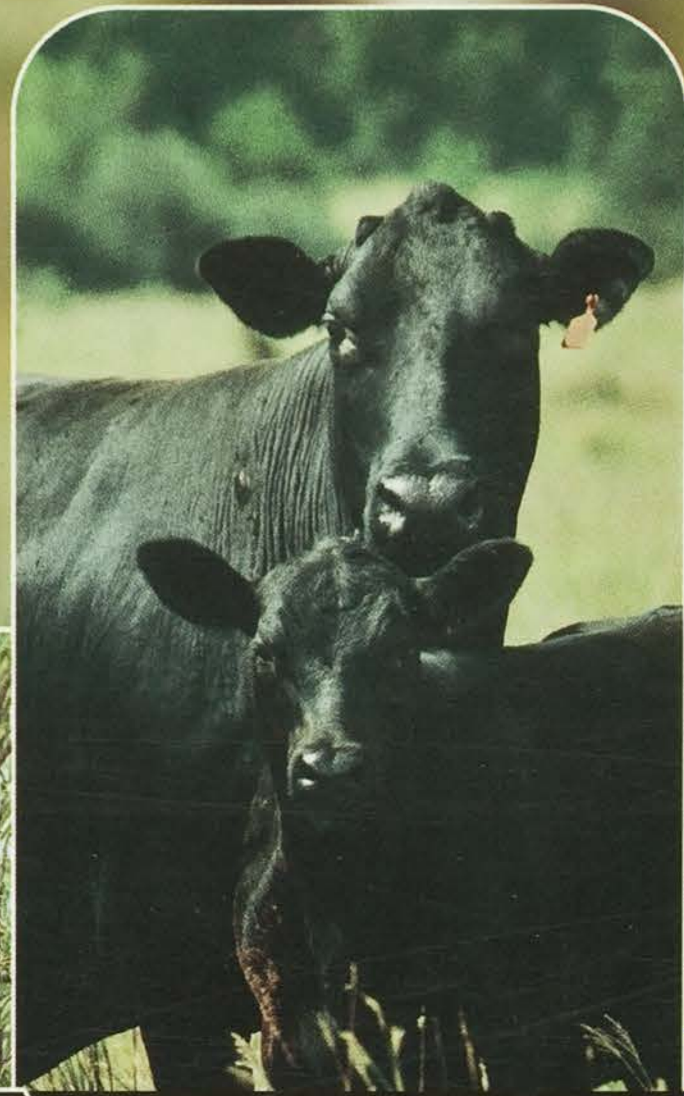

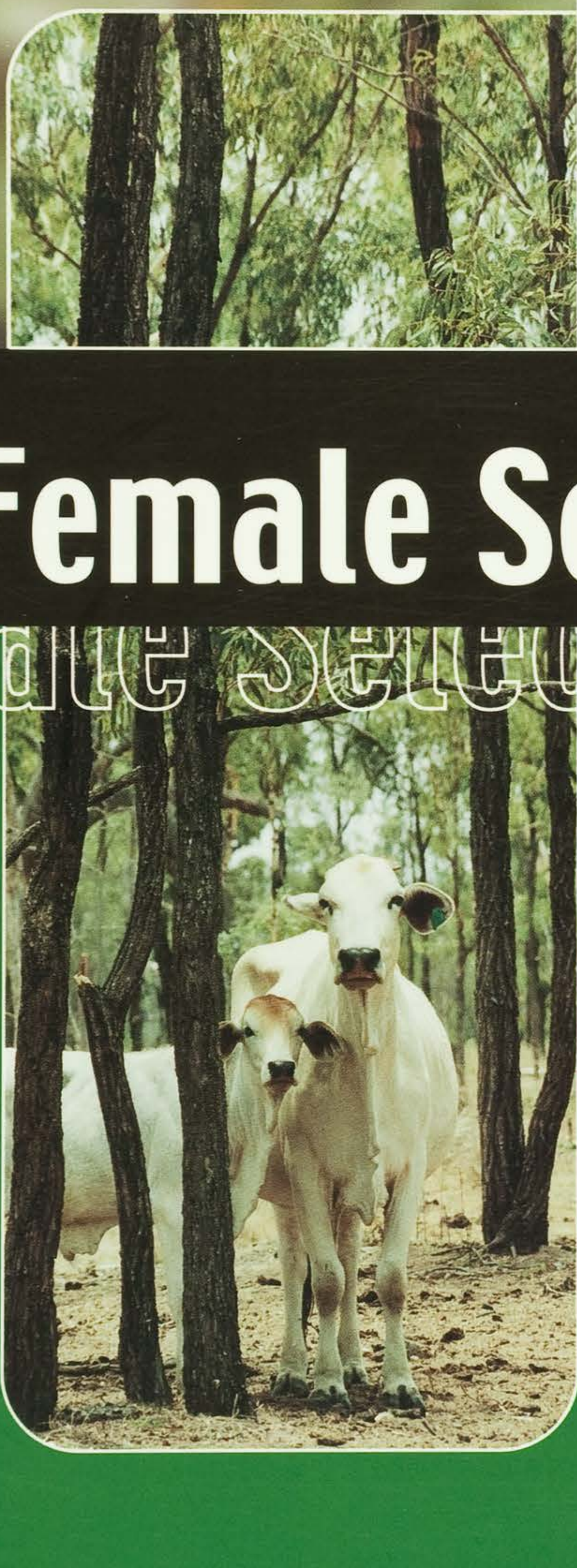

Female Selection

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in Beef cattle

Compiler

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Queensland Government
Department of Primary Industries

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Foreward

Females (maiden heifers and cows) comprise the basis of all beef breeding herds. Often the relative importance and contribution to the profitability of a beef enterprise by the females is understated.

Better beef breeding is achieved by a number of means. From a genetic viewpoint it is achieved through the identification and selection of superior males and females. This, coupled with a market-orientated approach to breeding and management, is essential if potential profitability is to be achieved. The aim of *Female Selection in Beef Cattle* is to provide a practical overview for beef producers on the principles of female selection.

Female Selection in Beef Cattle seeks to assist commercial and seed-stock producers to:

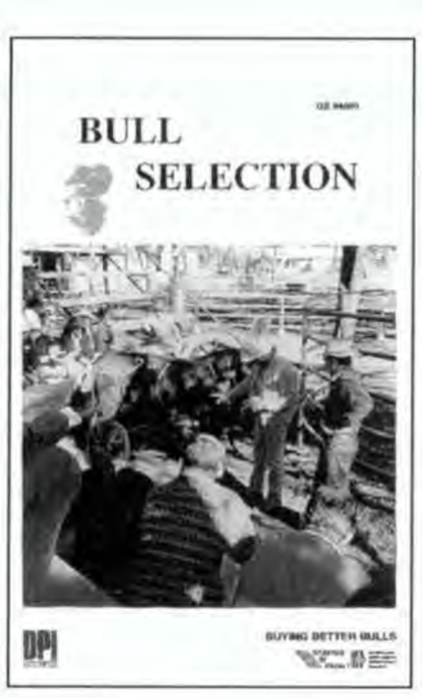
- understand the basis of female management and selection;
- better understand the relative contribution of female selection in the overall herd production;
- improve their skills in female selection and management.

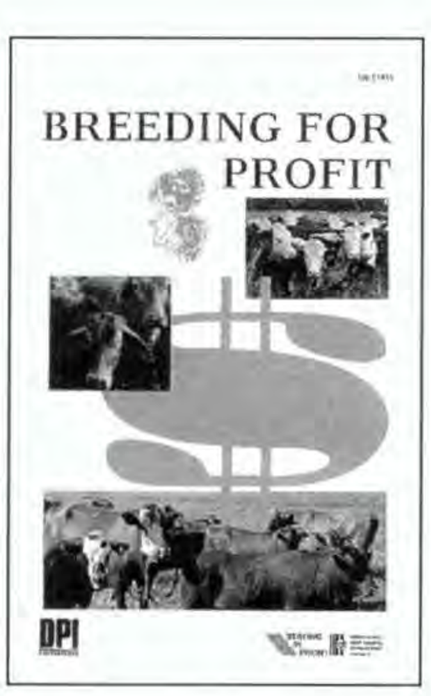
In addition *Female Selection in Beef Cattle* seeks to highlight the relative benefits and role of each female trait and the benefit of selection in planned breeding programs to meet market specifications. However, the book does not seek to be all-encompassing. Some important husbandry practices that impact on selection, and that selection impacts on, are either mentioned briefly or not at all. These practices include mating management, weaning management and nutritional management.

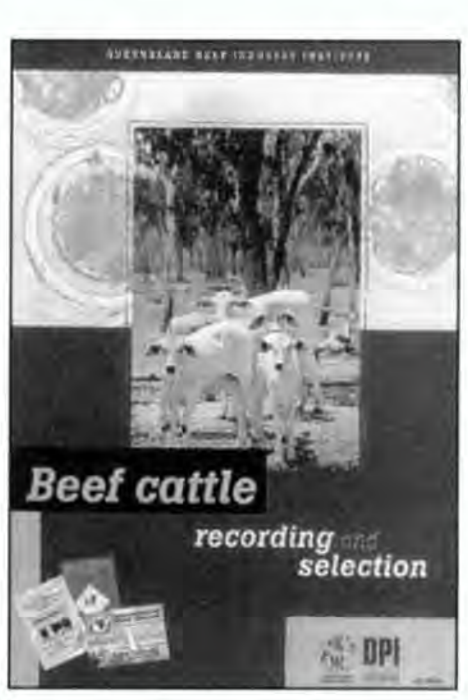
Female Selection in Beef Cattle is a companion publication to:

- *Bull Selection* (1992);
- *Breeding for Profit* (1993);
- *Beef Cattle Recording and Selection* (2000).

All of these publications have been produced by the Queensland Beef Genetic Improvement Project Team to assist beef producers to stay in front.







Introduction

The first and most important step in planning a balanced breeding program is to establish a clear set of breeding objectives.

To do this it is necessary to know:

- the production potential or capacity of the property
- the current production level of your herd
- the requirements of the market, or markets, you plan to supply
- limitations imposed by the environment.

Once the breeding objectives have been established the next task is to determine the selection criteria that will be utilised in the herd to meet the objectives.

To do this, list:

- traits of economic importance
- future production targets.

Selection criteria may include, among others:

- culling all non-pregnant females
- selecting bulls for high growth rates.

It is important to establish any genetic connection or correlation between traits through which selecting for one trait may have an effect on another trait. This effect could be positive or negative. An example is selection for growth rate, which may cause an increase in birth weight therefore increasing the incidence of dystocia (calving difficulty).

Selection criteria should be prioritised according to the economic importance of the trait.

Some selection criteria will be applied on an 'all or none' basis. Temperament may be such a trait where if an animal is deemed to be of bad temperament, it is culled irrespective of how it meets other criteria.

The herd manager should be aware of the influence female selection has on the whole herd. In a lifetime, a breeding cow may produce eight calves whereas a bull may sire 120 calves.

It is important to establish which aspects of herd management a herd manager can influence in terms of manipulating female production. These are:

- nutrition
- mating management
- genetics (selection)
- disease.

While nutrition has probably the greatest influence on female performance, it is not discussed in detail in this publication. This book will address:

- reproduction (the anatomy and how it functions)
- the value of selection
- selecting the right female
- tools that can assist with selection and culling.

1

Female reproduction

Introduction

A sound working knowledge of the reproductive biology of the bovine female is necessary to enable managers to control and improve the reproductive performance of cattle. Improved management of reproduction can increase economic returns to cattle producers.

Reproductive anatomy

The ovary

The primary sex organs of females are the ovaries. Ovaries have two functions. These are the production of sex cells and the production of hormones. The sex cells of females are called ova (eggs). Cows possess over 100 000 ova per ovary at birth. However, during a cow's lifetime a small number only will ever be fertilised and develop into a calf.

Hormones released by the ovary control behaviour and growth and development processes. These will be discussed in detail later.

A large part of female reproductive management involves management of the ovary.

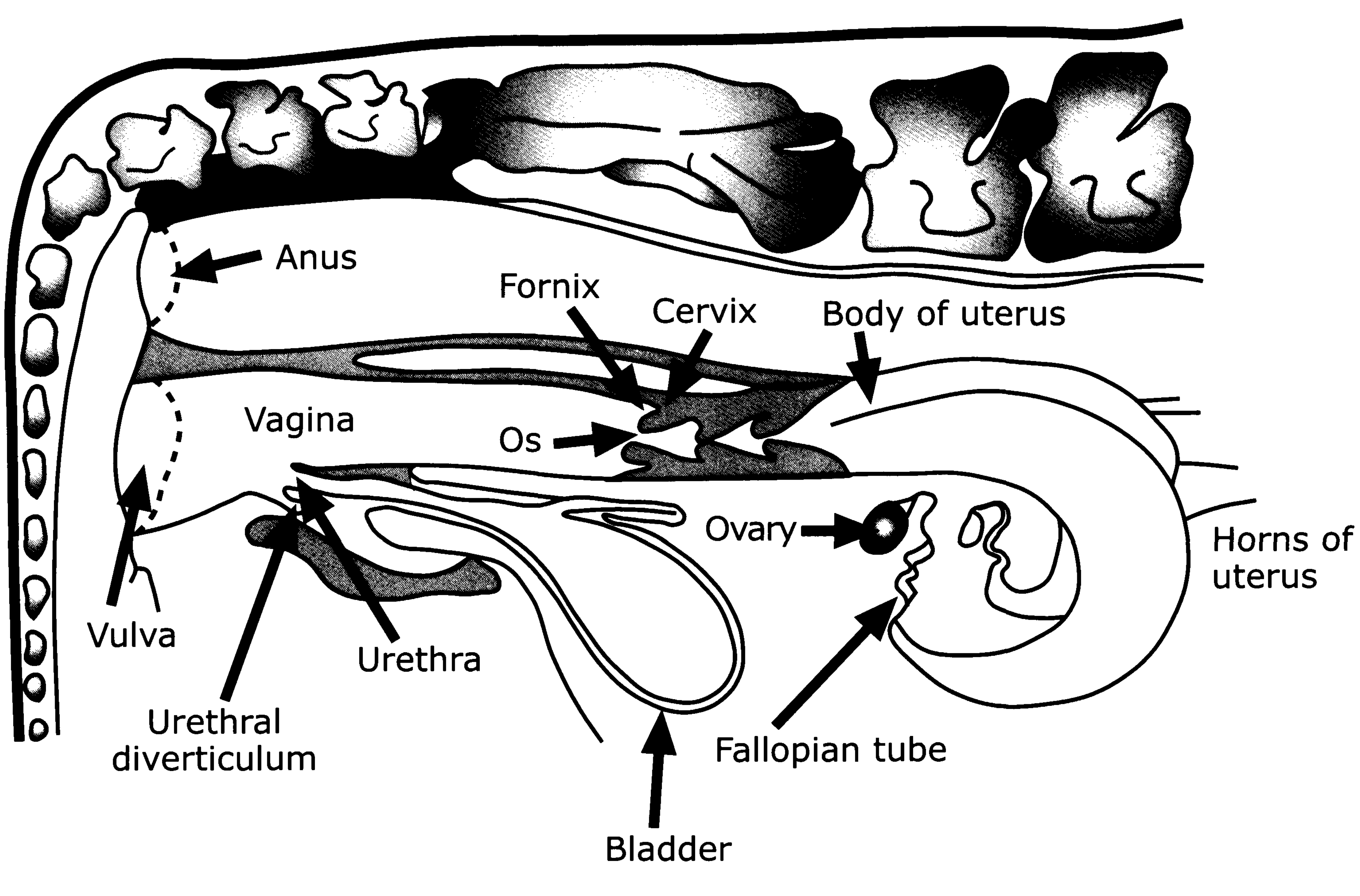


Figure 1. The reproductive tract of a cow

The size and shape of ovaries in cows are highly variable. Experienced pregnancy testers are able to feel the ovaries of a cow during rectal palpation. Ovaries are pea-sized or smaller in heifers that have not reached sexual maturity (puberty). At the onset of puberty they are approximately 2 cm long. Their size and shape after this is highly variable. On average in mature cows they are similar in size and shape to an almond.

The reproductive tract

The vulva (see Figure 1) is the visible part of the female's reproductive tract. It is directly under the anus and protects the entrance to the vagina. The vagina is about 24 to 30 cm long in most mature cows and is tubular in shape. During mating, semen is deposited in the vagina near the cervix. The cervix is a thick muscular tubular organ, which connects the vagina to the other parts of the tract. It can be felt easily during rectal palpation by an experienced operator.

In pre-pubertal heifers the cervix diameter may be less than 10 mm. At puberty the cervix in most heifers is between 1 to 2 cm in diameter. In older cows it may be up to 6 cm or more in diameter and 15 cm or more in length. The cervix increases in size with age and the number of calves the cow has had, and tends to be bigger in *Bos indicus* derived breeds. The cervix acts as a protective barrier between the vagina and the delicate tissues of the uterus.

The uterus (womb) divides into two horns about 2 to 4 cm from the cervix. The uterine horns curl forward and down and may be up to 40 cm in length. The calf will develop in either of the horns after fertilisation of the ovum has occurred in the oviduct (or fallopian tube). The oviduct connects the infundibulum to the horn of the uterus and the rest of the tract. The ovary is surrounded by the infundibulum and this catches ova released from the ovary and directs them into the fallopian tube. The whole reproductive tract is held in position by a sheet of tissue on either side called the broad ligament. This is also attached to the rectum.

Reproductive physiology

Successful reproduction involves cycling (regular heat periods), mating, conception (fertilisation of the ovum), gestation (pregnancy), parturition (birth) and lactation (suckling the calf).

Each of these steps is controlled by hormones. Hormones are chemical messengers that are released into the blood stream and have an action in another part of the body. The reproductive hormones of females are released by the ovaries and by a gland situated at the base of the brain —the pituitary gland. The release of hormones from the pituitary gland is controlled by a feedback mechanism involving hormones released from the ovaries and messages received from the higher brain. The higher-brain messages are influenced by body condition, nutrition levels and other signals.

The oestrous cycle

The cow's ovary develops ova (eggs) continuously throughout life in small fluid-filled blisters called follicles. Each individual egg (ovum) is thought to take about 6 months to develop. Most never reach full development and are simply re-absorbed. Development of ova prior to puberty does not require brain hormones. After puberty, hormones produced by the pituitary gland in the brain enable selected ova to complete development and be released from the ovary, i.e. ovulation. The follicle may be 10 to 15 mm in diameter just prior to ovulation. Most other follicles reach only 1 to 2 mm in diameter before re-absorption. Peak fertility in heifers does not occur until the second or third heat cycle, although some heifers will be fertile at their first heat and will conceive if mated.

The typical oestrous cycle of a cow takes 21 days, however the range may be 18 to 24 days.

Puberty

Puberty is defined as the age or stage of development at which animals can reproduce, i.e. sexual maturity. The age at which heifers reach puberty varies between individual animals, breeds and prevailing conditions, especially nutrition.

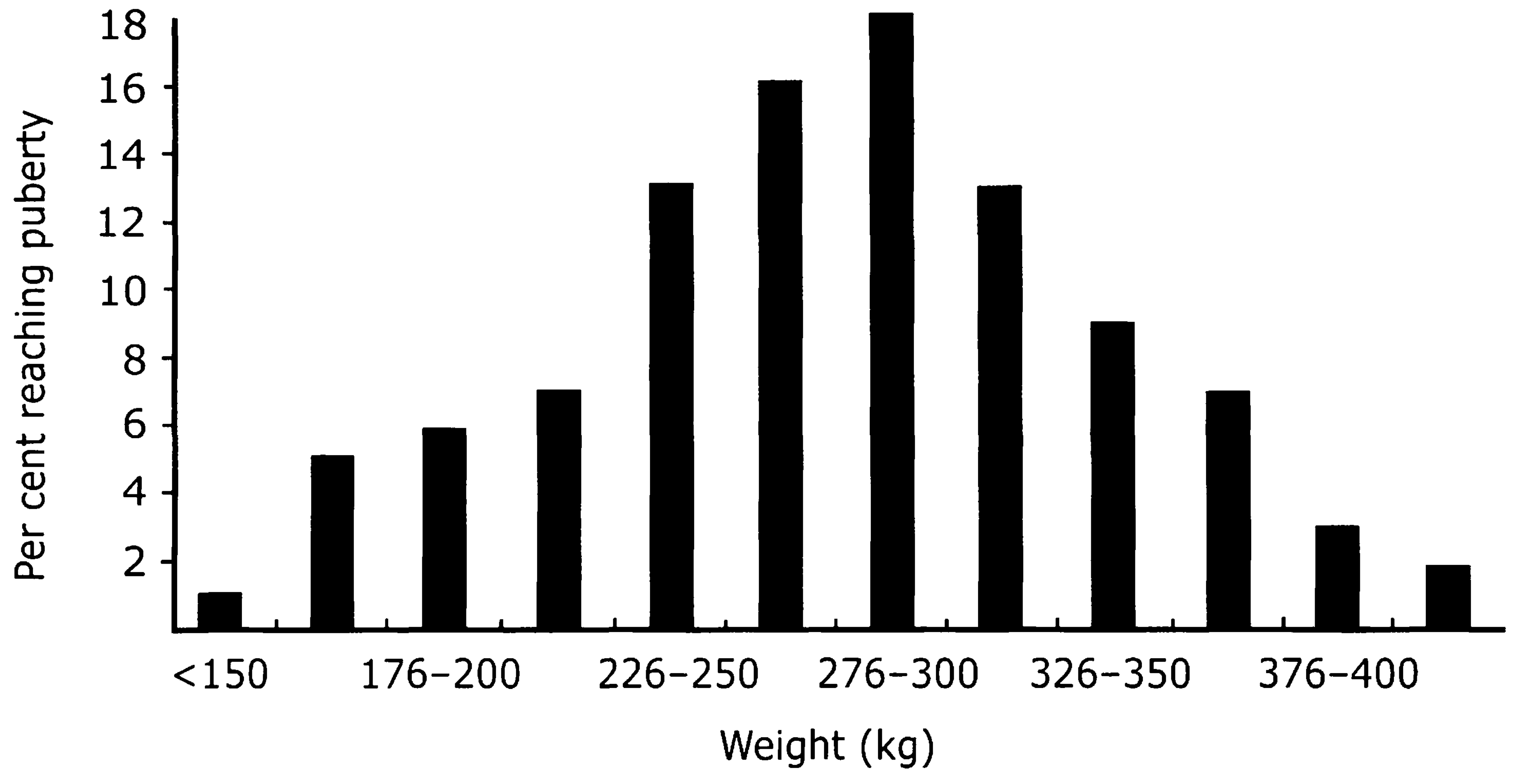


Figure 2. Weight at puberty in Brahman cross heifers in northern Australia (G. Fordyce, DPI Queensland, unpublished)

In temperate Australia where the conditions are generally favourable and growth rates are high, heifers reach puberty at lower weights and younger ages than is possible in harsher tropical environments such as those in northern Australia.

Yearling mating (usually between 13 to 17 months) may be a practical and desirable routine management option in good growth conditions. The so-called 'critical mating weight' of 280 kg for most British breeds of cattle is used as an indicator that most heifers have reached sexual maturity. It is used because at this weight 85 per cent or more of heifers will have commenced to cycle if grown under good nutritional conditions. The variation of weight-ranges at which heifers commence to cycle may be as little as ± 25 kg in good growth-rate conditions.

The situation is different in harsh tropical areas where DPI research has demonstrated a wide weight range for the onset of puberty of ± 100 kg (refer to Figure 2). First oestrus (cycling activity) was detected in 95 per cent of animals of weight range 175 kg to 375 kg and age range of 13 months to 33 months. In general the harder the conditions and the poorer the nutrition the longer the delay to onset of puberty. Cycling commences at much higher weights and ages under poor nutritional conditions than under good growth conditions.

The median age of onset of puberty for Brahman-cross heifers in northern Queensland was 20.5 months and at a weight of 285 kg, i.e. at this weight only half the animals had commenced cycling. However, because heavier weights are usually achieved by the commencement of the wet season, most will have grown sufficiently to reach puberty and be successfully mated by the end of the wet season. The average weight at puberty in good seasons at Swans Lagoon was about 260 kg and in poor seasons was around 300 kg.

In northern Australia, yearling mating (under 18 months) of *Bos indicus* heifers will result in about 20 to 30 per cent of them going into calf during a three month mating period. The range will vary from 20 to 80 per cent depending on the season and management. Low level supplementation may boost results by up to 15 units. In more favourable environments, 70–90 per cent successful conceptions may be realistic from a short mating period.

Mating

The mating period of the oestrous cycle in which the cow is receptive to and seeks out and attracts bulls is referred to as oestrus or heat. Oestrus lasts for an average of about 18 hours in cows and 12 hours in heifers. The normal range of oestrus is from 6 to 30 hours. *Bos indicus* females and cattle in hotter environments tend to display heat signs for a shorter period of time.

During heat females display typical behavioural signs that are caused by the large amounts of oestrogen (female hormone) produced by the follicle prior to ovulation, acting on the brain. These signs include chin resting, mounting other cows and standing to be mounted, as well as causing the cervix and uterus to release large amounts of clear stringy mucus commonly known as bulling strings. Other visible external signs of sexual activity include the vulva becoming reddened and swollen, hair being ruffled up on the tail and rub marks on the tail head and pin bones.

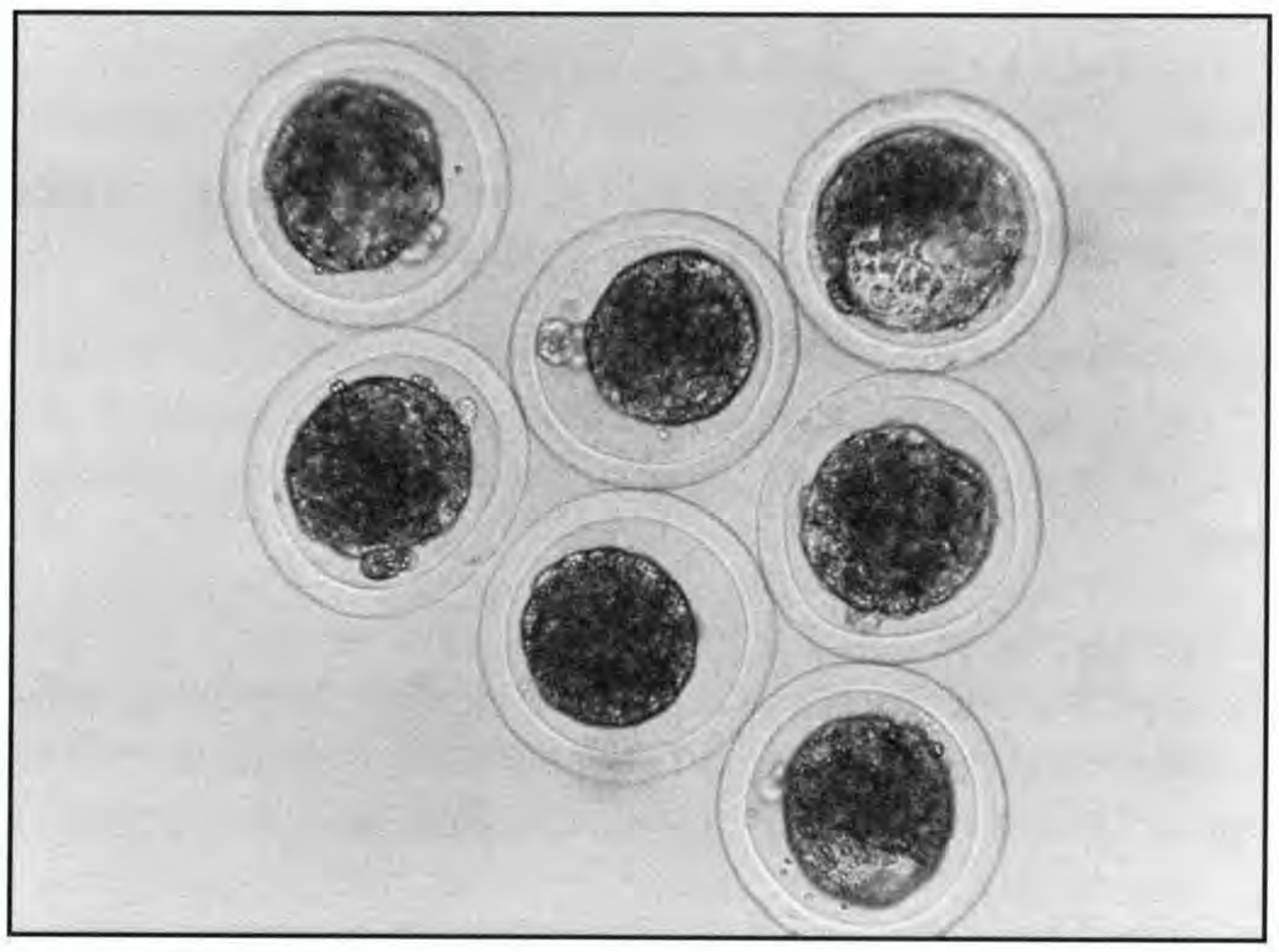


Figure 3. Cattle embryos.

Conception

Conception is the successful fertilisation of an egg by a sperm following ovulation. Ovulation is triggered by luteinizing hormone, which is released from the pituitary in the brain. Ovulation usually occurs about 12 hours after the signs of oestrus have finished. However the range may be 2 to 26 hours. The delay in ovulation following the signs of oestrus ensures that sperm have spent at least 1 to 6 hours inside the female reproductive tract prior to the egg travelling down the oviduct for fertilisation. This time allows the sperm to undergo a process called capacitation that enables fertilisation to occur. Capacitation changes the make-up of the head of the sperm making it able to fertilise an egg successfully.

Fertilisation must occur within 6 hours of ovulation. After this time non-fertilised ova degenerate or if fertilised, result in non-viable embryos. After fertilisation the embryo takes 6 to 7 days to travel down the oviduct and enter the horn of the uterus where it implants.

After ovulation the empty follicle in the ovary fills up with yellow-orange tissue which after 5 days forms the corpus luteum (yellow body). The corpus luteum produces progesterone, which is necessary to maintain pregnancy. After 5 to 6 months of pregnancy other structures such as the placenta, which becomes the afterbirth, produce enough progesterone to maintain the pregnancy. Progesterone also acts on the cow's brain inhibiting the release of pituitary hormones and preventing pregnant cows from showing oestrus signs.

If the cow does not become pregnant, the uterus will release prostaglandins about 16 or 17 days after ovulation. Prostaglandins dissolve the corpus luteum and thus prevent further production and release of progesterone. Subsequently, follicle stimulating hormone (FSH) is released from the cow's pituitary gland causing a new reproductive cycle to start. FSH enables one of the smaller developing follicles (1–2 mm diameter) to grow to a sufficient size for ovulation.

A female will continue to cycle every 21 days unless she becomes pregnant or suffers nutritional stress that causes the brain to lower production of hormones from the pituitary gland.

Pregnancy

The embryo leaves the oviduct and enters the uterus by day six or seven. A few days later the embryo attaches itself to the uterus wall. The embryo then releases a chemical signal alerting the cow's system to its presence. This prevents the cow's uterus releasing prostaglandin, which would dissolve the corpus luteum and cause the pregnancy to terminate.

Not all conceptions result in pregnancy. Normally about 25 per cent of embryos are lost within 17 days from conception. This is most likely due to minor genetic defects or the embryo not being viable enough to send a strong chemical signal to the cow's hormonal system. Realistically a 75 per cent pregnancy rate is all that can be achieved from a single cycle. This explains why three cycles or more (9 weeks minimum) are needed to achieve up to a 95 per cent pregnancy rate.

Increased embryo losses up until 17 days may be expected where the cow is under stress from extremes of temperature, poor nutrition or disease. In most cases these early embryonic losses are thought to be just a failure to conceive, because the cows will return to oestrus at their normal time.

Pregnancy failure after 17 days should not exceed 3 per cent. Losses above this level should be investigated as they may involve diseases such as Vibriosis, Trichomoniasis or Leptospirosis.

Cows have an average gestation period (pregnancy) of 283 days, with a normal range of 270–295 days. Some breeds, such as Jersey, have shorter gestation lengths while European breeds may have longer gestation lengths. *Bos indicus* cattle usually have the longest gestation at about 290 days. Male calves are usually born one or two days later than female calves.

Twinning occurs in about 2 in 1000 births in *Bos indicus* cattle and their crosses, but in up to 30 in 1000 births of dairy cattle. In 90 per cent of twin pregnancies, a shared blood supply occurs between the calves. If there is a male and female calf, hormones produced by the male foetus between days 80 and 120 of pregnancy can disrupt development of the female calf's reproductive tract, resulting in a condition called freemartinism. Freemartins have external masculinisation and are usually missing segments from the reproductive tract. They are infertile and should be culled. Ten per cent of mixed-sex twins result in a normal female.

Parturition

Parturition or birth is initiated by the calf not the cow. On reaching a certain stage of development the calf's brain releases a stress hormone called corticosteroid hormone and this starts the birth process. The timing of parturition is partly heritable. This means that gestation length can be altered by selection.

The birth process involves and is under the control of many hormones. The release of corticosteroid hormone by the calf causes the cow's uterus to release prostaglandins. Prostaglandins dissolve the corpus luteum, help dilate the cervix and also cause contraction of the uterus. The hormone relaxin causes the pelvic ligaments to relax. It is this hormone that causes the looser walking action and the tail appearing to be set higher when the cow is 'springing'. Oxytocin causes the stronger uterine contractions that occur in late parturition. Oxytocin is also the milk let-down hormone.

Most calves are presented with the forelimbs extended and the head resting on or between them. If the hind legs are presented first it is referred to as a breech birth. The birth process is complete when the placenta (afterbirth) is expelled.

Most calf mortalities occur within one week of birth. Calf losses of up to 10 per cent between confirmed pregnancy test and weaning may occur in harsh environments. Losses occur for a variety of reasons and include calves being born dead or weak due to dystocia, diseases and other stresses or a failure of the cow to 'mother' the calf, including lactation failure. Predation is a problem in some areas.

Lactation

The ability of a female to lactate is a key determinant of calf survival and the weaning weight reached by her calf. The feed and energy requirements for a cow during late pregnancy and lactation are very high. Producers can gauge this by assessing change in the cow's condition score.

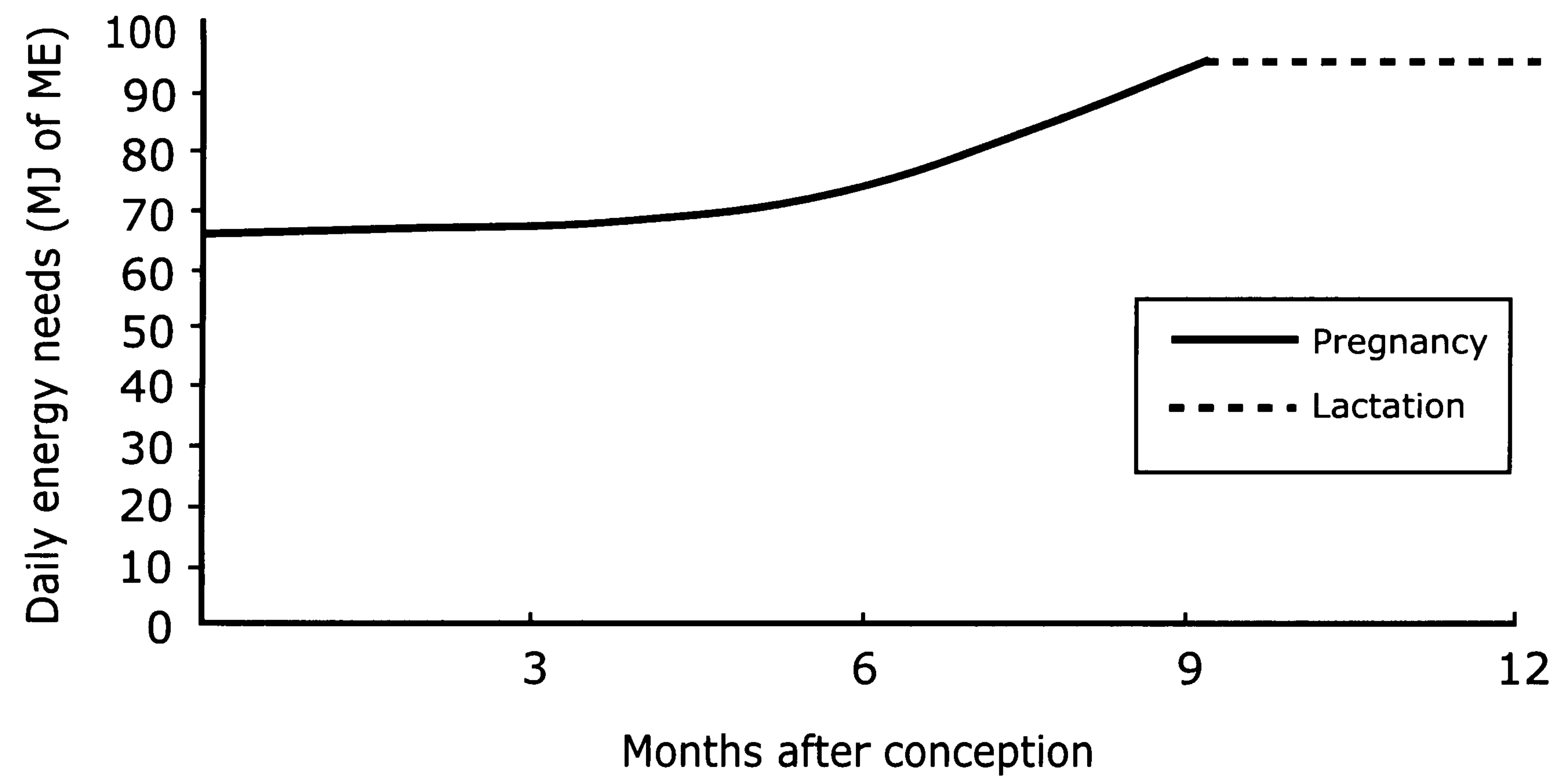


Figure 4. Daily energy demands for a 400 kg Brahman cross cow maintaining condition (calculations by G. Fordyce, DPI, Charters Towers).

Cows can partially compensate for this extra energy requirement during lactation by increasing feed intake. This increase may be as much as 20 per cent. In conditions of good nutrition this extra intake may be enough for the cow to maintain (or in exceptional cases even increase slightly) body weight and condition while supporting a calf. This may occur in northern Australia for cows calving in the wet season.

Because of the energy demands of lactation, optimum cow performance is achieved when managers match the cow's lactation with the period of best nutrition. Cows calving in adverse times such as the dry season will attempt to overcome their energy deficit by drawing on body reserves (losing weight and condition) and by producing less milk.

Calf growth-rates suffer under these conditions. At Swans Lagoon (dry tropics) in northern Queensland, suckling calves typically grow at 0.8–0.9 kg/day in the wet season. However, this reduces to 0.5 kg/day in the early part of the dry season, and to only 0.3 kg/day late in the dry season.

Nutrient deficiency (protein and energy) is most extreme late in the dry season. At this time, the dry matter intake of unsupplemented late-pregnant or lactating cows on a typical poor quality pasture is about a third to a half of needs. Cows in this situation will lose weight at rates as high as 1.25 kg/day.

Return to cycling after calving

A cow's return to cycling is affected by her nutritional and lactational state. After calving, it takes at least 3–4 weeks for the reproductive tract to resume normal size before cycling can commence. The first cycle after calving is generally weak, shorter than normal, and of low fertility. Few cows will conceive if mated then. Therefore, as pregnancy lasts approximately nine and a third months and a percentage of embryonic loss is normal, cows need to cycle within two months of calving to have a reasonable chance of a twelve month intercalving interval. The average interval between calving and cycling is about seven months in northern Australia where the average weaning rate is about of 55–60 per cent. This is mainly a result of poor nutrition, lower fertility and extended suckling.

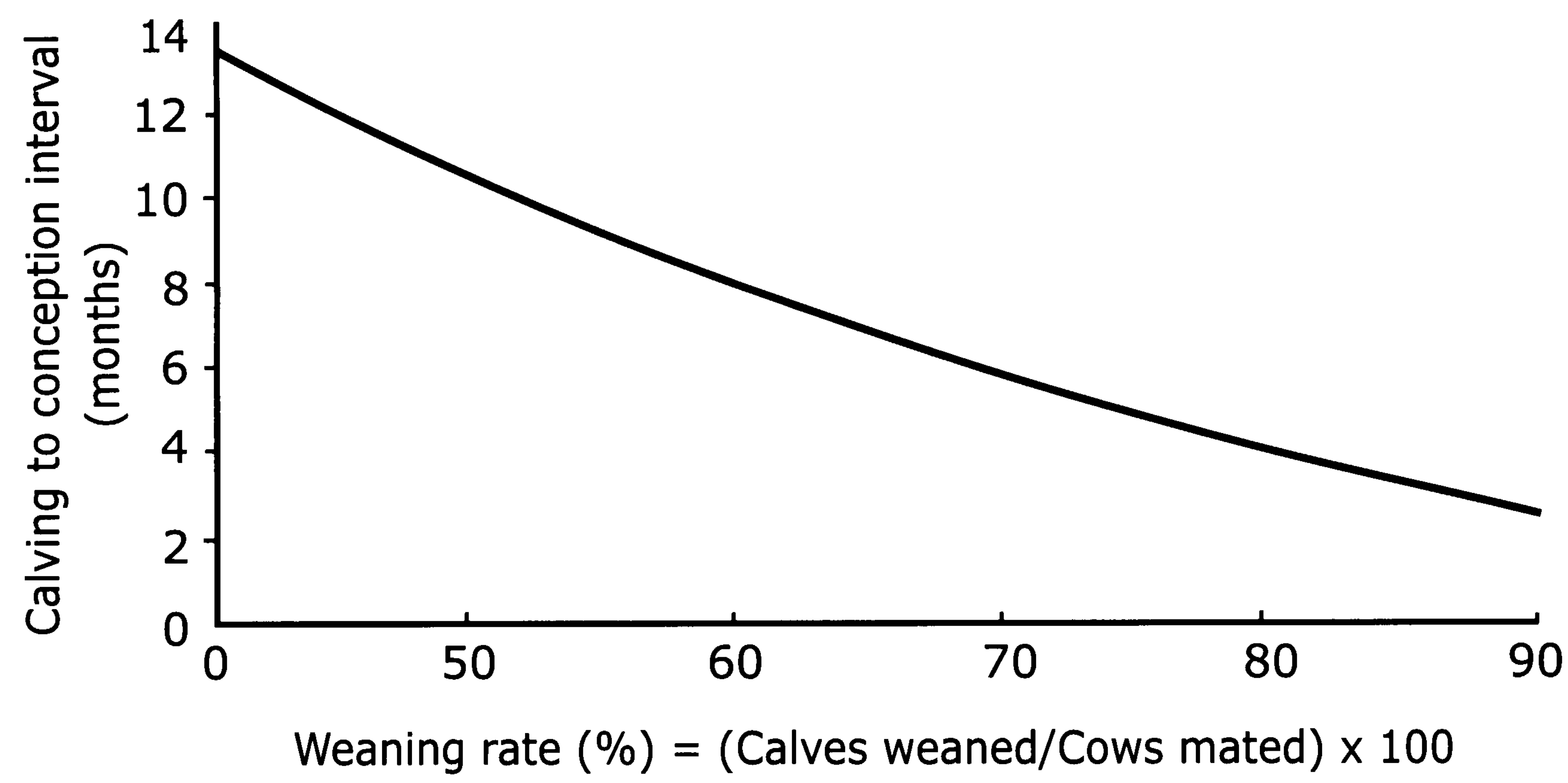


Figure 5. Weaning rates and estimated post-partum anoestrous intervals for continuously mated northern Australian beef herds (Calculations by G. Fordyce, DPI, Charters Towers).

Figure 5 shows that to achieve an 80 per cent weaning cows must conceive within four months of calving. To cycle, the cow must have a population of healthy developed follicles that can ovulate with appropriate support. Nutrition is the primary regulator of follicle development. When the ovaries have reached a state where ovulation can occur, it does not proceed automatically. While nutrition has further effects on follicle growth, suckling has the most powerful influence on follicle development, as explained in the following sections.

The effect of nutrition

As the energy status of cows declines over the dry season, follicle growth in their ovaries is retarded. This is the primary reason why cows in poorer condition take longer to reconceive after calving and have lower pregnancy rates at weaning. To avoid this situation, producers can use management techniques (e.g. weaning, lower stocking rates, seasonal mating, supplementation) to hold the weight and condition on cows over the dry season, thereby ensuring normal follicle growth. Usually the increased value of the calves realised far outweighs the cost of these management inputs. However the factors of compensatory gain, pregnancy rate effects and the salvage value of cows need to be considered when costing any supplementary feeding regime.

Follicle development never ceases and occurs even during a pregnancy in preparation for the subsequent pregnancy. Ovulation is prevented during pregnancy and all follicles are reabsorbed. If follicle development is retarded by nutritional stress, a high-energy diet is required before advanced, healthy follicle development is restored.

To avoid fertility problems caused by cows grazing poor-quality pasture prior to calving, they can be provided with an energy-protein supplement, such as cottonseed meal or molasses with urea (fortified molasses) for at least 50 days prior to calving. This will restore follicle growth when it has been severely retarded. This is called spike feeding. If there is a break in the season soon after the supplementation period, advanced follicle growth is retained into the period after calving, thus enabling earlier conceptions and higher conception rates before weaning.

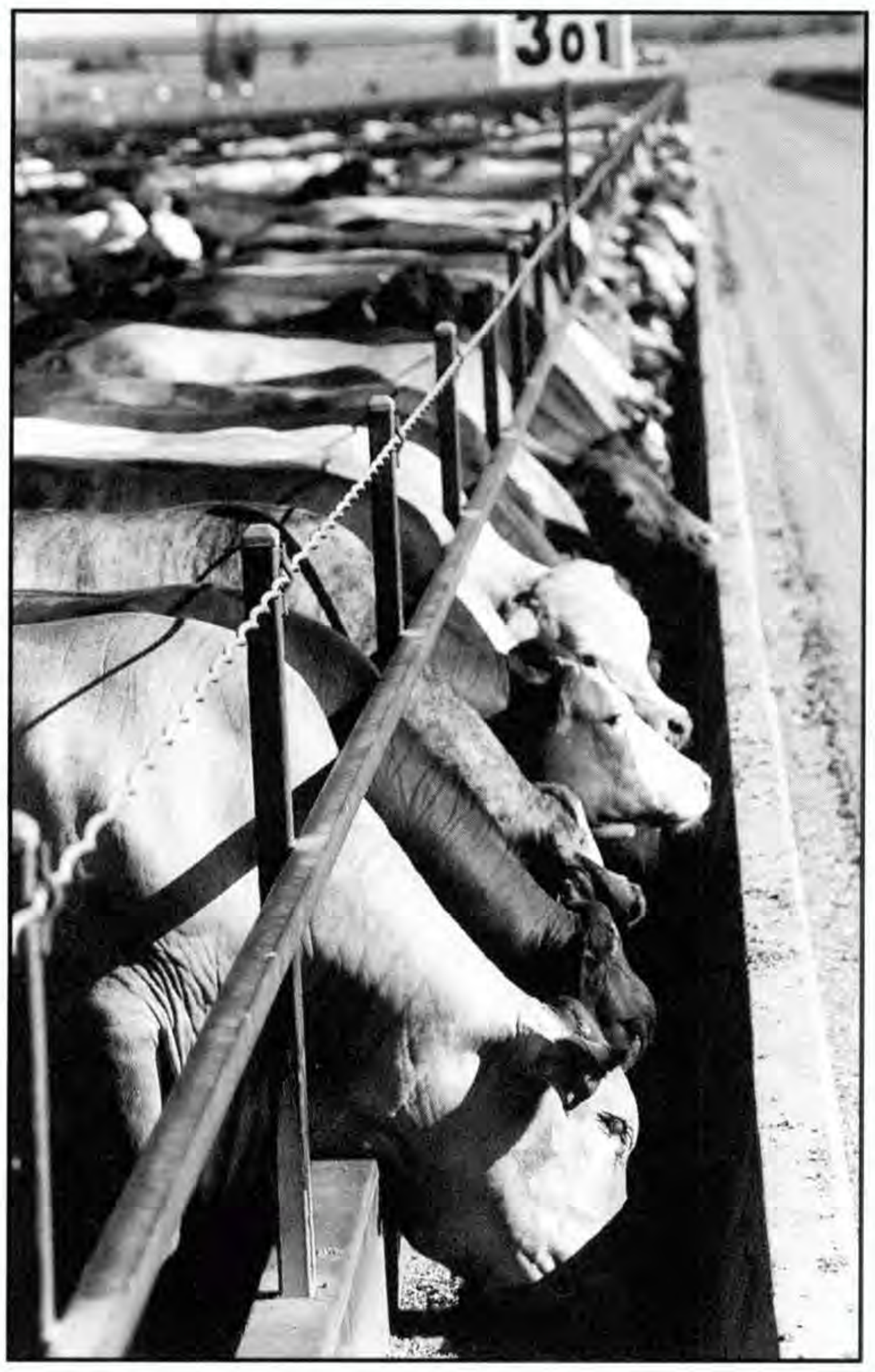


Figure 6. Cattle taking supplementary feedstuffs.

If the provision of high-energy supplements to restore follicle development is deferred until after calving, feeding needs to continue for at least two months. Many studies have confirmed that during lactation, cows tend to direct nutrients into milk production. Cow and calf growth will improve but fertility responses will be very slow. Therefore this form of supplementation is usually uneconomic.

The Effect of Suckling

Suckling suppresses the release of reproductive hormones from the brain, and therefore the cow's ability to cycle. As well, there is the diversion of energy into milk production. Once suckling stops, a cow will often rapidly recommence cycling. Weaning practices that enable cows to hold better condition through the dry season will improve the probability of conception by reducing nutritional stress.

Temporary weaning for 48–72 hours, has received much unwarranted publicity as a method of improving fertility. Temporary weaning has achieved significant responses in some situations, but it would seem to be only a chance effect. A further complication is that if temporary weaning does trigger the first oestrus after calving, this is a short and relatively infertile oestrus. The only time temporary weaning is recommended is when used in conjunction with specific oestrus synchronisation methods (using progesterone type therapy) in artificial breeding programs for lactating cows.

It has been suggested that creep-feeding of calves will reduce the potency of the suckling effect and enable an earlier return to oestrus. However research to date suggests that there is generally no improvement and creep-feeding under extensive management conditions is not recommended.

General management

The preceding information describes the basic biology of producing a calf. Animal needs must be synchronised with the available resources and markets to achieve production objectives. Following extensive research, financial analyses, demonstrations over many years and on-property experience, very productive management systems are available for all regions.

Female mortality is a widespread problem particularly in extensive areas. For many years, the ratio of females to total turn-off in Queensland was about 35 per cent, indicating overall an annual death rate of 10 per cent. Improved management has seen the total annual female turn-off rate increase to 40 per cent. The most cost-effective way of improving profitability in many herds has been to reduce female mortalities. The main ways this can be done are by reducing stocking rates, better weaning practices, vaccination, and strategic supplementation in combination with segregation for targeted management.

Nutrition

Beef production from grazing animals is about turning pasture into beef of good eating quality. Pasture is the cheapest feed available. Therefore, good cattle control, ensuring cattle have sufficient feed to satisfy requirements, and provision of well-placed, good-quality waters are the basics of successful cattle management.

Nutrition (pasture quality) is rarely optimal. There are two primary ways of dealing with pasture nutrient deficiencies (apart from improved species and the inclusion of legumes): management and supplementation. Management options include adjusting stocking rate, segregating, controlling mating, weaning at the best times, and selecting the right genetic material. Supplementation (usually with various combinations of nitrogen, sulphur, phosphorus and energy, depending on the time of year and region) can be expensive

Breeding

The right cattle are those that will produce efficiently on the country available under the management imposed, and satisfy identified market needs. In areas where nutritional stress is regularly severe and particularly where there are other environmental stresses such as parasites and heat, a higher level of tropically-adapted breeds (e.g. Zebu and/or Sanga) should be used to reduce costs and increase production. Zebu or Sanga content must be balanced against the higher production potential of British and European breeds in better environments.

Mating

In areas with better pasture production, seasonal mating is often used to restrict calving, thereby concentrating breeder and weaner handling times and producing more uniform lines of weaners of cattle of a similar age. In areas with poor or seasonally poor pasture the prime objective of seasonal mating is to prevent dry-season lactations. It is preferable that cows lactate during the pasture-growing season. This will also produce the heaviest weaners and improve the chance of cows having a calf every year. The time to start mating is more critical than the length of mating. In some regions, continuous mating of cows from their second joining onwards may be the best practice.

Weaning

In well-managed herds in good environments, cows should be pregnant at weaning. However, for those cows that are still not pregnant at weaning, the cessation of lactation will in many cases trigger cycling. In poor seasons earlier weaning can improve conception and preserve body condition thus reducing the cost of managing cows and ensuring survival. The weight and condition advantage is carried into the next mating season, and can substantially improve conception rates. However calves weaned at a young age must be managed to ensure that they continue to grow.

Herd health

A number of diseases and parasites have the potential to reduce the profitability of Queensland beef herds. Fortunately, with good cattle management and the strategic use of vaccines, a very high level of herd health is easily maintained. More information on herd health can be obtained from your local Stock Inspector, Veterinary Officer or private veterinarian.

Heifers

Harsh environments

In the dry tropics of northern Australia, pregnancy rates of maiden 2-year-old heifers are often below 50 per cent. As well, initial lactation often occurs during the dry season, thus reducing both survival and subsequent fertility. To counter these problems, an appropriate heifer management philosophy is that heifers and young cows up to 3.5 years of age require special management. Good management achieves early puberty, high weaning rates, low mortalities, and early identification of females for turn-off. Only efficient, easy-care breeders enter the cow herd at 3.5 years of age.

The following is an example of a system that maintains separate management for cows and heifers. Two main heifer paddocks are required; one for weaners up to 18 months of age, from where they are transferred to a second larger paddock for the following two years. Small heifers are segregated until heavy enough to join older weaners.

A restricted mating period of 3–4 months is recommended for heifers even where mating of cows is continuous. Yearling mating, if managed well, can increase calf output of a herd by 5 units at little cost. All calves are weaned at the end of mating. Supplementation may be used very effectively as the cattle are segregated into ideal target groups. At 3.5 years of age, young cows are either transferred to the main cow herd, or turned off.

Areas with good nutrition

The same principles apply to heifer and young cow management as in harsh environments. However, because yearling mating is virtually the norm and heifers reach mature weights much earlier, then young cows enter the main herd at 2.5 years of age. Weight at puberty is usually less than 280 kg for British breed cattle.

Some differences in management are:

- supplementary feeding to achieve post-weaning growth of 0.5 kg/day may be a viable practice;
- undernutrition during the first half of pregnancy should be prevented as it may limit pelvic growth and result in dystocia (calving difficulty);
- mating should be generally for 9 weeks only. It may be started a month earlier than for cows as long as feed quality is appropriate around calving;
- weaning should be carried out in parallel with weaning for cows, or slightly earlier;
- use of yearling bulls or low birth-weight EBV bulls.

2

The value of female selection

Introduction

The females that make up the breeder herd in a beef cattle operation comprise the profit-generating factory of the enterprise. In any factory, profitability depends on the number of units produced and the relative value of each of those units less the costs to produce them, i.e.

Profit = Turn-off numbers x Sale prices received - Costs.

The female herd affects all parts of this equation. Through female selection, producers can improve fertility, weight of calf weaned, the subsequent growth of weaned animals and the ultimate value of the sale animals through carcase quality etc. Improvements in fertility and survival will increase the turn-off numbers. Selection for environmental adaptation, growth rates, temperament, structural soundness and carcase traits will affect the price achieved or the relative value of turn-off animals. Factors such as environmental adaptation, including resistance to diseases and parasites and increased growth rates will affect the cost to produce each animal to turn-off weight.

The focus of the herd manager should be on breeder-herd selection and management decisions that improve long-term herd profitability.

The most rapid progress in genetic improvement of a beef herd is achieved through accurate and effective bull selection. On average, each sire can have a genetic influence over about 50–150 calves during his working life, while each female passes on her genetic make-up to about 5–10 progeny in her lifetime. However, because of the number of females and their critical relationship to the environmental constraints of the property, for example carrying capacity, they absorb many of the resources involved in herd management. This is justified because many of the gains made by the breeder herd result from changes in management, for example, nutrition of the improved breeders.

Beef producers spend many hours selecting heifer replacements and assessing mature females for retention in the herd. Selection is by either visual (subjective) means or by using a mixture of visual traits and measured (objective) traits, for example pelvic measurement and pregnancy test results. When we 'look over' a herd from either a management perspective or as a visitor to a beef enterprise, we notice:

- the visible characteristics of the breeder herd (e.g. breed, colour and what they look like);
- the suitability of the turn-off animals for the targeted markets (e.g. age variation, weight, finish, breed and other market specifications).

The breeder herd represents 'the stamp' of the management decisions made in combining the environmental constraints of the property, the management decisions made in focussing on markets, the genetics of the individual animals and the breeds used, and the opportunities available to the manager for selection.

Reproductive efficiency

Probably the most important factor affecting the profitability of a beef cattle breeding operation is reproduction, particularly with the trend to reduce turn-off age.

In addition to the immediate financial losses resulting from low reproductive performance, there is a reduction in genetic progress in the herd. A poor calving performance produces fewer heifers from which to select needed replacements. Consequently, the options are to retain inferior heifers, defer the culling of poor performing cows or resort to purchasing additional replacements. Regardless of the value or potential of a cow, she is a failure if she doesn't rear a weaner regularly. What 'regularly' means will depend on the type of country on which the herd is run. On good country, regularly may mean producing a calf every 12 months. However in harsher environments such as in northern Australia, this may mean every 18 months or cows producing two calves every three years. The important point is that the herd performance must be compared relative to other herds in the same region or type of country.

Producing a healthy weaner from each cow every 12 months requires sound skills in planning, selection, feeding and reproductive management. Inadequate nutrition, disease and poor management of the breeding herd can result in a drastically reduced calving percentage.

To evaluate the reproductive management of a beef herd you need a measure of reproductive efficiency. Calving percentage is generally used to express breeding efficiency and is calculated by dividing the number of live calves born by the number of cows joined and multiplying by 100.

$$\text{Calving percentage} = \frac{\text{calves born}}{\text{cows joined in previous year}} \times 100$$

The average calving percentage on individual beef properties in Queensland usually varies between 55 and 85 per cent, indicating that reproductive efficiency is an important economic problem for many beef producers. Calving percentage doesn't give the total economic picture of the breeding herd. Terms such as the percentage of calves weaned or weight of calf weaned per cow joined provide a much better measurement of reproduction, feeding, selection and management.

$$\text{Weaning percentage} = \frac{\text{calves weaned}}{\text{cows joined in previous year}} \times 100$$

$$\text{Weight of calf weaned per cows joined} = \frac{\text{total weight of all calves at weaning}}{\text{number of cows joined}}$$

While a herd may have high individual weaning weights, the percentage of calves weaned has a marked effect on the weight of calf weaned per cow joined, as shown in Table 1.

Table 1. Effect of calving percentage on average weight of calf per cow joined

Average weaning weight	260	220	180	150
Calving percentage	Average weaning weight/Cow joined in previous year			
100	260	220	180	150
90	234	198	162	135
80	208	176	144	120
70	182	154	126	105
60	156	132	108	90

For example, if average weaning weight of a herd was 220 kg and the calving percentage was 80 per cent, the average weight of calf weaned per cow joined would be 176 kg.

What is achievable in any beef enterprise depends on a number of factors. In very good environments it may be possible to achieve 90 per cent weaning rates coupled with average weaning weights of 260 kg. This equates to 234 kg of weaned weight per cow in the breeding herd. However in harsher conditions only a 70 per cent weaning rate may be possible. With an average weaner weight of 180 kg, this equates to 126 kg of calf weaned per cow joined.

The important point is that producers should not be too concerned about what other producers are achieving in other environments, but rather what other producers in similar environments are achieving.

To improve reproductive efficiency producers need to:

- calculate the reproductive rate for their herd;
- assess which improvements are realistically achievable in their environment under their conditions;
- assess selection and mating strategies that will improve reproductive performance;
- determine what level of increase is cost effective;
- implement the strategies;
- monitor and assess results and fine tune the strategy.

Careful assessment of breeder performance and production costs is necessary to determine the level of inputs that can cost-effectively increase weaning rates.

Figure 7. Cow with healthy calf.

Improving calf output through female selection

Genetics, management and your selection strategy can influence calf output.

Genetic improvement is slow owing to the low heritability of fertility traits and the fact that a large percentage of heifers is often needed for replacements. Hence the selected females may be only marginally better genetically than the herd average. Female selection will at best, only improve the number of calves born per cow lifetime by a maximum of 1 per cent per generation, i.e. for 100 cows that had 6 calves in their lifetime, it equals a total of only 6 calves, or 1 extra per year. While genetic improvement through female selection is slow, it is permanent. If bulls are also selected for fertility an additional gain can be achieved. The exception to this 'rule' is in crossbreeding. First cross females typically display significant improvements in fertility over purebreds due to hybrid vigour.

Nutritional and husbandry management (for example, strategic weaning and synchronising lactation to feed availability) can improve fertility substantially. A 5–10 per cent improvement in calf output is realistic in those environments where nutrition is a significant depressor of fertility. These options need to be weighed up economically, but may be very cost effective ways to improve calf output.

Table 2. Summary of expected increase in calving rate per year from selection, management and genetic improvement.

Strategy	Expected increase in calving rate
Genetic improvement/year (female selection)	< 1 calf per 100 females
Genetic improvement/year (male selection)	> 1 calf per 100 females
Management (nutrition, mating time, weaning)	1–10 calves per 100 females

Improving growth rate through female selection

It is difficult to select females to genetically improve growth or weight at sale. Simply selecting the biggest is very inaccurate because we tend mainly to select the oldest. To be able to improve the accuracy, we would have to adjust for age. Under ideal conditions, heritability of yearling weight is about 25–30 per cent. Heritability (h^2) is the proportion of the measured variation among animals attributable to genetic differences among them.

Where we can't adjust for the animal's age, heritability of differences is much less. If we assume heritability in these cases is only 10 per cent, we can estimate the likely responses to selection for growth over several generations.

Table 3. Possible gains from female selection.

	Selected Group		Control Group	
	Generation 1	Generation 2	Generation 1	Generation 2
Number of females	100	100	100	100
Average weight (kg)	300	301*	280	280
Weight difference (kg)	20	21	0	0
Genetic difference (kg)(h^2=10%)	2	3*	0	0
Av no. calves/female	5	5	5	5
Total calves @ 90% weaning	450	450	450	450
Number of heifers retained for next generation	100	100	100	100
Total sales (less retained females)	350	350	350	350
Extra sale wt (kg) (total sales x $^1/_2$ genetic difference)	350	525	0	0
Total gain realised in 2 generations (kg)#	875		0	

* 301 kg comprises 300 kg raw weight plus 1 kg due to genetic gain. The 3 kg genetic difference comes from 10 per cent of 20 kg plus 1 kg genetic gain due to selection.

Does not include extra sale weight of cows.

Note that two generations would take 12–14 years to complete. This isn't much gain, but it is permanent and only requires weights to be collected prior to selection. Where weighing is a routine practice there is no significant extra cost.

Compare this to the gains possible through bull selection. For this example bulls selected have a yearling weight EBV of +20 better than the current herd, i.e. they have genes for yearling weight of 20 kg above the herd's average performance. Therefore their progeny on average will be 10 kg heavier than the existing herd.

Table 4. Possible gains from bull selection.

	Selected Group		Control Group	
	Generation 1	Generation 2	Generation 1	Generation 2
Number of females	100	100	100	100
Average weight (kg)	300	290	280	280
Weight difference (kg)	0	10*	0	0
Female genetic difference (kg)	0	10*	0	0
Bull genetic difference (kg)	20	20	0	0
Av no. calves/female	5	5	5	5
Total calves @ 90% weaning	450	450	450	450
Number of heifers retained for next generation	100	100	100	100
Total sales (less retained females)	350	350	350	350
Extra sale wt (kg) (total sales x $^1/_2$ genetic difference)	3500	5250	0	0
Total gain realised in 2 generations (kg)#	8750		0	

Extra weight in the females is all due to genetic traits from their sire.

Does not include extra sale weight of cows.

*Female genetic difference is 10 kg, from bulls at +20 and the dams assumed to be average or 0.

The message from these examples is that selection of females for growth is important but the genetic gain is small compared with that which can be achieved by the selection of genetically superior bulls.

Improving carcase traits

Visual assessment of carcase quality traits in live animals is fairly difficult and so accuracy for selecting for these traits is low. Age can also affect assessment as animals of different ages can display different degrees of development related to their age, e.g. fatness could vary quite markedly between 12 months and 15 months in British animals as maturity changes tend to accelerate between these ages. To move to objective methods of live animal assessment in commercial herds at this stage requires more expensive techniques that would probably outweigh the benefits of selection. As with growth, much more gain can be achieved through accurate bull selection.

Summary

Female selection should be aimed at improving herd profitability. This means implementing selection and management strategies to improve turn-off weight and the value of turn-off animals while reducing costs. Most progress will be from increasing calf output.

This chapter may seem to suggest that there is little to be gained from female selection and that producers should be concerned only with bull selection. This is not true. The point is that larger gains are possible through bull selection. However by combining bull and female selection the greatest possible genetic gains will made.

The subsequent chapters endeavour to increase producer understanding of female management strategies to achieve this gain. Management tools that can be used in the process are also discussed.

3

Selecting the right females

Introduction

Traits of economic importance for which cattle can be selected include:

- environmental adaptation
- fertility
- growth rate
- temperament
- carcase traits
- structural soundness.

The relative importance or ranking of these traits will depend upon the location of the individual property and the make-up of the current herd.

The 'right' breed of cattle will be that which produces efficiently on the country available, under the management imposed, while satisfying market needs. In harsh conditions, environmental adaptation is the most important trait of the female herd as this directly affects survival of the animal. In areas where nutritional stress is regularly severe and compounded by other environmental stresses, a higher component of tropically adapted breeds (e.g. Zebu and Sanga) should be used. This will reduce running costs and increase productivity. Environmental stresses also include heat and internal and external parasites.

The level of Zebu or Sanga used to provide tropical adaptation must be balanced against the higher production potential of British and European breeds of cattle. The appropriate mix will be determined ultimately by each individual property situation. Selection within breeds is important because for many traits there is often as much difference within a breed as there is between breeds.

Basic selection principles

Genetic gains are permanent and cumulative. This means that genetic gains made within the herd will remain unless inferior bulls or cows are introduced from outside the herd.

More genetic gain is possible from selecting bulls than cows. This is simply because we retain far less bulls than females as a proportion of those available for selection and therefore impose much greater selection pressure on the bulls. Placing selection pressure on both bulls and cows will maximise genetic gain.

Effective selection not only requires individual animal identification but also property infrastructure such as fences and water points which allow animal segregation and control of mating.

There are a number of factors that are important to consider when selecting animals for breeding. If a particular trait is to be included in a breeding program it must meet the following criteria:

- be reasonably heritable
- be economically important
- be measurable (either directly or indirectly)
- be characterised by variation in the population.

Heritability

Heritability (h^2) is defined as the degree to which a parent's attributes are passed on to their progeny. The variation that is not genetic results from factors such as nutrition, management, disease and all other environmental factors.

The higher the heritability of a trait, the greater is the proportion of the parental genetic merit that will be passed on to the offspring. Most of the growth traits in beef cattle have a heritability between 30 and 50 per cent. This means that of the measured differences in growth rate between animals in a group, 30–50 per cent are from genetic factors and 50–70 per cent of the differences are from non-genetic or environmental factors.

Carcase traits generally have heritabilities of 30–55 per cent. The heritability of scrotal circumference is of the order of 20–50 per cent, while for serving capacity it appears to be 15–30 per cent (*Bos taurus* only). Female fertility traits tend to have much lower heritabilities (e.g. 5–20 per cent). This means that less of the measured differences between animals for fertility are due to genetic differences and so the rate of improvement in a genetic improvement program will be slower than for the other traits. Heritability estimates for some of the important traits of beef cattle are shown in Table 5.

Table 5. Heritability estimates for some traits in beef cattle in temperate and tropical environments.

Trait	Heritability % (BREEDPLAN*) Temperate (Angus)	Heritability % (BREEDPLAN*) Tropical (Brahman)
Reproduction		
Conception	0–5	5–20
Days-to-calving	0–10	0–10
Gestation length	15–25	na
Maternal ability	20–40	na
Calving ease (heifers)	15–60	na
Semen quality	25–40	6–44
Scrotal circumference (18 months)	20–50	28–36
Serving capacity (18 months)	15–60	na
Conformation and growth		
Body length	25–45	na
Chest girth	25–55	na
Wither height	30–50	na
Birth weight	35–45 (39)	35–45 (46)
Milk yield	20–25 (10)	(4)
Weaning weight	20–30	3–50
200-day weight	(18)	(28)
Weight gain, birth to weaning	25–30	16–40
Yearling weight gain (pasture)	30–45	20
400-day weight	(25)	(37)
18 month weight (pasture)	40–50	30
600-day weight	931)	(43)
Mature cow weight	50–70 (41)	25–40 (39)
Dry season gain	na	17–30
Wet season gain	na	18
Carcase (US)		
Carcase weight/day of age	25–45 (36)	(36)
Rib fat (12/13th rib)	(27)	(27)
P8 rump Fat	29 (28)	18 (28)
Intramuscular fat %	15 (22)	30 (22)
Eye muscle area	20–25 (23)	(23)
Dressing percent	15	37
Tenderness	4–25	16–30
Retail meat yield	29 (36)	36 (36)
Yield % carcase weight	49	52
Other traits		
Eye cancer susceptibility	20–40	na
Eyelid pigmentation	45–60	na
Temperament	25–50	25–50
Tick resistance	na	20–42
Worm resistance	na	25–36
Buffalo fly resistance	na	20–30

na: not available; (BREEDPLAN*) = BREEDPLAN heritability values.

Sources: (a) Hammond, K. (ed) et al. 1981 Selecting Beef Cattle for Maximum Production in the 80s, AGBU, UNE. (b) Davis, G.P. 1993 Genetic Parameters for Tropical Beef Cattle for Northern Australia. *Aust. J. Agric. Res.*, **44**, 170–198. (c) Robinson, D.L., Ferguson, D.M. and Skerritt, J.W. 1998 Genetic Parameters for Beef Tenderness, Marbling and Yield'. Proc. 6th World Congress Genet. App. Livestock Prod.

Economic importance

All traits that we use in selection must be economically important. 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. Additional traits included in a selection program usually decrease the rate of improvement in each individual trait. It is best to concentrate selection on fewer traits, each with high economic value.

Economic importance can mean different things to different producers. For most beef producers, 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 that will improve the returns to be made from the sale of breeding animals. With increasing emphasis in the industry on meeting specific market requirements, the economically important traits irrespective of the market are merging.

Measurability

Objective measurement of beef cattle performance traits enables the producer to compare the traits irrespective of season, bias, year or environmental effects and allows the calculation of estimates of genetic merit. Live weight is easy to measure and was a logical first choice for most of the animal growth research involving genetic improvement programs.

Growth rate is easily measured and highly heritable. The first estimated breeding values (EBVs) were calculated for growth rate. Relative to growth, fertility traits are more difficult to measure. Emphasis initially was on two relatively easily measured fertility traits, which are scrotal circumference in bulls and days-to-calving in cows. More recently, measurements of calving ease and gestation length are available from Group BREEDPLAN in some British breeds of cattle.

Some carcase attributes are now measurable and therefore are included in EBV determination. These include eye muscle area (EMA), rib and P8 rump fat, % intramuscular fat and retail beef yield. The measures of these attributes can be made from ultrasound scanning or abattoir carcase measurements.

Variation

With greater variation in a trait there is more scope for change by selection. Some traits vary considerably more than others and even if a trait has a low heritability a large variation may mean that changes can be made. Most traits that are governed by more than one gene fit a 'normal' distribution. A normal distribution is simply a pattern of distribution where the majority of animals are close to the average while away from the average there are fewer animals (Figure 8).

A trait with a large variation (such as growth rate and milk production) will have a lower, wider curve (more animals further from the mean) while a trait with small variation (e.g. intra muscular fat per cent or marbling) will have a higher, narrower curve (more animals close to the average). If we select 10 per cent of animals in each case then the distance from the average will be greater for a trait with the larger variation. Hence the trait with greater variation from the average can be expected to achieve greater gain than one with less variation.

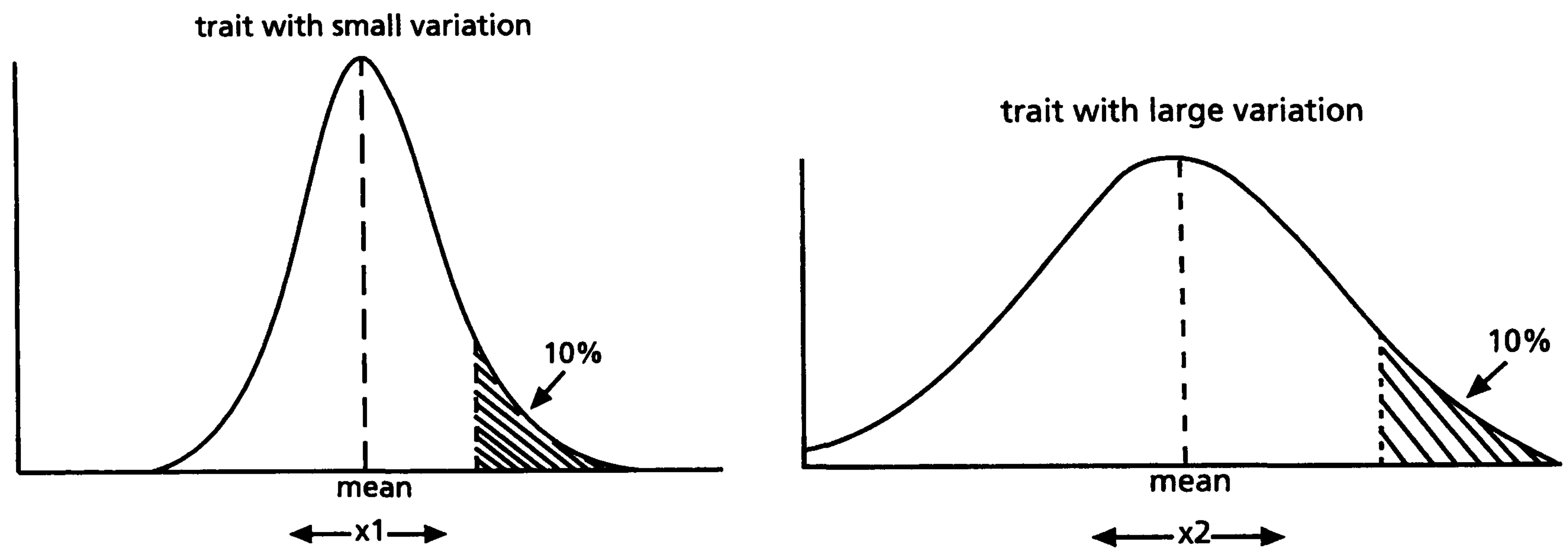


Figure 8. Normal distributions for traits with large and small variations.

Establishing breeding objectives

The first and most important step in planning a successful breeding program is to establish a clear set of objectives. Defining the breeding objectives of your beef enterprise requires clear measures of the current performance of the herd for all beneficial traits and considering these in conjunction with the environmental constraints and the customer requirements or the markets that you choose. There are a number of steps that provide a systematic approach to establishing these objectives. These include:

- list the traits of economic importance;
- list your customer's requirements;
- list your future herd production targets —set realistic targets for important traits;
- list your current herd performance —objectively measure the performance of your herd;
- list your breeding goals —traits requiring special emphasis;
- list your selection criteria —the means of achieving the above goals;
- prioritise the selection criteria —'weighting' the relevant traits.

Balancing selection

Selection for some traits may have undesirable effects on other economic traits. The most obvious example of this in beef cattle is in the area of growth traits. It is now possible to select very effectively for increased growth rates by using BREEDPLAN Estimated Breeding Values (EBVs). For an explanation of 'BREEDPLAN' refer to Chapter 4 —Herd Management Tools.

Herds using EBVs for this purpose have reported noticeable increases in weight gains. However unless a 'balanced' selection approach is taken, increased growth rates may lead to increased incidences of dystocia (difficult birth) resulting from larger birth weights. Growth starts at conception and high growth-rate calves are usually larger at birth. Correlation between traits, positive or negative must be considered in any selection program.

'Balanced' selection is needed to ensure fertility traits are not sacrificed for possibly less economical traits such as growth rate or milking ability.

Selecting breeding females

There are two opportunities to select females: pre and post-mating. Selection of breeding females can increase the level of desirable traits in the herd. Also, selection through the use of objective pre-breeding selection tools and the removal of non or poor performers from the herd is important for subsequent profitability. Selection either allows 'culls' to be replaced by more productive females or allows the remaining productive animals more access to available feed and water. Because planned selection and culling can markedly improve turn-off and reduce grazing pressure it is a critical component of breeder management.

As a previously desirable female may now not be acceptable it is important to note here that although reproductive performance is not highly heritable, it is highly repeatable. This means cows that have calved regularly in the past are more likely to do so in the future.

Pre-mating selection

The number of replacements required is determined by:

- current herd reproductive performance;
- herd policy for culling and selection
  - culling for age
  - culling for reproductive failure
  - culling for non or poor performance in other production traits;
- maximum cow age;
- annual culling and mortality rates.

Higher reproductive rates allow increased culling for performance and/or a lower heifer retention rate.

Table 6. Comparison of replacement heifers available in herds with different management of high and low reproductive performance.

Herd of 100 breeders	Herd A Intensively managed Favourable environment	Herd B Well managed Harsh environment
Number of pregnant females	95	85
Calves born	93	82
Calves weaned	90	76
Weaner heifers	45	38
Culling age (years)	10.5	8.5
Total culling (%)	11	5
Mortalities (%)	1	2
Heifers available for selectionat 26 months	44	37
Replacement heifers needed	18 (40%)	18 (50%)

Table 6 shows that in Herd A only 10 cows per 100 need culling for reproductive failure. If culling for age those cows reaching 10.5 years old, Herd A will require an additional 10 to 13 replacements per year for this purpose. If culling is done for other reasons such as temperament, bottle teats, structural breakdowns or failure to rear a suitable calf, additional replacements will be required. Additionally, extra replacements will be required for losses from deaths and other causes. This means that in most cases even in very well managed herds over 50 per cent of the available heifers will be required as replacement breeders.

The situation in Herd B allows for almost no selection pressure to be applied on replacement heifers if culling for reproductive failure is carried out in the breeder herd. Every available heifer will be required as a replacement. In those cases where selection pressure is limited the amount of genetic progress that can be made is also limited.

The more traits selected for, the less the gain in any one trait. It is important to select heifers for as few traits as possible and only for those of economic importance. Depending on the circumstances the order of importance may be:

- fertility
- temperament
- structural soundness
- growth rate.

At present there is little opportunity for, or benefit gained by, selecting females for carcase traits. Often, environmental adaptability will be expressed in other traits such as growth rates. Selection should be done objectively wherever possible and be 'balanced' to avoid extremes.

In summary, because few commercial herds have objective information such as from a BREEDPLAN or a Group BREEDPLAN analysis on which to base their selection practices, selection before mating should be minimal. Only those animals with obvious bad temperament or structural faults that will severely impede their survival or their ability to reproduce and grow should be culled. The remainder of the heifers should be mated for a sufficient period and the required number of pregnant replacements retained.

Fertility

Fertility in females is an all or none issue, i.e. a cow either successfully rears a calf or she doesn't in a given period of time. Although the heritability of fertility is low, fertility is highly repeatable and simply retaining females that wean a calf will lift herd performance.

Objective selection is possible only when pedigree information or information on animal parentage is available. The ideal is to select on fertility EBVs (refer to Chapter 4 —Herd ImproveManagement Tools). As with most traits the quickest genetic improvement is gained through bull selection but this is only normally possible in a stud or nucleus herd where records are available.

If calving ease is a problem one way in which it can be improved genetically is by selecting heifers with a large pelvic area. This must be measured internally using a pelvimeter, and cannot be assessed visually with parameters such as width between the pin bones or hip bones. Pelvic area is highly heritable and in the future, pelvic area EBVs may be available. At present raw figures still yield beneficial results (when using raw figures an age correction may be necessary). The bigger the pelvic area at a given age the better. These heifers can more safely and easily give birth.

Internal palpation of the reproductive tract by a competent operator to assess ovary size and cervix size can provide a rough guide to which heifers are sexually mature at time of selection and hence have the highest chance of conceiving earlier. Internal palpation may also detect heifers already pregnant, the possible occurrence of freemartins and hermaphroditism, and other conditions affecting reproduction.

Temperament

Temperament is of economical importance because quiet cattle are easier to handle, safer to handle and have less pre-slaughter stress (and therefore may have more tender meat).

Unfortunately at present there is no readily available, practical method of objectively measuring temperament. Methods to assess temperament range from that of 'flight speed' (speed of exiting a crush) to purely subjective assessments. However as this trait is so highly heritable (up to 0.7), responses to subjective assessments are usually marked.

Structural soundness

In the breeder herd structural soundness is associated with increased longevity and decreased breakdowns, and in turn-off cattle, structurally sound animals are better suited to feedlotting.

Assessment prior to mating should be a relatively minor component of breeder selection and should focus on obvious faults that will impede the animal and its progeny from functioning normally and effectively.

If faults are extreme or appear that they will affect the function of the heifer then the animal should be culled. Extremes in factors such as post leggedness, sickled hocks, uneven hooves, abnormal walk, overshot or undershot jaw, poppy eyes, entropian or ectropian eyelids, eye tumours and so on should be considered for culling.

Growth rate

Growth rates cannot be assessed accurately other than by using objective measurements such as weights. The best available method of improving growth rates is to use growth EBVs from BREEDPLAN or Group BREEDPLAN. These are roughly twice as efficient as using weight ratios or raw data (refer Chapter 4 —Herd Management Tools) but this is not an option for the vast majority of commercial herds.

Visual assessment of growth is not successful as in most cases it merely identifies the largest animals at the time of selection. At weaning, the largest calves may be those animals that were born the earliest, or those that had the best milking mothers, not necessarily those having the best growth potential. Often selecting for post-weaning gain is more important than selecting large weaners. Selecting for post-weaning gain will more readily identify animals suited to the environment and market requirements. But milk is important as a significant proportion of growth occurs pre-weaning.

High growth-rate cattle are desirable because they reach target market weights at younger ages. This is an important factor in eating-quality of the carcase. Additionally, high growth-rate cattle are thought to be more efficient. However high growth rates should not be confused with extremes in mature animal size, even though in many cases larger animals have higher growth rates. Growth rate is only of economic benefit until the animal reaches the target market weight at a specified fat cover. Growth after this time is of no benefit and may in some cases be detrimental. Cows with higher mature weights have a higher maintenance requirement.

BREEDPLAN and Group BREEDPLAN (refer Chapter 4) in some breeds now has available mature cow weight EBVs, which will aid some stud cattle breeders to select for higher growth rates without unduly increasing mature animal size.

Post-mating selection

Post-breeding selection is primarily concerned with identifying productive females. The most productive cows are those that wean the most kilograms of calf in their lifetime and require minimal inputs. To do this they must calve frequently (preferably every 365 days or less) and rear a large calf to weaning. The weight of calves reared in a cow's lifetime will vary with conditions and management. In southern Australia in favourable conditions and with intensive management, a cow may need to wean 250 kg or more of calf each year to be classed as highly productive. In tropical areas, cows weaning calves over 150 kg three out of every four years may also be regarded as highly productive.

There are a limited number of times during the year that cows can be assessed for productivity. The best times are at weaning and during a pregnancy test. Management is made easier if cows can be pregnancy tested at or after weaning. Problems of mothering-up and drafting can be simplified or eliminated. These procedures are simpler in herds that practise restricted joining than in those that run bulls all year round.

Fertility

Failure to become pregnant, particularly if not lactating, and failure to produce a live weaner are the critical criteria. In some intensively managed herds with short-period calving, cows that produce lighter or lower quality calves may also be culled.

Structural soundness

Culling for unacceptable temperament and structural faults such as bottle teats should be on-going during the life of the female.

Mothering ability

Mothering ability is the female's ability to feed and look after her calf. Some females will abandon a calf after birth or become separated from the calf later on. The ability to protect the calf from predators is also a factor in mothering ability. Culling cows that fail to wean a calf eliminates poor mothers.

Benefit of seasonal mating

Selection of more productive cows and hence gaining genetic improvement for the herd is made easier by restricting the time that breeder cows are exposed to bulls. If calves are born at approximately the same time their growth rates can be compared validly, and their mothers can be assessed for ability to rear a calf to weaning. Restricted mating eliminates the need to compare out-of-season calves, and allows the manager to more easily identify those cows that calve regularly and are the better milkers. Other management tasks such as branding, weaning and vaccination can be condensed to only once or twice per year, and uniform lines of calves are more easily managed and marketed. Restricted mating enables pregnancy testing to be done at a time that affords maximum benefits in terms of accuracy and animal welfare. This is usually at the first convenient opportunity 13 weeks after bulls have been removed. However, in extensive areas with poorer nutritional conditions, seasonal mating is practised to minimise dry season lactation. Therefore a six to eight month joining may be more appropriate.

The intensity of selection will range from:

- just retaining all pregnant and lactating cows in very harsh areas;
- retaining only lactating pregnant cows;
- retaining only those pregnant or lactating cows that are expected to wean calves within a defined period.

Selection of productive cows is much harder in year-round mated herds because:

- It is common where herds are year-round mated for the intercalving interval of many cows to be greater than 365 days. This is principally due to feed quality rather than the year-round mating. The end result is that many animals calve later each year even if they were managed as heifers to calve at the optimum time.

- When cows calve outside the optimum time their chances of reconceiving are reduced and mortalities are potentially higher.
- There is potential for error because animals less than 4–6 weeks pregnant are not detectable by rectal palpation.

However, producers, veterinarians and advisers have developed systems that enable:

- the most productive females to be selected;
- the most suitable culls to be identified in terms of returns, impact on future herd performance and survival risk;
- efficiencies in mustering and supplementation to be achieved;
- bull requirements to be reduced and efficiency of bull use to be improved.

Dry cow management system

This program can be used in any year-round mated breeder herd. If a heifer management system as previously outlined is in place the dry cow program is used with breeders from their second calving onwards.

At the first draft, remove dry cows and return wet cows to the most appropriate paddock. The wet cow group will contain those cows whose calves have been recently weaned or will be weaned at the second draft. Consequently, all these animals will be dry from the second round until calving commences late in the year. Cull cows with structural faults or poor temperament.

The dry cows are pregnancy tested when appropriate numbers are available. Empties are culled and pregnant animals drafted into a management group or groups. The composition of management groups is based on the pregnancy status of the mob, paddock availability, seasonal conditions and time of the year. Paddocking on pregnancy status allows for the most effective allocation of feed and better targeting of supplementation.

Example of dry cow paddocking and management based on pregnancy status

Table 7 provides an example of how animals at different stages of pregnancy can be grouped for optimal management.

Table 7. Management groups and expected calving dates for cows at different stages of pregnancy on 1 May.

Group	Pregnancy status @ 1 May (months)	Expected calving date
1	P1	9 January
	P2	10 December
	P3	10 November
2	P4	11 October
	P5	11 September
	P6	12 August
3	P7	13 July
	P8	13 June
	P9	14 May

Group 1: Cows 1-3 months pregnant

This group comprises the latest calvers which will not wean a calf in the current year and are consequently the least productive of the pregnant animals. These cows will generally be in good condition with good carcase weights and are consequently the ideal group from which to draw sale cows. Early pregnancies have negligible effects on dressing percentage.

If these animals are retained and cannot be paddocked separately they can be put with the wet cows, as their calving pattern will be similar.

Group 2: Cows 4-6 months pregnant

This group will not wean a calf in the current year unless radical weaning is undertaken. By paddocking them separately the calves can be branded at the end of the second round to avoid large cleanskin weaners in the following year.

These animals are most at risk under poor seasonal conditions, as they will lactate for the longest period during the dry season and this should be considered when allocating paddocks and planning supplementation.

If extra cow sales are required this is the next most appropriate group to draw from. Under severe drought conditions it may be best to sell some of these animals so as to avoid losses and minimise supplement costs. Agistment is a possibility but it is important to consider that these animals will still be the group most at risk.

Rejoining these cows in December will enable them to reconceive at the optimal time.

Group 3: Cows 7-9 months pregnant

This group can be weaned during the second round and earlier weaning can be undertaken, if necessary, to reduce the stress on these cows. As with Group 2, these cows can be rejoined in December to achieve a more timely calving.

Dry cow management systems enable easy identification of the most appropriate animals to cull. Animals that fail to raise a calf for any reason identify themselves by being dry when the rest of their group is wet.

Culling for age

Because a system of dry cow management is continuously removing animals with poor reproductive performance, the aged cows will be animals that are well adapted and fertile. Many of these animals have the potential to be kept beyond ten years under normal seasonal conditions if desired.

The most appropriate way to deal with these animals when they reach the traditional culling age of eight to ten years is to assess their condition and pregnancy status in relation to seasonal conditions and cull accordingly. This system provides maximum herd flexibility. Since the 'high risk' animals will be in the first round, dry cow group, they can be identified and sold early in the year.

Removing bulls from aged cow groups the year before culling makes it easier to get cows calved out and prepared for sale. It also frees up bulls for use elsewhere.

Weaning calves down to three months of age increases the rate at which culls can be turned off.

Intensive female selection

The most intensive selection pressure that should be applied to females is in those cases where they are used to breed bulls for use as seedstock, either in stud herds or as part of a nucleus herd in larger commercial herds. The minimum requirements should be that a cow:

- has calved every year (if fertility is the major trait);
- has calved easily (i.e. with no assistance, even as a maiden);
- weans calves that are regularly above average in weight;
- has calves that are regularly above average for post-weaning gain;
- is structurally correct and has structurally correct calves;
- possesses a quiet disposition and has calves that are quiet.

Adaptation to the specific environment should be the primary requirement for inclusion in the nucleus herd and wherever possible the performance of these cows should be analysed objectively, such as in BREEDPLAN, so as to give the best possible chance of maximising genetic gains.

Summary

Female selection should be based on traits of economic importance. These may include environmental adaptation, fertility, growth rate, temperament, carcase attributes and structural soundness. The relative importance or ranking of these traits will depend upon the location of the property and the make-up of the current herd.

Females should be selected at two main points; pre and post-breeding. The pre-breeding selection identifies animals with the maximum potential for conceiving and the post-breeding selection identifies animals that have conceived.

In the selection process there are some tools that can assist this process and this is the focus of the next chapter on herd management tools.

4

Herd management tools

Introduction

Herd improvement is a long-term process involving three main steps. First you need to identify the goals or breeding objectives of your herd. Once you have set these objectives you will then need to undertake the two following steps to achieve these objectives. The level at which these steps are undertaken will be determined by the complexity of the breeding objectives.

- Constant monitoring of the performance of animals in the breeding herd to identify superior cattle. This includes good record keeping, the analysis of performance data of animals in the herd for the various traits for which the animals are being selected and the removal of non or poor performers.
- Planned mating programs to ensure that the desirable genes are spread throughout the herd. This may range from natural mating in which the desired bulls are run with the correct cows, through to use of artificial insemination (AI) and embryo transfer (ET).

There are a number of tools available to enable cattle breeders to carry out these steps and conduct a herd improvement program.

Identification of superior animals

Requirements for the identification and selection of superior animals include:

- easy individual identification
- objective measurement of the performance of the desired traits
- thorough analysis of performance data.

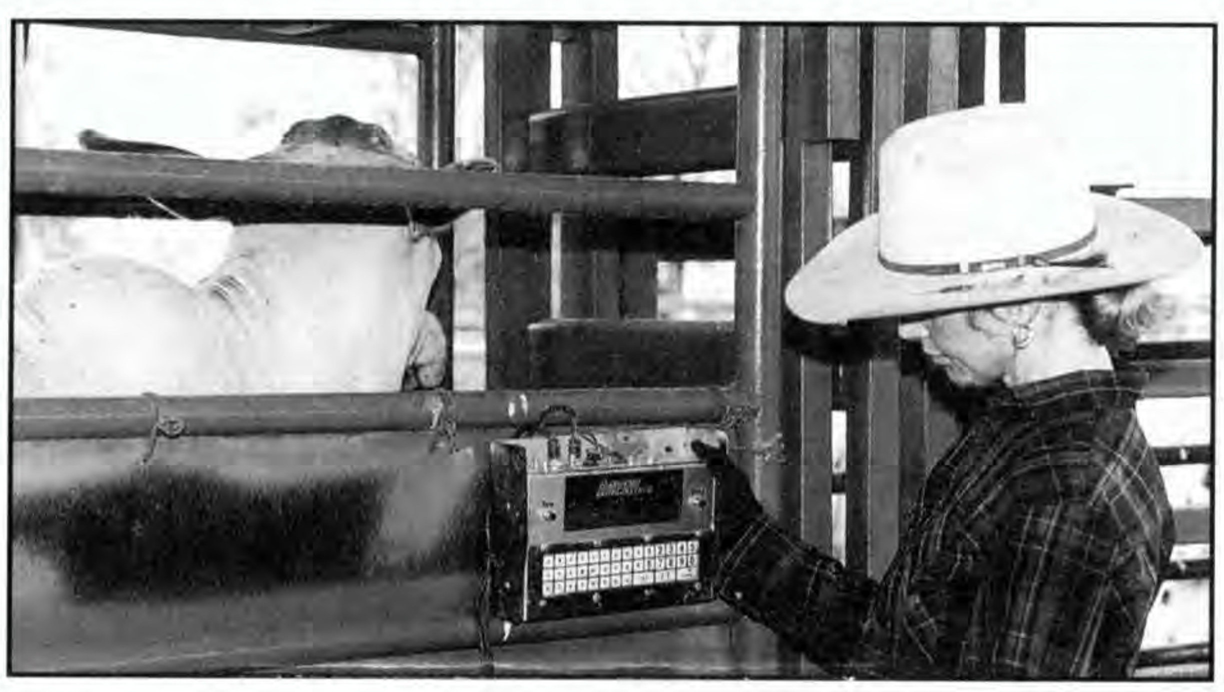


Figure 9. Recording data for individually identified animals.

Recording and using data

To derive trait values for monitoring performance and selecting of cattle requires collection of and analysis of data. Initially, work out your objectives in data collection and analyses. The method of achieving these objectives is satisfactory if:

- the data collected are what is needed;
- the data can be stored in a time- and cost-efficient system that is simple to use and enables easy access to the data;
- accurate data analyses can be conducted by the data owner or a third party;

- other objectives for data collection are also met, e.g. for quality assurance programs, or diagnosis of productivity problems or potential.

A fundamental aspect of using data is to have an effective animal identification system. Useful features of the ID include:

- It is unique and unambiguous.
- It is descriptive for the herd and or business. A good system to use is a 6-digit number. The first 2 digits denote the year of branding. The next 4 are an individual number within the year group. Series of numbers with year may denote such information as management group or sire line.
- It can be easily used in book work and on computers. It is often much better not to have letters in the ID.
- It is easy to mark on animals and tags, and easy to use in the field.

It is recommended that data be stored in well-designed systems. All data must be linked to an animal ID, and where appropriate to a date. A basic system is based on using books alone. It is wrong to believe that a computer is necessary. Computers are a valuable aid for those who can use them and need complex data analyses. Computer systems are basically an advance on the book approach. The basic approach is to collect all data against a date in paddock books in which animal numbers are listed; sheets of paper are not recommended. Paddock books should also include a comprehensive diary. Data are then transferred into a series of office records, which give a history of:

- unchanging information, including pedigree, weaning dates, turnoff dates and reasons, etc;
- growth, including weight, condition, height, carcase data;
- female reproduction, giving annual details of mating outcome;
- male reproduction, providing annual details of breeding soundness examinations and mating;
- treatments, including management groups, paddocks, preventative or production treatments, illness, etc.

To meet objectives, it is often most time- and cost-efficient for graziers to use book or basic computer systems to store and manage data and to do basic analyses, and then to contract specialists for data entry and analyses with complex software. For those who can and prefer to use the computer themselves, much care is required in selecting a computer system to handle data. The options range from standard commercial software to purpose-built software. Useful features include:

- The system suits the level of expertise of the user and suits the user's objectives.
- The system is preferably compatible with other software. Incompatible systems suit their makers as it locks users into the costs for continuing support and upgrades.
- The system can link with other software as required.

Measurement and analysis of performance

The beef industry has traditionally selected animals based on visual appraisal. Visual appraisal is still the basis for assessment of colour, temperament and structural soundness. Visual assessment can also be effective for selecting traits that involve only a few genes. These traits tend to be expressed in an all or none manner, e.g. polledness, where an animal either has horns or it doesn't. Visual assessment is far less effective when selecting for traits involving many genes and where objective measurement is possible, such as those of growth rates and fertility.

Measurement and analysis of growth rate

Measurement of growth rate is simple, requiring only a set of scales, accurate individual animal ID and a recording system for weights, dates and identification. Analysis of and use of results is more complex.

Animals gaining the most weight over a given length of time are said to have the highest growth rate. The common term in use is average daily gain (ADG) and is expressed in kg/day, for example 0.3 kg/day. These will not necessarily be the largest animals at the time of weighing or even those with the greatest genetic potential for growth rate. Selecting those animals with the highest growth rates will result in some genetic progress. More detailed analysis and use of data could yield a higher rate of genetic gain.

Use of Weight Ratios

In order to be able to more easily make more useful comparisons between animals, weight ratios can be used. Weight ratios rate an individual animal's performance against the average of the group with which it is being compared. The group average is rated as 100, and individual animals are rated as being above or below this average.

For example, when comparing weaning weights, if the average weight for the group is 150 kg, and the animal under scrutiny weighs 180 kg, it will have a weight ratio of 120, i.e. it is 20 per cent above the average for the group (30/150 x 100% = 20%). Weight ratios generally reflect the magnitude of differences between animals more realistically than do raw figures, leading to more accurate selection.

Weight ratios have limitations whenever they are used. The most important of these is the inability to make valid comparisons of genetic merit of animals born in different years, or of animals born and/or reared in different conditions, e.g. different land types, paddocks or on different properties. These sorts of comparisons can only be made using advanced computer analysis systems such as that used for BREEDPLAN.

BREEDPLAN

BREEDPLAN is the commercial name applied to a system for evaluating the genetic merit of cattle, conducted by the Agricultural Business Research Institute (ABRI), University of New England, Armidale. Detailed explanations of how BREEDPLAN operates and how calculations are made are available in another DPI publication '*Beef Cattle Recording and Selection*'.

BREEDPLAN is an advanced system for assessing the genetic merit of animals for traits of economic importance. It takes into account the performance of all known and recorded relatives as well as heritability. BREEDPLAN enables a more accurate identification of those animals that are most likely to pass on to their progeny the genes for improved performance than do weight ratios or raw weight measurements. It helps to avoid selecting the 'freaks' which have performed well because of luck or because the conditions at that particular time may have suited them.

Cattle breeders can expect to make substantially more genetic progress using BREEDPLAN information than when using weight ratios or measuring ADG. Also, it allows comparisons between animals born in different seasons or years, enabling valid comparison of different calf crops. BREEDPLAN on individual properties can be extended to an across-herd analysis. This is only possible under certain conditions such as when there is sufficient genetic linkage between properties in the analysis. This extension or across-herd analysis is called Group BREEDPLAN.

BREEDPLAN expresses its estimates of genetic merit for measured traits as estimated breeding values or EBVs. At present BREEDPLAN has EBVs for growth, fertility and some carcase traits. The growth EBVs are:

- 200-day or weaning weight;
- 400-day or yearling weight;
- 600-day or final weight;
- milk;
- birth weight;
- mature cow weight.

Birth weight EBVs are an important factor in fertility. Unfortunately for cattle breeders, high growth rates are quite often associated with high birth weights (the single most important measurable component involved in dystocia). Animals with low birth weight and high growth rates are rare. How to use EBVs in planned breeding programs is explained in other DPI publications (*Bull Selection* and *Beef Cattle Recording and Selection*).

Measurement and analysis of fertility

Expression of fertility in females is seen on an 'all or none' basis, i.e. a cow either rears a calf or she doesn't in a given period of time. Most animals are capable of reproducing if given enough time or chances —the issue is how readily or regularly they reproduce. Fertility involves numerous genes and is affected by a myriad of environmental factors.

Pregnancy testing is an under-utilised management tool in the cattle industry. The function of a cow is to rear a calf. The more regularly and frequently a cow weans a calf, the more profitable she is. It costs little more to run a pregnant profitable cow than it costs to run an empty one. Even though the heritability of most female fertility traits is low, the repeatability of fertility is high. This means cows that have calved regularly in the past have a high probability of doing so again in the future.

Pregnancy Testing

There are numerous methods for testing cows to determine pregnancy status. Not all are practical or effective. Methods include:

- use of records of cycling (sexual activity);
- hormone assays of milk, blood, urine;
- histology of cells of the reproductive tract;
- ultra sound devices (both audio and visual, such as real time ultrascan);
- vaginal probes to determine electrical conductivity of mucus;
- external palpation;
- rectal palpation of the reproductive tract.

Rectal palpation is commonly referred to in the cattle industry to as 'pregnancy testing'. At the present time it is the method of choice for pregnancy testing in most situations. When done by a competent operator it is cheap, reliable and can be used on most properties. Pregnancy testing gives results on the spot for instant culling decisions and requires a minimum of equipment.

There is no ideal time to pregnancy test. However if possible, pregnancy testing should be carried out 13 weeks after the bulls have been removed from the breeder herd. This ensures that the testing procedure is safe for the cow and the developing calf, and it helps ensure that the accuracy of testing is high. There is a slight risk of causing foetal losses if testing is done earlier than 13 weeks. For this reason it is imperative that the pregnancy testing is performed by a competent large-animal veterinarian or by a non-veterinarian who possesses the necessary skills and experience. After 13 weeks, the accuracy of testing for a competent operator should be 99 per cent or better. If testing from 8 weeks onwards, the accuracy will not be as high, but still should exceed 95 per cent.

If pregnancy testing is timed to coincide with weaning, management is simpler and an extra muster may be avoided. There will be less work in drafting and mothering-up of pregnant and non-pregnant cows.

In herds where bulls are left with the cows all year round pregnancy testing is harder to implement successfully. However, systems are available that can identify the most productive animals and produce useful data on herd performance.

Fertility EBVs

The use of fertility EBVs from either a BREEDPLAN or Group BREEDPLAN analysis is an effective method of raising the base level of the breeder herd's fertility. There are a number of EBVs that affect some facet of fertility. These include both male and female factors:

- scrotal size (SS);
- days-to-calving (DC);
- birth weight (BW);
- gestation length (GL);
- direct calving ease (CEdir);
- daughter calving ease (CEdtr).

The simplest and easiest way to improve the genetic level of fertility (or any trait) in the breeding herd is through bull selection. As with most traits, EBVs allow a greater rate of improvement than that afforded by simple measurements alone. Scrotal size EBVs are the single most useful EBV available to improve the genetic level of fertility of the breeder herd in Queensland. If these are not available simple scrotal circumference measurements are still useful. Producers should avoid using bulls with a circumference of less than 32 cm, at 24 months of age or older.

Scrotal size

Scrotal size EBVs are important for two reasons. First, bulls with bigger testicles produce more sperm, giving a higher chance of conception. Second, bulls with large testicles produce more fertile daughters. This means they have heifers that reach puberty at younger ages and conceive sooner after calving, i.e. they have shorter days-to-calving EBVs (see next section). With this trait, positive EBVs are desirable, as these indicate that the bull has the genetic potential to increase fertility.

Days-to-calving

Days-to-calving EBVs are indicators of the time taken for cows to conceive after exposure to bulls. These are calculated by measuring the length of time cows take to calve after the bulls have been introduced. Those cows that have calved the earliest are assumed to be those that have conceived the earliest. DC EBVs are measured in days above or below the breed base. A cow with a DC EBV of +2 days means that it calved two days later than the breed base. Those calving the earliest are the most desirable and have a negative days-to-calving EBV. For days-to-calving EBVs a positive reading is not desirable.

Birth weight

Birth weight EBVs are measured in kilograms above or below the breed base. As with all traits on BREEDPLAN, the breed base was originally set at zero. A positive birth weight EBV means that that an animal's birth weight is above the breed base. Birth weight is the most important measurable contributing factor to dystocia. Where possible, producers should use bulls with low birth weight EBVs but which possess growth and other EBVs that are suitably high for the breeding program and intended markets. Note that birth weight EBVs are also growth EBVs.

Gestation length

Gestation length EBVs are estimates of genetic differences between animals in the number of days between conception and birth. Gestation length is determined by the foetus not the mother, and has a genetic component which can be selected for. Shorter (negative) gestation length EBVs are associated with lighter birth weights and hence improved calving ease. Shorter gestation length EBVs are also associated with improved re-breeding performance of cows and are thus regarded as desirable. Shortening the gestation length is thought to be a way of overcoming the problem of high birth weights.

Calving ease (direct)

This EBV is a measure of how easily a bull's calves are born. It is usually applied to the proportion of a bull's calves that are born unassisted from two-year-old heifers. A more positive figure is desirable indicating fewer assisted births.

Calving ease (daughter)

This EBV reflects how easily a bull's daughters calve as two-year-olds. Again a positive figure indicating less calving difficulty is desirable. Neither of the calving ease EBVs are currently used in tropical breeds. At present, calving ease EBVs are mainly used in some British and European breeds.

Pelvic area measurement

Over 50 per cent of the known and measurable causes of dystocia are a combination of birth weight and pelvic area. Both of these factors have a genetic component. Birth weight is the more important of the two, estimated to account for about 35 per cent of the known causes of dystocia. Birth weight EBVs were explained earlier in this section.

There are a number of other known contributors to dystocia such as calf shape, excessive muscularity of the calf, breech birth, limbs not presented properly and dam effects involving breed and nutritional effects especially mineral deficiency. At this stage none of these factors are proven to be genetically related and cannot be objectively measured. Dystocia is more prevalent in *Bos taurus* breeds than in *Bos indicus* breeds.

At present there is no EBV for pelvic area. Pelvic area is thought to explain about 15 per cent of the causes of dystocia. Pelvic area cannot be objectively assessed except by internal measurement using a pelvimeter. Subjective assessment of features such as width between hips or pin bones, or by using hip to pin slope as a guide has not proved useful.

There are two pelvimeters currently available for use in Australia; the Rice pelvimeter and the Krautmann pelvimeter. The former is merely a set of callipers, which is robust, moderately cheap and easy to use. The Krautmann model has a hydraulic mode of operation and is more complicated to use.

Cattle breeders can still use raw data when selecting replacement heifers. By selecting those heifers with the biggest pelvic area, immediate benefit is gained by removing those animals most likely to experience difficulty when calving for the first time. Pelvic area is highly heritable, i.e. bulls with big pelvic areas will have daughters with big pelvic areas.

Mating management

A controlled mating program will assist cattle breeders to achieve genetic progress in their herd. The degree of mating control can range from a minimum of putting genetically selected bulls into a paddock and hoping for the best, to single sire mating with genetically selected sires, to the use of artificial insemination and embryo transfer.

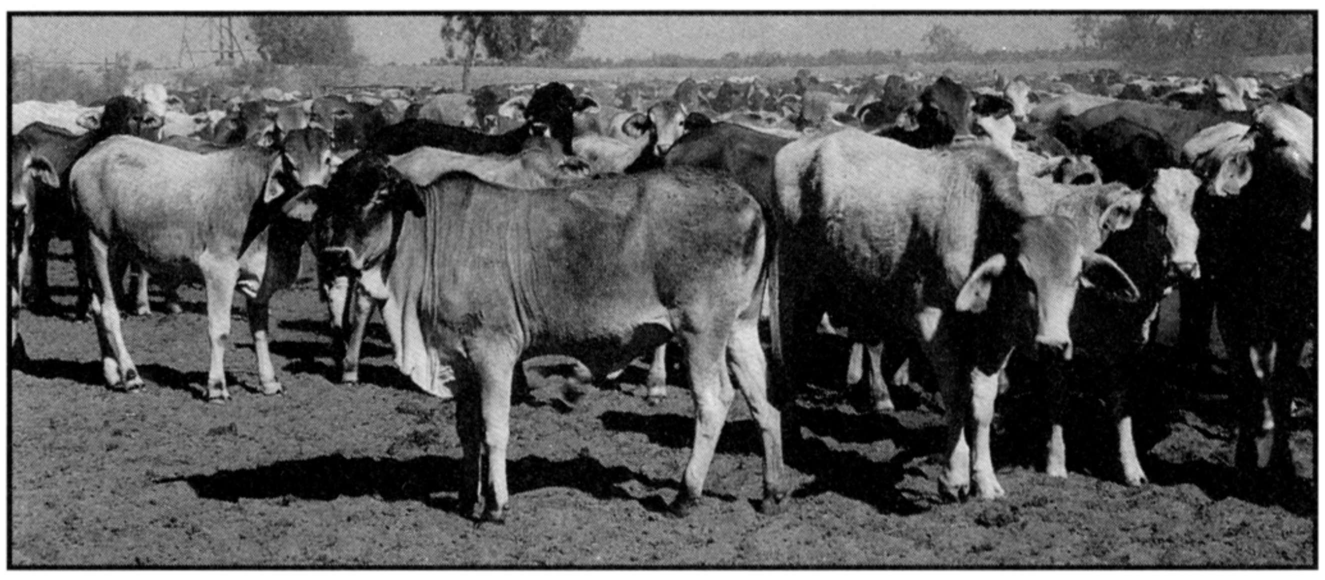


Figure 10. An even line of weaners.

Continuous joining

Continuous joining or all-year-round mating is basically a system where the bulls are left with the cows all year. In large extensive herds it is difficult to make genetic progress in continuous joining systems particularly in traits such as fertility, because monitoring of reproductive performance is very difficult. In these herds the only progress made is that gained through bull selection. Progress made using female selection for most traits will be slight to nil.

Restricted joining

Restricted joining refers to a system where the cows are exposed to the bulls for a restricted period of time. This can range from six weeks in very intensive situations to eight or nine months in more extensive situations. Additionally, in some herds, bulls may be put out with the females for two periods of three or four months. Restricting the joining period allows for easier monitoring of fertility and affords better opportunity for valid comparisons with other traits. Intensity of selection pressure will vary with intensity of management. Nine-week joining periods for cows and six weeks for maiden heifers, combined with single sire mating groups, enables performance to be monitored and intense selection pressure to be applied.

Multiple sire joining management practices and extended joining periods, restrict the selection pressure and hence the genetic progress that can be made. The bull to cow ratio in extensive situations is often 4 per cent or more. However recent research from 'Bull power project' suggests that in most cases 2.5 per cent of selected bulls is sufficient. This may help cattle breeders reduce the total bull cost and the cost per live calf.

Figure 11. Artificial insemination of cows.

Artificial breeding (AB)

Artificial insemination is commonly referred to as artificial breeding. Artificial insemination has a number of uses in the cattle industry. In most cases it is the cheapest way of introducing new and superior genetic material on a large scale. It is also the most cost-effective way of obtaining the genetic linkages necessary for the conduct of within-breed genetic evaluation schemes such as Group BREEDPLAN.

AB programs can be successful, even on extensive properties, under certain conditions. The following points must be considered when undertaking an AB program:

- Artificial insemination programs in beef cattle are most practical for use with maiden heifers. Cows with calves are less suitable. Lactation requires a great deal of energy and the action of the calf suckling the cow will delay the onset of cycling and depress fertility. The presence of calves also interferes with heat detection, drafting and insemination routines. If cows are to be used weaning is a good way to induce cows to recommence cycling, however this will increase intercalving intervals dramatically unless calves are weaned very young.
- A convenient area with sufficient high-quality feed to sustain the group of cows in the program for the duration of the program is essential.
- Any AB program using cows that failed to conceive from natural mating is doomed to fail. This is not an uncommon procedure even on some otherwise very well organised programs. First calf cows are the least suitable as a group for any program.
- Acceptable results are obtained only after thorough planning and meticulous attention to detail. For programs involving large numbers of cows it is realistic to expect only one live calf for every two straws of semen used, even in good conditions.
- In times of stress from heat, poor nutrition, mineral imbalances and disease the level of early embryonic losses may rise. Similarly, these and other stresses can cause later embryonic mortality or abortion.
- The use of synchronising drugs should be considered for programs involving large numbers of cows. Correctly used they can reduce labour requirements, shorten the length of time of the program, concentrate the heat detection and when effective, allow the bulk of inseminations to be done at times to suit the operator. If used incorrectly or without sufficient attention to detail these products will reduce conception results and add greatly to the costs per calf obtained.
- Heifers must be well-grown and prepared well in advance. It is vital to prevent diseases causing infertility, such as vibriosis, trichomoniasis and leptospirosis.

Embryo Transfer (ET)

Embryo transfer can be used to spread the genes of genetically-superior females more widely and quickly than could be achieved with natural breeding. At birth each female has the potential to produce over 100 000 ova. Under natural conditions only a small number of ova are released and available for fertilisation. These ova are usually released only one at a time.

With appropriate hormone treatment cows can be induced to shed a number of ova during ovulation. If fertilised, the resulting embryos can be collected (usually 7 days later) and then transferred to recipient cows which then carry and rear those calves as if they were their own. The transfer of embryos can be done either surgically via the flank or non-surgically. The non-surgical transfer operation is similar to an advanced AI procedure.

At present surgical procedure achieves a slightly higher success rate of embryos than does the non-surgical method. However, non-surgical embryo transfer is quicker and allows a cow to be used many more times than the surgical method.

Embryo transfer is expensive and is not a commercially viable method for production of slaughter animals. It has been used by some commercial dairy cattle breeders but generally with beef cattle its use is restricted to use by seedstock producers. Embryo transfer has become slightly easier and more practical since it has become possible to implant embryos after freezing and thawing. Embryo sexing is now possible making the procedure more attractive to some breeders. Future developments in freezing and thawing may make embryo transfer available to a wider range of beef cattle breeders.

Preventing pregnancy in culled females

Spaying is the surgical removal of the ovaries. Non-surgical contraception refers to hormonal treatments, which prevent normal ovarian function but do not remove or destroy the ovaries. Ovarian function and normal fertility are returned on cessation of hormonal treatment.

There is only one valid reason for spaying cows —to prevent pregnancy. Contrary to popular belief spayed females do not grow faster or fatten more readily than unspayed cows —they just don't get pregnant. Good bull control can often eliminate the need to spay but access to live export markets may sometimes be easier with spayed females.

There are three methods of surgically spaying cows —flank spay, passage spay and the Willis or dropped ovary method. Spaying should be performed only by a competent large-animal veterinarian or by non-veterinarians who possess the appropriate knowledge and experience.

Flank spaying

Flank spaying involves cutting through the skin and muscle layers in front of the hip and behind the ribs to gain access to the reproductive tract. The ovaries are removed with either a 'spay-mate' or spaying scissors.

Flank spaying is simple, can be done on almost any female animal regardless of age or pregnancy status and requires only a minimum of equipment. However it is painful to the animal, is not aesthetically pleasing to outside observers and may result in some mortalities. It also causes hide damage. Sound animal welfare considerations dictate that as a minimum, operators should use a local anaesthetic for pain mitigation. Time and costs involved make this an uneconomic proposition.

Passage spaying

Passage spaying involves making an incision in the fornix area of the vagina to gain access to the ovaries, which can then be pulled into the vagina for removal (by 'spay-mate' or spaying scissors).

Passage spaying is relatively painless, as there are very few nerves in the fornix area of the vagina. The technique is more difficult than the flank spaying method and cannot be done easily (if at all) on pregnant animals. Sexually immature animals are also difficult to spay by this method. These will generally be too small at the vulva to allow insertion of the hand. This can be overcome by the use of 'spreaders' (a mechanical device to stretch the vulva), but these are often as painful to the animal as is an incision in the flank. Losses from well-conducted passage spays should be minimal.

Willis dropped ovary technique

With the Willis method, an instrument (spear) is passed through the vaginal wall into the pelvic cavity. The ovaries are located by a gloved hand in the rectum and each ovary in turn is placed into the head of the spear and is severed from the uterus. The severed ovary then drops into the abdominal cavity. Of all the surgical methods, this method is recognised as the most appropriate one. This is because it is the least invasive of the current surgical spaying methods.

There should be no need to spay pregnant cows on any property that has very good control of bulls.

If a cow is pregnant less than five months and has both ovaries removed, spaying usually results in the termination of the pregnancy. In advanced pregnancies (more than five months) removal of ovaries has little effect on the pregnancy. A common practice with pregnant cows is to remove the ovary from the non-pregnant uterine horn and to 'web' the ovary on the pregnant side. 'Webbing' is the tearing and removal of the oviduct and membrane surrounding the ovary to prevent further pregnancies.

Glossary

Abortion Expulsion or removal of the foetus from the uterus before it is viable.

Anoestrus The non-breeding period when there is no evidence of oestrus.

Artificial insemination (AI) The technique of collecting the male sperm and inserting it via a pipette into the female reproductive tract.

Bos indicus The species from which cattle referred to as tropical or humped breeds have been developed, e.g. zebu breeds including Brahman, Sahiwal and Boran.

Bos taurus The species from which temperate, British and European breeds of cattle have been developed, e.g. Hereford, Angus, Charolais and Limousin.

Breeding value Assessment of the future genetic potential of an animal; the value of an animal's genes to its progeny.

Breeding objective The desired direction of a breeding program; can be in terms of increases or decreases in one or more traits.

BREEDPLAN The Australian national beef genetic evaluation scheme that produces Estimated Breeding Values (EBV) of genetic merit for animals.

Cell Basic unit of all living tissue.

Cervix Opening into the uterus or womb.

Crossbred Progeny from crossing two or more breeds, lines or strains.

Culling Removal of unwanted animals from a population.

Cycle or Oestrous Cycle Regular sequence of stages that the cow undergoes from one heat to the next. The oestrous cycle is divisible into four stages:

1. Oestrus — the heat or season phase of the cycle.

2. Metoestrus — the phase of the oestrous cycle immediately after oestrus.

3. Di-oestrus — the quiet period in between normal heat periods.

4. Pro-oestrus — the phase of the oestrous cycle immediately before oestrus.

Dystocia Difficulty in the process of giving birth.

EBV An abbreviation for Estimated Breeding Value. For a particular character, an EBV refers to twice the difference in mean performance of a large number of progeny of one bull or cow over that of another, when bred to equivalent females or males and assumes that management and environmental factors are constant. EBVs measure differences due to the additive genetics of sires. EBVs are produced by various genetic evaluation schemes such as BREEDPLAN (beef cattle), PIGBLUP (pigs), A.D.H.I.S (dairy cattle), WOOLPLAN (Merino sheep) and LAMBPLAN (meat sheep).

Embryo An organism in the early stages of development, in the uterus for mammals or shell for birds.

Embryo transfer (ET) Technique of removing an embryo from one female (donor) and implanting it into another female (recipient).

Estimated Breeding Value See EBV.

Fallopian tube Tube that extends from the uterus towards the ovary and in which the ova are fertilised.

Fertility A measure of the ability of the female to conceive and produce offspring, or of the male to fertilise the female.

Foetus Unborn animal inside the uterus.

Follicle A small cavity, sac or gland in animal tissue.

Genes The basic units of inheritance that occupy specific positions (loci) within the genome or chromosome of an animal. Each gene has two or more forms. Genes give the potential for the development of characteristics.

This potential is affected by interactions with other genes and the environment. A gene is a unit that has one or more specific effects upon the phenotype (appearance) of an animal.

Genetic improvement The improvement (increase or decrease) in the population average of a trait.

Genetics The science of inheritance, which involves the structure and function of genes and the way genes are passed from one generation to another.

Genetic value A measure of the genetic potential of the animal.

Genotype The genetic make up of an animal.

Hereditary A condition controlled or influenced to some degree by gene action. This is in contrast to characters that are controlled by environmental variables.

Heritability (h^2) The degree to which a parent's attributes are passed on to their progeny.

Heterosis (hybrid vigour) Differences in performance or vigour of crossbred progeny from the average of the parental breeds.

Hormone A chemical compound released by glands in one part of the body that has an effect on another part of the body.

Hybrid vigour Heterosis.

Linkage Association of genes that appear to be inherited together.

Maintenance The feed required to keep an animal alive and carry out its basic functions.

Mean Average, calculated as the total divided by the number of observations.

Natural selection Genetic selection pressure exerted by all aspects of the animal's natural environment.

Normal distribution The bell-shaped frequency distribution graph that describes the normal variation in a characteristic in a population.

Nucleus (plural nuclei) The central part of the cell in which the genetic material, chromosomes and genes, are found.

Objective trait A trait that can be defined and measured in a precise way.

Oestrus or Heat The time in the oestrous cycle when mating by the male is accepted.

Ovum egg (plural ova).

Ovary The female organ that produces the ova, or eggs.

Performance test Method of evaluating an animal on its own phenotypic performance in relation to the phenotypic performance of other like-treated, or contemporary, animals.

Phenotype Physical make-up of an animal which is a result of interaction between the genotype and the environment.

Placenta Structure in the uterus of the dam through which the foetus is nourished during pregnancy via the umbilical cord. It is expelled at birth, at which time it is also called the afterbirth.

Progeny test Evaluation of an animal by examining the performance of its progeny, often used for comparing the breeding value of sires in terms of the average performance of each sire's progeny.

Puberty Sexual maturity.

Sanga *Bos taurus* breeds that over thousands of years have developed tropical adaption traits, e.g. Africander and Tuli.

Semen The sperm and fluids produced in the testicles and other glands of the male's reproductive system.

Spermatozoa Sperm; the male gametes.

Subjective trait One that cannot be defined or measured in a precise way.

Superovulation Act of stimulating the ovary to produce more eggs than normal.

Trait Character or characteristic.

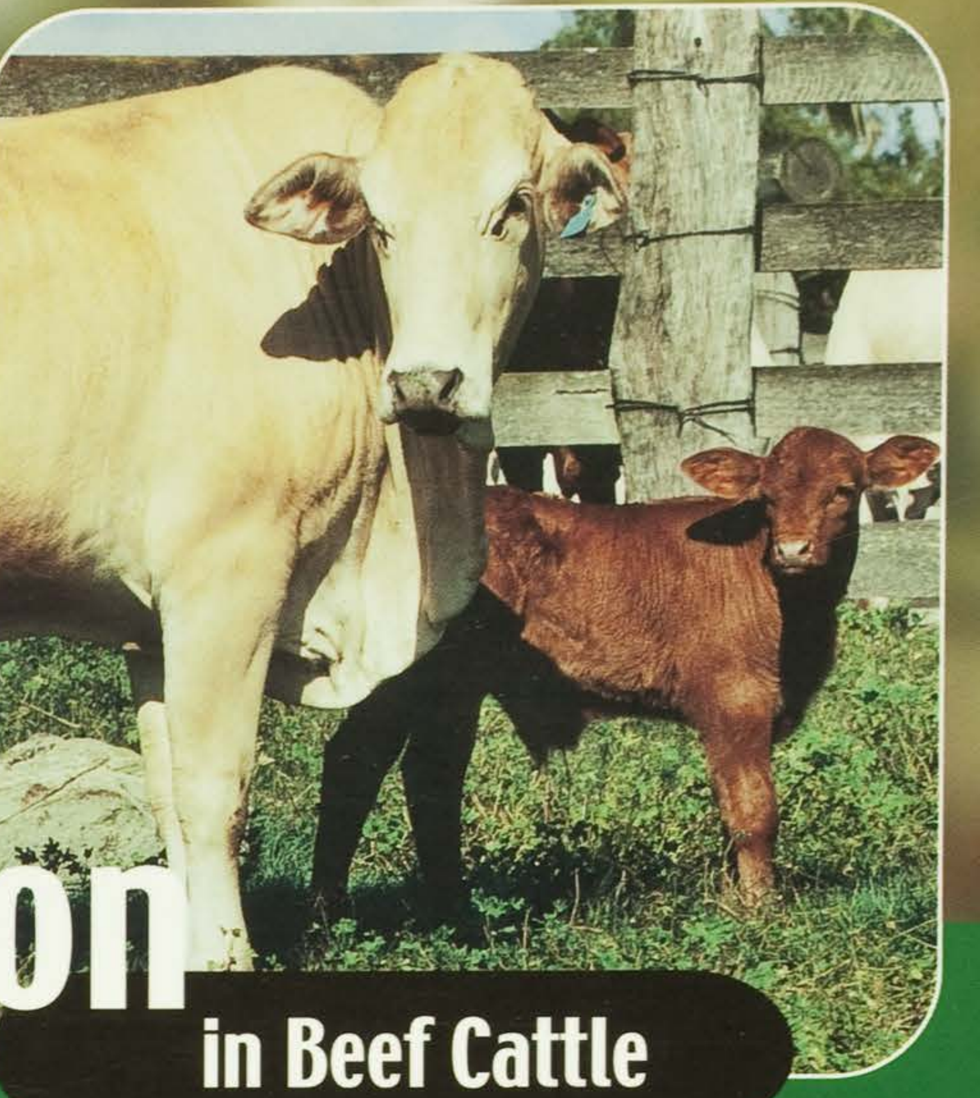
Traditional selection Selection based on performance of the animals to be used for breeding the next generation of progeny. Traditional selection strategies in animal breeding programs have been based on either selection by eyeball, phenotypic performance or the use of EBVs, which are determined from the statistical analysis of the performance of an individual and its relatives.

Ultrasonic Equipment that uses high frequency sound waves to assess what is below the skin of a live animal such as fat layers and muscle area.

Uterus The female organ in which the foetus develops during pregnancy.

Variation Measure of animal differences in a group or population.

Yearling Animal of approximately one year of age.



Female Selection

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in Beef Cattle

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